PHASE I AVIAN RISK ASSESSMENT

Mount Wachusett Community College Wind Energy Project

Worcester County, Massachusetts

Report Prepared for:

Mount Wachusett Community College

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Executive Summary

Mount Wachusett Community College (MWCC) proposes to construct one or two wind turbines on its campus in Gardner, Worcester County, Massachusetts. Although the turbine model has not yet been specified, it would likely be about a between 900 and 1,650 kW turbine. Although final turbine dimensions have yet to be determined, with the rotor tip in the 12 o'clock position, the wind turbines could reach a maximum height of between 252 and 397 feet above ground level (agl. One or both turbines would be lit according to the Federal Aviation Administration (FAA) advisory circular, probably with red strobe-like lights or newer LED's (FAA type L-864) on the nacelle.

This report details a Phase I Avian Risk Assessment and a breeding bird census conducted for the Mount Wachusett Community College Wind Energy Project (hereafter referred to as the "Project"). The purpose of a Phase I Avian Risk Assessment is to determine potential collision and displacement risk to birds from project construction and operation at a proposed site. The risk-assessment process is based on: 1) a site visit, 2) a literature and database search, and 3) written consultations with wildlife agencies regarding special-interest species, as well as other wildlife concerns.

A review of the literature on avian mortality at wind plants reveals nearly 30 post-construction fatality studies at wind plants in the U.S. Bird fatalities at these facilities range from zero to more than seven birds per turbine per year. Birds involved have mostly been common species and none have been federally endangered or threatened. Fatalities have not been considered to be biologically significant and overall fatalities at wind plants in the U.S. were revealed to be orders of magnitude less than fatalities caused by communication towers, roads, buildings, transmission lines, pesticides, cats, oil pits, hunting, and other human activities such as habitat destruction.

The site visits were conducted on April 15 and 16, and June 3, 4, and 5, 2008. The Project site is located in a small, isolated field on the outskirts of an urban center. Habitat surrounding the 13-acre field includes a small pond and wetland, fragmented secondary woodland, and commercial development (a college campus, parking lots, district court, hospital, golf course, and a highway). Given the poor habitat quality, the breeding-bird community has relatively low species diversity and bird abundance. According to the Massachusetts Division of Fisheries and Wildlife (MADFW)/ Natural Heritage and Endangered Species Program (NHESP) and U. S. Fish and Wildlife Service (USFWS; letters provided in Appendix D), no Massachusetts-listed or federally species are at the site, but a small breeding population of the *Yellow WatchList*[1] Willow

[1] The recently published *2007 WatchList for United States Birds* highlights all the highest priority birds for conservation in the United States. See Section 4.1 discussion.

Flycatcher has established itself in the shrub zone bordering the pond, wetland, and field. Despite the field's small size, it was found to attract three male Bobolinks, whose displays in turn attracted two females. Nonetheless, no other obligate grassland birds were found to use the field to breed. Breeding Bird Atlas (BBA) and Breeding Bird Survey (BBS) data support these findings.

There are no ecological magnets or barriers that would attract or concentrate migrating birds in large numbers at the Project site or nearby. In the case of night-migrating songbirds, raptors, and waterbirds, migration will be broad front in nature and generally at altitudes above the sweep of the wind turbine rotors.

Christmas Bird Count (CBC) data indicate that the Project site will have very few birds in winter. Outside of the Massachusetts special-concern Sharp-shinned Hawk, no listed or *WatchList* species appears likely to occur at the Project site in winter. In the case of the hawk, occasional individuals found to forage at the site would probably not be from the Massachusetts breeding population.

The Project site does not overlap an Important Bird Area (IBA), nor is its habitat distinct in character, habitat, or ornithological importance from surrounding landscape. Instead, the Project site is a small, isolated field on the outskirts of an urban center. Given these findings, no sensitive habitats and increased avian risk are indicated.

Regarding avian risk from the Project, disturbance and displacement effects resulting from the Project are expected to be minor. Project construction will be of limited duration and unlikely to affect species of greatest conservation concern, which do not occur at the site. Habitat modification may affect the small Bobolink population, but there is reason to consider reducing the grassland further in favor of shrubland to provide habitat for *Yellow WatchList* species, such as Willow Flycatcher. Turbine operation could potentially displace breeding Bobolinks, but the presence of Bobolinks is already significantly threatened by various demographic and environmental events, including annual mowing of hay. Displacement of some birds may occur, although Bobolinks have been shown to tolerate the proximity of wind turbines.

Regarding collision risk, post-construction fatality studies, particularly those that have taken into account searcher efficiency in finding carcasses, as well as carcass removal by scavengers, have demonstrated that fatalities are relatively infrequent events at wind farms. In a 2005 review of the literature on U.S. wind farms, mortality estimates were similar among projects, averaging 2.51 birds per turbine per year and 3.19 birds per MW per year. Rates were slightly higher in the Eastern U.S. than in the West, likely because of denser nocturnal migration of song and other birds in eastern North America. No federally listed endangered or threatened species have been recorded, and only occasional raptor, waterfowl, or shorebird fatalities have been documented. In general, the documented level of fatalities has not been large in comparison with the source populations of these species, nor have the fatalities been suggestive of biologically significant impacts to these species.

Fatality numbers and species impacted at the Project site are likely to be similar, on a per turbine per year basis, to those found at Eastern and Midwestern U. S. projects that have been studied.

Because there will be only one or two turbines, the absolute numbers of fatalities will in all likelihood be very small and when distributed among several species, are not likely to be biologically significant. When compared with most other wind power facilities, collision risk factors for raptors are minimal. Collision risk to night-migrating songbirds is likely to be similar to other sites examined because the altitude of migration is generally above the sweep of the wind turbine rotors.

The following recommendations have been formulated to minimize avian risk:

Construction Guidelines

- Electrical lines within the project site should be underground between the turbines.

- Permanent meteorology towers should be freestanding (i.e., without guy wires) to prevent the potential for avian collisions.

- Size of roads and turbine pads should be minimized to disturb as little habitat as possible. After construction, any natural habitat should restored as close to the turbines and roads as possible to minimize habitat fragmentation and disturbance/displacement impacts. To accomplish this, topsoil or marsh should be replaced as a means of encouraging plant growth.

- Lighting of turbines and other infrastructure (turbines, substations, buildings) should be minimal to reduce the potential for attraction of night migrating songbirds and similar species. Federal Aviation Administration (FAA) night obstruction lighting should be only flashing beacons (L-864 red or white strobe) with the longest permissible off cycle. Steady burning (L-810) red FAA lights should not be used. Sodium vapor lamps and spotlights should not be used at any facility (e.g., lay-down areas or substations) at night except when emergency maintenance is needed.

Recommended Post-construction Studies

- A mortality study following best practices should ideally be conducted during a two-year period post-construction, with the second year contingent on what is found during the first year. If fatalities are recorded at levels that could be construed as biologically significant, or if significant numbers of special-status species are involved, a second year of study would be called for. The design of the post-construction protocol should follow the designs now being used and refined at existing wind-power sites and approved by various government agencies, including MADFW and U. S. Fish and Wildlife Service (USFWS). Such a study could be integrated into MWCC's environmental program. Students and faculty of MWCC would conduct the study with technical support from a biologist trained in conducting post-construction fatality studies.

- Results of the fatality study should be compared with impacts to birds from other types of power generation now supplying electricity in Massachusetts. This comparison would facilitate long-term planning with respect to electrical generation and wildlife impacts.

The study should seek information from USFWS and MADFW on existing energy-generation impacts to wildlife. If information is not available, as our preliminary review appears to reveal, these agencies should consider providing financial support for such studies. This project should be conducted by a team involving faculty, students, and a wind industry consultant.

Recommended Habitat Enhancement

- The most significant breeding bird that presently occurs at the Project site is the *Yellow WatchList* Willow Flycatcher, which nests in the shrubland zone between the field and pond. We recommend developing a habitat management plan that would expand shrubland habitat to increase this flycatcher's population (presently at six territorial males). This step also has the potential to attract two other *Yellow WatchList* species to the site: the Blue-winged and Prairie Warblers, both of which were recorded regionally in the Breeding Bird Atlas and more recently in Breeding Bird Surveys. Ideally, MWCC students should be involved in the development and implementation of this plan. It should be noted, however, that increasing the shrubland zone will likely reduce habitat for the Bobolinks that presently display and possibly nest in the field. Nonetheless, the future of this Bobolink population is uncertain, given that it is so small and isolated. Furthermore, the flycatcher's status on the *Yellow WatchList* makes it of higher conservation concern. In any event, the field should not be mowed until about July 15, after Bobolink young have fledged (if they are nesting in the field). A discussion of the impacts from hay mowing is provided in this report.

Agency Coordination

Early coordination letters were sent to MADFW and NHESP, and the USFWS . Response letters from those agencies are provided in an Appendix to this report. This coordination and the work done for this report helps to meet the recommendation of the MADFW, that potential impacts to birds be considered during the Project's design and permitting process.

The U.S. Fish and Wildlife Service (USFWS) recommended that three years of pre-construction radar study be conducted. We do not believe that such a study is warranted because it will not improve on this risk assessment. Radar has never been documented to be a precise or reliable predictor of risk at wind power or other structures. As discussed in Section 4.2.1, the nocturnal migration pattern (in terms of traffic, altitude, percent of birds flying at rotor height, etc.) has been well documented at more than 20 sites across the northeastern U.S. The weight of these studies gives no reason to believe that the migration pattern would be substantially different at the Project site. Furthermore, as discussed in Section 6.1.2, all post-construction fatality studies at wind energy facilities have established that the average fatalities per turbine per year are relatively low (averaging perhaps three night migrants per turbine per year at wind farms in the northeastern US.), and no mass or large-scale fatality events have ever been recorded. Therefore, detailed knowledge of night-to-night and year-to-year variation in nocturnal migration at a site will not improve on our mortality forecast.

USWFS has also recommended that the effects of habitat fragmentation be considered. With regard to birds, we find that the creation of an access road and one or two turbine-construction areas in the field will reduce functional grassland by a small percentage. The Project will not fragment woodland, which is already heavily fragmented and degraded, nor will it modify shrubland, wetland, or other native habitat.

Conclusion

Based on our extensive studies at wind power facilities in many states, the literature gathered on impacts to birds at wind power facilities, and on our site specific work, the MWCC project appears to be one of the lowest risk wind power facilities that we have studied. With only one or two turbines situated in an area without significant avian nesting, foraging, migrating, or wintering habitat, significant collision and displacement impacts are highly improbable. In addition, we do not recommend further pre-construction study at this site. Finally, the avian mitigation measures recommended in this report, combined with a post-construction fatality study, will certainly prevent or reduce avian impacts to non-significant levels.

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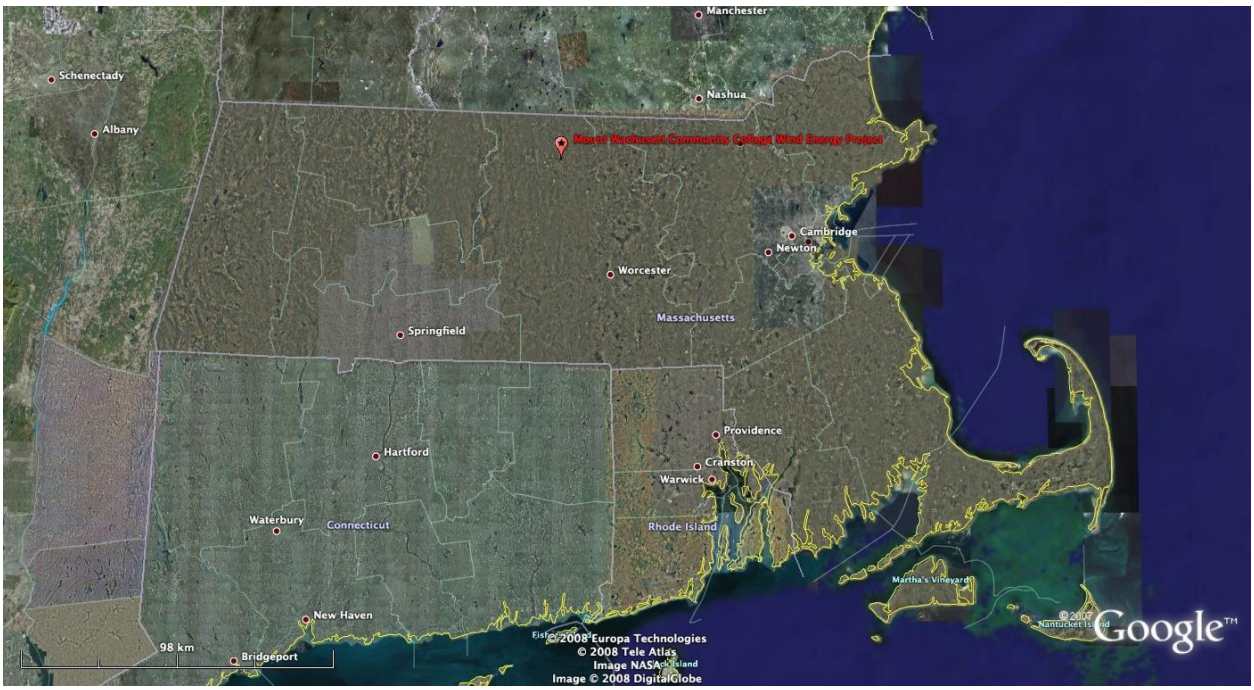

Figure 2. Regional View of Project Site in Outskirts of Gardner, Massachusetts.

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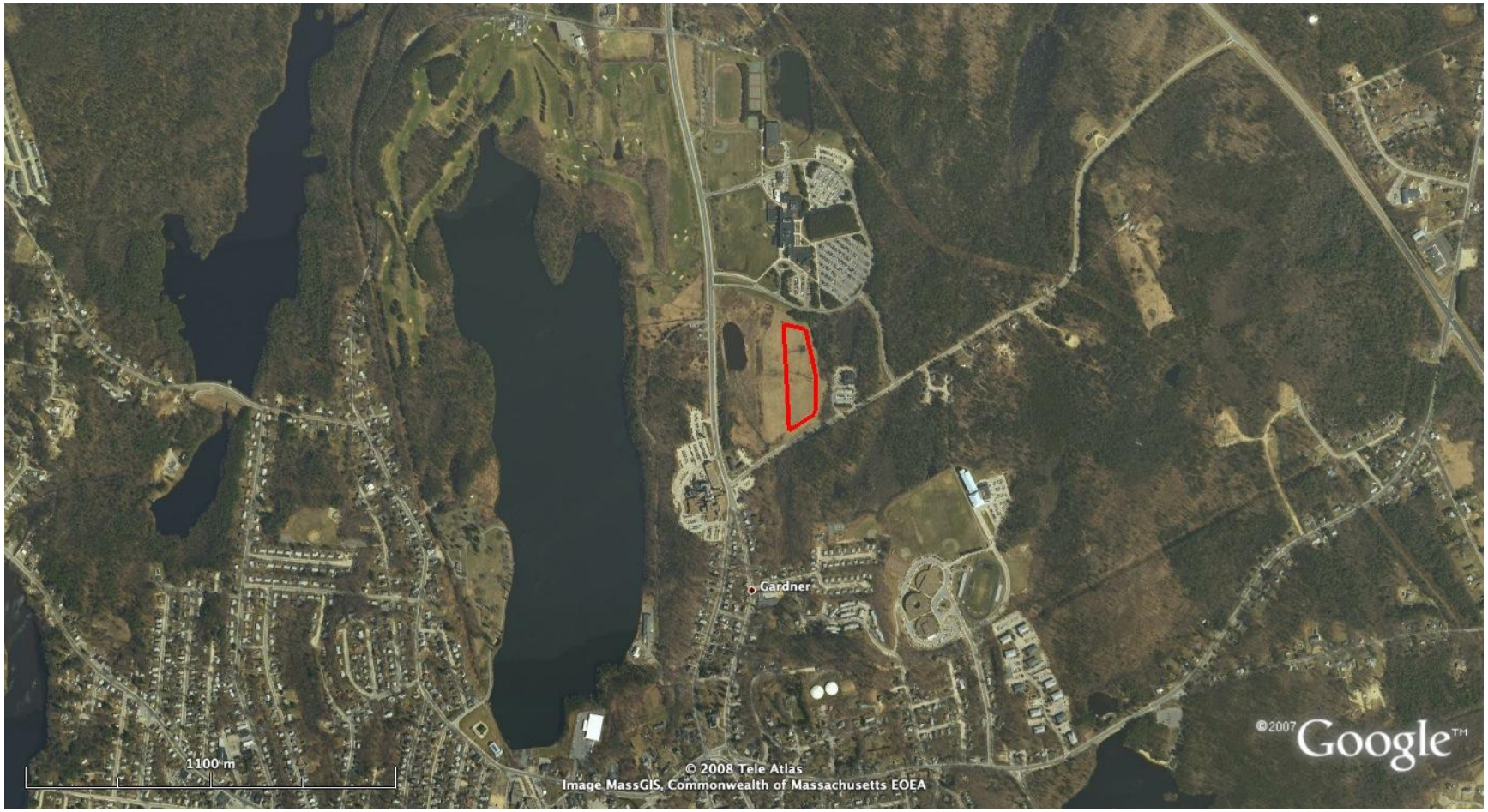

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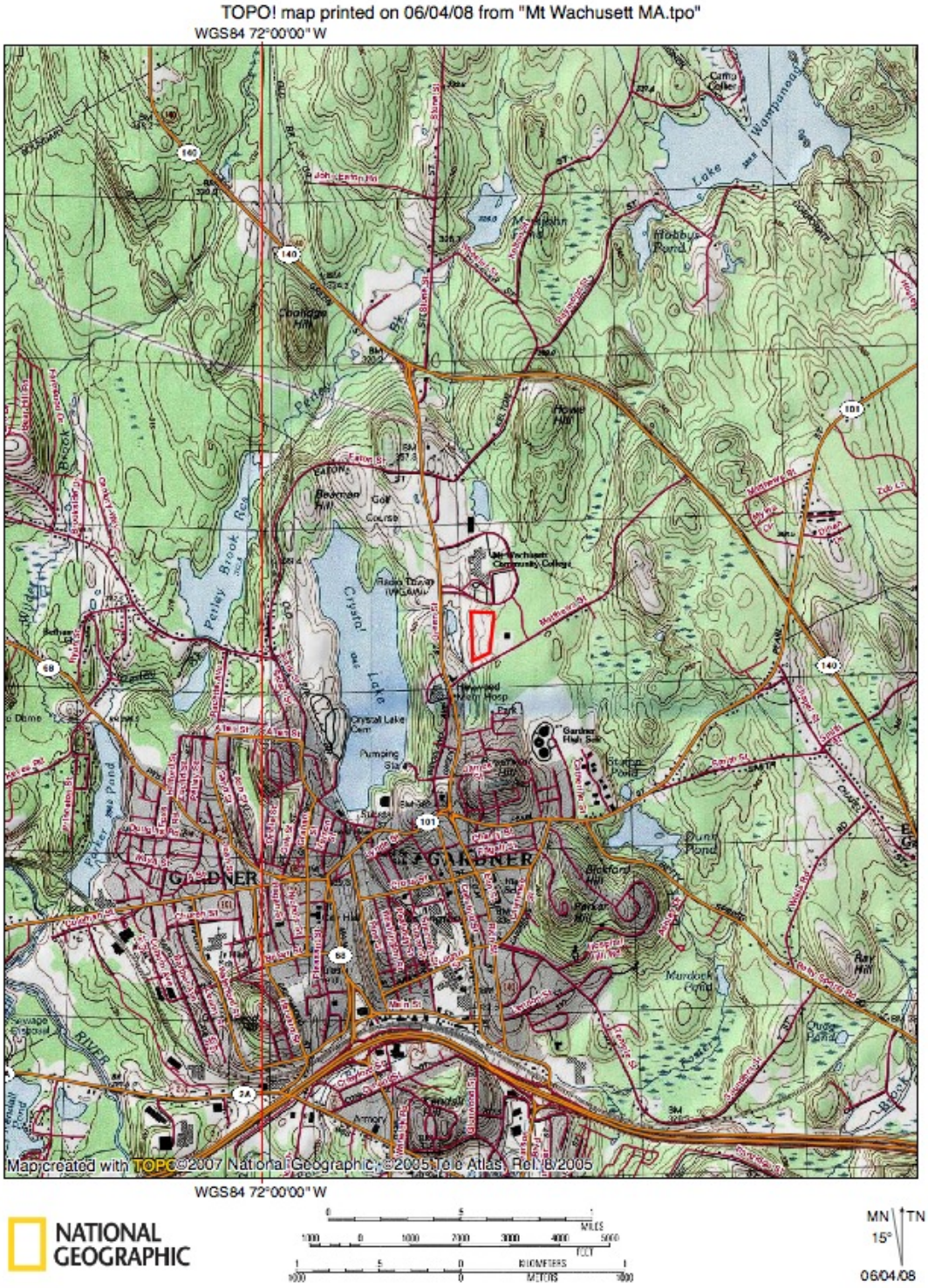

1.0 Introduction

Mount Wachusett Community College (MWCC) proposes to construct one or two wind turbines on its campus in Gardner, Massachusetts (see Figures 1 through 4). This report details a Phase I Avian Risk Assessment conducted for the Mount Wachusett Community College Wind Energy Project (hereafter referred to as the "Project").

The purpose of a Phase I Avian Risk Assessment is to determine potential risk to birds from project construction and operation at a proposed site. Birds are generally at risk from collisions with turbine rotors and meteorology tower guy wires, and from disturbance and displacement by construction activities (e.g., habitat clearing) and new, large infrastructure. The Phase I Avian Risk Assessment walks developers, regulators, environmentalists, and other stakeholders through a risk assessment process at a particular site, including how evaluation of potential impacts may require further study. The process is based on: 1) a site visit, 2) a literature and database search, and 3) written consultations with wildlife agencies regarding special-interest species, as well as other wildlife concerns. The Phase I also addresses compliance issues and recommendations set forth by the U.S. Fish and Wildlife Service (USFWS) in its *Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines* (USFWS 2003; see Appendix A).

An avian expert skilled in bird identification and habitat evaluation undertakes the site visit. Over a two or three-day period, this researcher conducts a thorough tour of the site by car and on foot, noting the different bird habitats present and recording the birds seen or heard. The expert also documents the various landscape features and habitats with photographs. In the field, habitats and topography are evaluated with special consideration for: 1) federal and state-listed endangered, threatened, and other special-status bird species; and 2) probable avian use during the nesting, migration, and winter seasons. The site visit is not intended to be an exhaustive inventory of species presence and use. Nonetheless, it adequately records habitat and topographic features so that a list of species that might conceivably be present at different times of the year can be assembled and the potential for risk to those birds from a wind power project can be assessed.

Avian literature and databases examined include records of the USFWS and the Massachusetts Division of Fisheries and Wildlife (MADFW), as well as data from the Massachusetts Breeding Bird Atlas (BBA, 1974-1979), North American Breeding Bird Survey (BBS), Audubon Christmas Bird Counts (CBC), hawk migration literature (e.g., Hawk Migration Association of North America), Important Bird Areas (IBA), and other information on birds that might nest, migrate, forage, winter, or concentrate at the site. An additional part of the literature search focuses on the empirical findings of studies that have focused on wind turbine impacts to birds.

Consultations are conducted via letter with wildlife agency biologists – in this case, MADFW and USFWS – to request information they may have on listed species at or near the Project site. These letters seek to improve knowledge of the site's avifauna and of the potential risk to birds that are likely to be present. Additionally, such consultations can determine the scope of work that may be needed to further assess risk after the avian risk assessment has been completed.

Based on the process outlined above, this report summarizes known and likely bird use of the Project site's habitats, compares the Project site with wind-energy projects where risk has been determined (with special consideration given to wind-power projects in the Eastern U.S.), determines the potential risks birds may face from the construction and operation of wind turbines at the site, and presents recommendations for further studies and potential mitigation, if warranted.

2.0 Project and Site Description

2.1 Project Description

The Mount Wachusett Community College Wind Energy Project is proposed for north-central Massachusetts, more specifically northern Worcester County (Figure 1). The Project is located within the city limits of Gardner, just outside the city center (Figures 2 and 4).

Mount Wachusett Community College (MWCC), the Project proponent, proposes to construct one or two wind turbines. Although the turbine model has not yet been specified, it would likely be about a between 900 and 1,650 kW turbine. Although final turbine dimensions have yet to be determined, with the rotor tip in the 12 o'clock position, the wind turbines could reach a maximum height of between 252 and 397 feet above ground level (agl).

The turbines would be mounted on steel tubular towers and one or both would be lit according to Federal Aviation Administration (FAA) guidelines. As with most modern wind farms, FAA lighting would probably be red strobe-like lights or newer LED's (FAA type L-864) on the nacelle. Electrical collection lines between the turbines would be underground. An electric substation is not needed, although each turbine would have a pad mounted transformer (90" per side) immediately adjacent to the base of the turbine. There will also be a pad-mounted switching assembly at the turbine closest to the campus buildings. That strcture would be 6 feet tall by 6 feet deep by 12 feet long.

2.2 Site Description

Various literature sources and Internet sites, the Massachusetts Atlas & Gazetteer (DeLorme 2004), satellite imagery viewable through Google Earth Pro, USGS topographic maps viewable through National Geographic's TOPO! mapping software were consulted to understand the Project site's physiography, topography, and habitat. This information was checked against a site visit conducted by an avian researcher on June 3, 4, and 5, 2008.

The Project site is located in the Worcester/Monadnock Plateau of the Northeastern Highlands ecoregion, which Petersen and Meservey (2003) describe as follows:

> This is a large and important subregion that includes most of the mountainous and hilly areas of the central uplands of Massachusetts. Elevations range from 500 to 1,400 feet (150 to 425 m), with the exception of Mount Watatic (1,832 feet [559 m]) and Mount Wachusett (2,006 feet [612 m]), both of which provide easterly outposts for northern breeding species more typical of the higher elevations of western Massachusetts. Forest types are largely transitional and northern hardwoods, with pockets of spruce on the higher hilltops.

The Project site is relatively flat, with elevations ranging from 1,130 to 1,165 feet (345 to 355 m). As may be noted in Figures 2 through 4, the site is located in the outskirts of an urban center. Beyond the city, land cover is mostly forest/woodland with interspersed fields and lakes. Residential development is also a significant land use.

3.0 Results of Site Visit and Avian Census

An experienced field ornithologist visited the MWCC site on April 15 and 16, June 3, 4, and 5, 2008. The latter site visit was at the peak of the nesting bird season. During the June visit time was spent listening for nocturnal species on two days after sunset and two mornings before sunrise. Weather during the first visit was mild and clear. And during the second visit was cool and overcast, with some fog, drizzle, and rain on June 4.

The entire site and adjacent areas were walked. The region around the Project site was explored by car to improve understanding of bird distribution. Photographs in Appendix B show the site's major habitats and landscape features.

The Project site is a 13-acre (5.2-ha) field located about 600 feet (180 m) south of the main building on the MWCC campus (Figure 3). Low, secondary oak-pine woodland and the Gardner District Court abut the site to the east. Matthews Road forms the site's southern boundary, across which taller, secondary oak-pine woodland occurs. To the west, the field descends to a 2-acre (0.8-ha) pond surrounded by a 9-acre (3.6-ha) wet, shrubby meadow. Beyond the pond to the west is a narrow band of upland habitat bordering Green Street, a major traffic artery, across which a golf course and Haywood Hospital are located.

During the June 2008 site visit a nesting bird census was conducted. A census is an attempt to record all species that likely nest at a given site. This census included visits to the site at dusk and into darkness to determine which, if any, nocturnal species were present. The MWCC site is small enough to permit a census to be done. In total, 43 species (Appendix C) were recorded at and immediately adjacent to the Project site. Of the 43 species that were observed, about 20-22 nest within the grassy field, forested edge adjacent to the field, or around the pond and wetlands adjacent to the field. The remaining species either nested within 200-400 m from turbine locations and some nested farther away. The species observed were mostly songbirds of upland fields and forest edges. A few, such as Ovenbird and Black-and-white Warbler, as well as Wood Thrush, are species of forest interior habitats. Those species would not nest in the field where turbines would be placed, nor would they nest at the adjacent wetlands and forested edge. Raptors do not nest in the turbine area, nor do shorebirds such as American Woodcock or Wilson's Snipe.

Of particular interest were three male Bobolinks displaying in the field. Most of the time, they were perched in the tops of the shrubs forming the western border of the field, and most of their singing occurred from those perches. Occasionally, however, they would perform flight displays at low altitudes (less than 50 feet [15 m]) over the field and alight on tall grasses and forbs and on the few trees and shrubs occurring in the field. On one occasion, one of the Bobolinks landed on a guy wire of the met tower. Two females were also seen, strongly suggesting that Bobolinks

breed in the field or adjacent wet meadow. Bobolink was the only obligate grassland bird found to use the field. Savannah Sparrow, for example, was not encountered.

Another bird of interest was the Willow Flycatcher, a species on the *Yellow WatchList*[2]. Five territorial males were found in the shrubland zone bordering the pond, and another male was found in shrubland bordering the golf course across Green Street. Other birds using the pond, marsh, and shrubland zone were Green Heron, Eastern Kingbird, Tree Swallow, House Wren, American Robin, Gray Catbird, Yellow Warbler, Common Yellowthroat, and Red-winged Blackbird.

One Wood Thrush (*Yellow WatchList*) and two Overbirds were heard singing from the taller woodland across Matthews Road. Pine Warbler and Yellow-rumped Warbler were found in pine plantings bordering the campus parking lots.

Birds noted in flight in the vicinity of the field were Canada Goose (flocks graze on the lawns of the MWCC campus), Mallard, Double-crested Cormorant, Great Blue Heron, Rock Pigeon, Chimney Swift, American Crow, Tree Swallow, Barn Swallow, European Starling, Bobolink (see above), Common Grackle, and American Goldfinch.

No federal or state-listed species were encountered, nor were any deemed likely to nest, stopover, or winter at or adjacent to the site, given the small size and isolation of the field and adjacent habitats. The Massachusetts endangered Bald Eagle, threatened Northern Harrier, and special-concern Common Loon and Sharp-shinned Hawk may occur over the site in migration, but individuals of those species would likely not originate from Massachusetts breeding populations.

4.0 Avian Overview of the MWCC Site

The North American Landbird Conservation Plan (Rich et al. 2004) locates the Project site at the southern end of the Atlantic Northern Forest (Bird Conservation Region # 14) of the Northern Forest Avifaunal Biome, a region covering much of northern North America. The New England/Mid-Atlantic Coast Bird Conservation Region (# 30) begins just to the east of the Worcester/Monadnock Plateau.

Based on information in the document, *DRAFT: Blueprint for the Design and Delivery of Bird Conservation in the Atlantic Northern Forest* (Dettmers, in preparation; visit http://www.acjv.org/documents/bcr14_blueprint.pdf), Northern Hardwood forest is the forest type covering the Project region. The dominant trees of this association are beech, birch, and maple species. Its characteristic birds include Ruffed Grouse, Yellow-bellied Sapsucker, Blue-headed Vireo, Wood Thrush, Veery, Black-throated Blue Warbler, American Redstart, Overbird, and Rose-breasted Grosbeak. Where this forest type has been logged or disturbed, the resulting early successional/shrubland habitats contain such characteristic birds as American Woodcock, Ruffed Grouse, Chestnut-sided Warbler, Mourning Warbler, and Whip-poor-will. Where

[2] The *2007 WatchList for United States Birds* highlights all the highest priority birds for conservation in the United States. See Section 4.1 discussion.

wetland habitats occur, characteristic birds include American Black Duck, Wood Duck, Common Loon, American Bittern, Bald Eagle, and Spotted Sandpiper.

Bird conservation issues in the Atlantic Northern Forest (see Dettmer, in preparation) revolve around balancing forest management for timber resources with the maintenance of forest successional stages. In the southern portion of the Atlantic Northern Forest region, including the Worcester/Monadnock Plateau of Massachusetts, declines in the availability of early successional forest habitats are of particular concern. Other concerns include forest health issues, mainly the spread of various invasive forest pest species and atmospheric deposition of toxic substances (such as mercury and acid rain), the latter resulting mainly from fossil fuel-based electricity generation. Wind-power development along forested ridgelines has also been flagged as a concern, as has urban sprawl and recreational development.

According to Rich et al. (2004), the Northern Forest Avifaunal Biome is a core breeding range for Neotropical migrants, particularly warblers, thrushes, vireos, and flycatchers. About 90% of the birds that breed in this region migrate out for the winter, with some wintering as far south as northern South America. Between 121 and 150 landbird species are recorded as breeding in the various habitats of the Northern Forest region of New Hampshire, but only between 41 and 80 landbird species occur there in winter (Rich et al. 2004).

A seasonal look at the avifauna at the Project site follows.

4.1 Breeding Birds

Table 4.1-1 (below) summarizes the MADFW and USFWS lists of endangered, threatened, and special-concern species. Given their special status, these species have been given particular attention in assessing avian risk at the Project site. Based on the site visit and other data sources. The suitability of habitat for nesting on the Project site was graded as suitable (S), marginally suitable (MS), or not suitable (NS) as listed in Table 4.1-1. Where there is uncertainty in this assessment, it is indicated by a question mark.

It is worth noting that a few of the species listed in Table 4.1-1 are also included in the recently published *2007 WatchList for United States Birds* (Butcher et al. 2007). Developed collaboratively by Audubon and the American Bird Conservancy (ABC), the *WatchList* highlights all the highest priority birds for conservation in the United States. It is based on the species assessment methodology that Partners in Flight (PIF; see Rich et al. 2004) has employed to rate the conservation status of landbirds. Audubon and ABC have taken PIF's standards and applied them to the other bird groups.

The *WatchList* is divided into two categories: 1) *Red WatchList: Highest National Concern* (59 species, including Piping Plover, Golden-winged Warbler, and Henslow's Sparrow on the Massachusetts list) and 2) *Yellow WatchList: Declining or Rare Species* (119 species, including King Rail, Roseate Tern, and Short-eared Owl on the Massachusetts list).

Some *Watchlist* species not listed in Table 4.1-1 may also occur at the Project site. Examples from the site visit were the *Yellow WatchList* Willow Flycatcher and Wood Thrush. The occurrence of *WatchList* species will be highlighted in the various data sources checked below.

USFWS and MADFW have responded to written inquiries about records of listed species in the Project vicinity. Their letters may be found in Appendix D. In summary, neither agency has records of listed species from the Project site or immediate vicinity, and neither has mapped the site as critical habitat. MADFW recommends that potential impacts to birds be considered during the Project's design and permitting process. USFWS, however, recommends that "1) the spatial and temporal uses of the rotor-swept zone be identified and evaluated using radar and remote sensing techniques for a period of three years, and 2) the local site environs be evaluated to determine the presence and magnitude of habitat fragmentation syndrome of effects that would be implicated by project construction and/or operation." We will comment on the two USFWS recommendations in Sections 7.0 and 8.0 of this report. Based on past agency consultations related to Eastern U.S. wind-power projects, the extensive information and data sources checked for this report generally address most concerns of the wildlife agencies.

Table 4.1-1. Massachusetts Listed Species and Habitat Suitability for Nesting at Project Site

Species	MA (Federal) Status[1]	Recorded Site Visit	Recorded BBA Block[2]	Recorded BBS Route[3]	Habitat Suitability at Site[4]
Endangered / Threatened[5]					
Pied-billed Grebe	E	No			NS
Leach's Storm-Petrel	E	No			NS
American Bittern	E	No	+	+	NS
Least Bittern	E	No			NS
Bald Eagle	E	No			NS
Northern Harrier	T	No			NS
Peregrine Falcon	E	No			NS
King Rail (*Yellow WatchList*)	T	No			NS
Piping Plover (*Red WatchList*)	T (E)	No			NS
Upland Sandpiper	E	No			NS
Roseate Tern (*Yellow WatchList*)	E (E)	No			NS
Short-eared Owl (*Yellow WatchList*)	E	No			NS
Sedge Wren	E	No			NS
Golden-winged Warbler (*Red WatchList*)	E	No			NS
Northern Parula	T	No			NS
Vesper Sparrow	T	No	+		NS
Grasshopper Sparrow	T	No			NS
Henslow's Sparrow (*Red WatchList*)	E	No			NS
Special Concern[5]					
Common Loon	SC	No			NS
Sharp-shinned Hawk	SC	No	+		NS
Common Moorhen	SC	No			NS
Common Tern	SC	No			NS
Arctic Tern	SC	No			NS
Least Tern	SC	No			NS
Barn Owl	SC	No			NS
Long-eared Owl	SC	No			NS
Blackpoll Warbler	SC	No			NS
Mourning Warbler	SC	No			NS

[1] E = Endangered, T = Threatened, SC = Special Concern – Federal status in parentheses
[2] BBA = Breeding Bird Atlas. Please see Table 4.1.1-1 for details.
[3] BBS = Breeding Bird Survey. Please see Table 4.1.2-1 for details.
[4] S = Suitable, MS = Marginally Suitable, NS = Not Suitable. Suitability determined by Consultant Evaluation and habitat observed on site.
[5] From http://www.mass.gov/dfwele/dfw/nhesp/species_info/mesa_list/mesa_list.htm (accessed 6/3/08). *WatchList* species are designated as *Red WatchList* or *Yellow WatchList* (see Section 4.1 discussion)

In addition to the breeding bird census that was conducted on site, two other data sources of breeding bird data were examined. These additional data sources are described in the following sections. One is the Massachusetts Breeding Bird Atlas (BBA, 1974-1979), because its coverage overlapped the Project site. It was checked for the occurrence of special-status species. The other source was the last ten years of available data from nearby routes of the Breeding Bird Surveys (BBS) of the U.S. Geological Survey (USGS). One of these routes was analyzed in detail to profile the breeding bird community. If Massachusetts endangered, threatened, or special-concern species, or *WatchList* species, are indicated in these analyses, they have been noted.

4.1.1 Breeding Bird Atlas (BBA) Analysis

Conducted from 1974 to 1979 and modeled after *The Atlas of Breeding Birds in Britain and Ireland* (Sharrock 1976), the Massachusetts Breeding Bird Atlas (BBA) was one of the first BBA projects conducted in the U.S. Based on the grid of 189 topographical quadrangle maps produced by the U.S. Geologial Survey to cover Massachusetts, the BBA project divided these quadrangles into six equal blocks roughly covering 10 square miles (25 km^2). This created a statewide grid of 989 blocks. Blocks were assigned to volunteer birdwatchers, who visited the various habitats within their assigned blocks in order to record evidence of breeding for the birds they saw. Evidence of breeding was graded as *Possible* (i.e., a species is simply observed in possible nesting habitat), *Probable* (i.e., a species exhibits certain behaviors that indicate breeding, such as territoriality, courtship and display, or nest building), or *Confirmed* (i.e., a species is observed nesting or engaged in behaviors associated with nesting, such as distraction display, carrying a fecal sac, carrying food for young, feeding young, etc.).

Results are mapped in the *Massachusetts Breeding Bird Atlas* (Petersen and Meservey 2003). Table 4.1.1-1 reports the special-status species recorded in the Gardner Quadrangle (D-13) overlapping the Project site and in the eight quadrangles surrounding it (C-12, C-13, C14, D-12, D-14, E-12, E-13, and E-14). This analysis gives some indication of the likelihood of finding special-status species in the Project vicinity, even though bird distributions have changed somewhat in the nearly thirty years since the Atlas was conducted.

As noted in Table 4.1.1-1, only the Massachusetts threatened Vesper Sparrow was recorded in the Gardner Quadrangle, but the Massachusetts endangered American Bittern and special-concern Sharp-shinned Hawk were recorded in surrounding quadrangles. Each was recorded in two of nine quadrangles. Of the 48 blocks represented in these nine quadrangles, Vesper Sparrow was recorded in three (including two in the Gardner Quadrangle), while American Bittern and Sharp-shinned Hawk were recorded in two. The highest breeding status for all was probable. The paucity of records indicates that these species were rare breeders in the Worcester/Monadnock Plateau in the late 1970s. It is likely that the sparrow's population has decreased further (if it has not been extirpated), as fields have been abandoned and have reverted to woodland.

Six *Yellow WatchList* species were recorded. Wood Thrush, Prairie Warbler, and Canada Warbler were recorded in the Gardner Quadrangle and in between six and eight of the surrounding quadrangles. Of them, however, only Wood Thrush was widely distributed,

recorded in 42 of 48 blocks. Olive-sided Flycatcher, Willow Flycatcher, and Blue-winged Warbler were much more localized in their distributions.

Table 4.1.1-1. Special-Status Species Records in 1974-1979 Massachusetts BBA[1]

Special-Status Species[2]	Recorded in Gardner Quad	% in 9 Quads[3]	% in 48 Blocks	Highest Breeding Status
American Bittern (MA-E)		**22%**	**6%**	**Probable**
Vesper Sparrow (MA-T)	**+**	**22%**	**4%**	**Probable**
Sharp-shinned Hawk (MA-SC)		**22%**	**4%**	**Probable**
Olive-sided Flycatcher (*Yellow WatchList*)		11%	4%	Confirmed
Willow Flycatcher (*Yellow WatchList*)		44%	8%	Probable
Wood Thrush (*Yellow WatchList*)	+	100%	88%	Confirmed
Blue-winged Warbler (*Yellow WatchList*)		44%	8%	Probable
Prairie Warbler (*Yellow WatchList*)	+	77%	21%	Probable
Canada Warbler (*Yellow WatchList*)	+	88%	50%	Confirmed

[1] Data from Petersen and Meservey 2003.

[2] Massachusetts listed species are indicated in boldface; see Table 4.1-1. *WatchList* species are indicated as *Red WatchList* or *Yellow WatchList*; see discussion in Section 4.1.

[3] Includes Gardner Quadrangle and eight surrounding quadrangles.

4.1.2 Breeding Bird Survey (BBS) Analysis

Now overseen by the Patuxent Wildlife Research Center of the U.S. Geological Survey (USGS), the North American Breeding Bird Survey (BBS) is a long-term, large-scale, international avian monitoring program that tracks the status and trends of North American bird populations. Each year during the height of the breeding season (normally June), mainly volunteer participants skilled in avian identification collect bird population data along roadside survey routes. Each survey route is 24.5 miles (39.4 km) long with stops at 0.5 mile (0.8 km) intervals, for a total of 50 stops. At each stop, a three-minute point count is conducted. The total survey time over the entire route, therefore, is 2.5 hours. At each point count, every bird seen within a 0.25 mile (0.4 km) radius or heard is recorded. Surveys start one-half hour before local sunrise and take about five hours to complete. Surveys are sometimes repeated several times each spring during the nesting season.

Two BBS routes survey countryside within 15 miles (24 km) of the Project site (see Table 4.1.2-2). The closest of these routes – North Orange – has been analyzed closely to gain a recent vantage of the breeding bird community in the Project area and to evaluate the likelihood of the occurrence of listed and other species as breeders. Based on satellite imagery, this route surveyed countryside with forest/woodland, agricultural fields, lakes, wetlands, and residential areas.

To profile the breeding bird community, Appendix E was prepared, listing the species recorded at least once during the last ten years on the North Orange route. Species are listed both in taxonomic order and in order of their average abundance. To calculate average abundance, the average number of birds per year over the ten-year period was divided by the survey time of 2.5 hours. This measure indicates which birds are likeliest to be found in habitats at the Project site.

Ninety-five species were recorded on the North Orange BBS route over the last ten years, of which 20 were recorded above 10 birds/hr and can be considered very common and 48 were recorded between 1 and 10 birds/hour and may be considered common (birds recorded in the site visit are indicated with an asterisk). They were:

Red-eyed Vireo*	51.11	Pine Warbler*	4.22
American Robin*	37.11	Baltimore Oriole*	4.11
Ovenbird*	37.00	Hermit Thrush	3.89
Black-capped Chickadee*	30.56	Barn Swallow*	3.78
American Crow*	27.44	House Wren*	3.78
Blue Jay*	27.22	White-throated Sparrow	3.67
Mourning Dove*	23.67	Black-throated Blue Warbler	3.56
Chipping Sparrow*	23.33	Downy Woodpecker	3.44
European Starling*	19.11	Wild Turkey	3.33
Chimney Swift*	13.33	Rock Pigeon*	3.22
Common Yellowthroat*	12.78	Yellow-bellied Sapsucker	2.89
Scarlet Tanager	11.78	Least Flycatcher	2.89
Black-and-white Warbler*	11.67	Yellow Warbler*	2.89
Red-winged Blackbird*	11.56	Great Crested Flycatcher	2.78
Tufted Titmouse	11.44	Eastern Kingbird*	2.78
American Goldfinch*	10.78	Blue-headed Vireo	2.67
Tree Swallow*	10.67	Hairy Woodpecker	2.56
Cedar Waxwing*	10.22	Canada Goose*	2.44
Eastern Phoebe	10.00	Red-breasted Nuthatch	2.44
Gray Catbird*	10.00	Eastern Towhee	2.11
American Redstart	9.56	Swamp Sparrow	2.11
Wood Thrush* (*Yellow WatchList*)	9.22	House Finch*	2.11
Chestnut-sided Warbler	8.56	Wood Duck	1.78
Veery	8.22	Northern Flicker*	1.56
Eastern Wood-Pewee	7.78	Brown Creeper	1.44
Yellow-rumped Warbler*	7.00	Great Blue Heron*	1.33
Bobolink*	6.78	Alder Flycatcher	1.33
Song Sparrow*	6.67	Northern Waterthrush	1.33
White-breasted Nuthatch	5.44	Purple Finch*	1.22
Common Grackle*	5.33	House Sparrow*	1.22
Brown-headed Cowbird*	5.33	Winter Wren	1.11
Black-throated Green Warbler	4.78	Nashville Warbler	1.11
Rose-breasted Grosbeak	4.56	Dark-eyed Junco	1.11
Northern Cardinal*	4.33	Barred Owl	1.00

Together, individuals of these 64 species made up 96% of all individuals recorded on the BBS route over the ten-year period. Thirty-one species, on the other hand, were recorded below 1 bird/hr and can be considered uncommon to rare species (see Appendix E).

Based on the most common birds, the bird fauna in the Project region is dominated by species of forest-interior, forest-edge, shrubland, and residential habitats. It is interesting that grassland bird diversity in the BBS route was minimal, with only one obligate grassland bird recorded: Bobolink, at 6.78 birds/hour. This matches what was found at the Project site. This was also confirmed in a reconnaissance by car of habitats in the Project region. Wherever there were sizeable fields, Bobolinks were invariably found, but no other grassland birds were encountered. An example is the Lake Wampanoag Wildlife Sanctuary of the Massachusetts Audubon Society.

Regarding special-status species (see Table 4.1.2-1), the only Massachusetts-listed species recorded in nearby BBS routes was the endangered American Bittern. It was recorded once (likely heard) on the North Orange route. Petersen and Meservey (2003) categorize it as rare and local in freshwater marshland and moist meadows.

The same six *WatchList* species as recorded in the BBA were registered in the two BBS routes sampled. Of them, only Wood Thrush was relatively widespread, found every year on the two BBS routes. Willow Flycatcher, Blue-winged Warbler, and Prairie Warbler appeared to be locally common. Olive-sided Flycatcher and Canada Warbler were locally uncommon.

4.1.3 Breeding Birds, Conclusions

The site visit was conducted at the peak of the nesting bird season. It is likely that all nesting species were noted during the census of birds on and adjacent to the property. The Project site is a small, isolated field on the outskirts of an urban center. Habitat surrounding the 13-acre field includes a small pond and wetland, fragmented secondary woodland, and commercial development (a college campus, district court, hospital, and golf course). Given the poor habitat quality, the breeding-bird community has relatively low species diversity and bird abundance. No Massachusetts-listed species are at all likely to breed at the site, but a small breeding population of the *Yellow WatchList* Willow Flycatcher has established itself in the shrub zone bordering the pond, wetland, and field. Despite the field's small size, three male Bobolinks were observed displaying, in turn attracting two females. Nonetheless, no other obligate grassland birds were found to use the field to breed.

4.1.2-1. Special-Status Species Records in BBS, 1996-2005

Route #	Route Name	County	Distance / Bearing from Site	# Years Surveyed	Species Min-Max	Special-Interest Species[1]	% Years Recorded	Range Birds per Year
47017	N. Orange	Worcester -Franklin	6.5 mi NNW	9	65-69	**American Bittern (MA-E)**	**11%**	**1**
						Olive-sided Flycatcher (*Yellow WatchList*)	11%	1
						Willow Flycatcher (*Yellow WatchList*)	44%	1-2
						Wood Thrush (*Yellow WatchList*)	100%	6-15
						Blue-winged Warbler (*Yellow WatchList*)	11%	1
						Canada Warbler (*Yellow WatchList*)	22%	1
47900	Ware River	Worcester	12.5 mi WSW	10	52-62	Wood Thrush (Yellow WatchList)	100%	2-8
						Blue-winged Warbler (Yellow WatchList)	100%	1-4
						Prairie Warbler (*Yellow WatchList*)	80%	1-3
						Canada Warbler (*Yellow WatchList*)	10%	1

[1] Massachusetts-listed species are indicated in boldface; see Table 4.1-1. WatchList species are indicated as *Red WatchList* or *Yellow WatchList*; see discussion in Section 4.1.

4.2 Migratory Birds

This section sheds light on how migratory birds are likely to use the Project site, particularly its airspace. Because bird migration is a complex phenomenon, this report examines the major migratory bird groups separately: nocturnal songbirds, raptors, and waterbirds (waterfowl, shorebirds, and others).

4.2.1 Nocturnal Songbird Migration

Night-migrating songbirds and allies are the most numerous of birds migrating over Massachusetts. Species include cuckoos, woodpeckers, flycatchers, vireos, nuthatches, wrens, kinglets, gnatcatchers, thrushes, catbirds, thrashers, warblers, tanagers, and sparrows. Based on the population estimates provided in Rich et al. (2004) for Northern Forest breeding birds, migratory songbird traffic above Massachusetts is probably on the order of tens to hundreds of millions of birds per season. In Massachusetts, songbird migration is concentrated from mid-March to early June (spring migration) and from late August through mid-November (fall migration) (Veit and Petersen 1993).

It is important to bear in mind that nocturnal migration across North America may be classified as broad front. In other words, there is no evidence that songbirds follow topographic structures such as coastlines, ridges, and valleys during night flight; instead, most night migration occurs along broad fronts (Berthold 2001, Alerstam 1993, Eastwood 1967). Berthold (2001) went so far as to say, “Individuals originating from geographically dispersed breeding areas cross all geomorphological features (lowlands, mountains, rivers, and so on) along their routes without deviating much from the orientation of their initial tracks.”

Because radar has been used for more than a half-century as a scientific tool to study migration, it has been recommended by the USFWS and others as a tool for potentially assessing risk at wind power facilities. In theory, the number of birds observed on radar and their behavior (altitude, flight direction, etc.) should be related to risk. Unfortunately, radars data varies greatly depending on the type of radar, power of the radar, the settings (attenuation, etc.) used, the manner in which the data are collected (manually vs. automated), the topographic situation, habitat at the study site, and the operator. In addition, there are disagreements among the experts as to how to filter out insects, whether birds, bats, and water droplets can be differentiated, and what the data actually mean. Radar has never been shown to be a useful or reliable predictor of risk to avian species. Despite these issues, there are valid scientific uses of radar. Some radar studies that have focused on wind power sites are summarized in the following paragraphs.

Radar studies conducted in the Eastern U.S., where the topography is pronounced, provide strong evidence that migration is generally broad front (Cooper et al. 1995, Cooper and Mabee 1999, Cooper et al. 2004a, 2004b). Perhaps the best evidence from eastern North America to support the contention that birds do not follow topographic features is a study by Cooper et al. (2004) from a ridge in West Virginia, and a comparison of radar studies on ridges in southwestern Pennsylvania, Maryland, and West Virginia (Kerlinger 2005). These studies showed that night migrants simply cross the southwest-northeast-oriented ridges of the Appalachians at oblique angles rather than following them. These same birds were not concentrated in large numbers on

the ridges, nor were they flying at low altitudes that would suggest ridge following. These findings are consistent with the phenomenon of broad front migration and would appear to refute a ridge-following hypothesis.

There are two accounts from the northeastern U.S. that appear to suggest that birds do, at times, change migration direction when confronted by topographic features. In New Hampshire, at Franconia Notch, at the northern edge of the White Mountains, birds appear to turn when they encounter the massive topographic features of these mountains (Williams et al. 2001). This is similar to the European findings of birds flying through passes in the Alps and diverting around the Alps (Bruderer and Liechti 1999). However, the Williams et al. (2001) report provides little information on high-flying migrants or migrants flying in other than a restricted location near Franconia Notch, so there is limited information from this site. A study done at two New York sites (one along the Hudson River, the other in the Helderberg Mountains, near Albany) suggested that birds might have been following the Hudson River (or the lights along the River) during fall migration (Bingman et al. 1982) when winds were strong from the west.

A bioacoustical study of noctural songbirds conducted by Evans and Rosenberg (1999) appeared to have demonstrated that night migrants in the central New York region follow topographic features. But, this study had significant flaws. Evans and Rosenberg attempted to quantify numbers of migrants and determine species composition of nocturnal migrants at seven sites across central New York State in the early 1990s. Evans (pers. comm.) found that, in general, during the fall migration, fewer birds migrated over the western portion of the state south of Lake Ontario than farther east. Evans also suspected that fewer birds fly over the hilltops than through the valleys, because as they come south they encounter the hills between the Finger Lakes and follow valleys so as not to utilize large amounts of energy to climb the steep hills. He stated that birds did fly over the hilltops and some were judged to fly at less than 300 feet (93 m) above the ground.

There is no foundation in the scientific literature for the contention that night migrating birds follow ridges or valleys at topographic situations other than those similar to the Alps or other massive topographic structures. Because the acoustical devices used by Evans and Rosenberg (1999) are unlikely to detect higher flying migrants, studies based on acoustical devices are typically biased toward lower flying birds. In addition, a recent report by Farnsworth et al. (2004), in which results from acoustical studies were compared with those from radar studies, indicated that the acoustical methods proved a poor indicator of the numbers of birds aloft. The degree of correlation between the two methods was so low (mostly not significant) as to discount the use of acoustical studies for estimating traffic rates of night migrants at given sites. Furthermore, there has never been confirmation that the acoustical method is a valid means of determining the volume of migration at a particular site.

The above studies indicate that neither the location nor the topography or habitat of the Project site suggests anything but broad-front migration. Therefore, nocturnal migrants are not likely to be concentrated at or above the Project site.

Regarding the traffic rate, altitude, and direction of nocturnal migration above the Project site, Kerlinger, J. Plissner, and others (in preparation) have reviewed marine surveillance radar

studies conducted at more than 15 sites in the eastern U.S. These sites were distributed in western Maine (1), Vermont (2), northern (5) and western (3) New York (including studies from the Tug Hill Plateau adjacent to the Project site), southwestern Pennsylvania (3), western Maryland (1), eastern West Virginia (2), and western Virginia (1). Sites were studied in the spring, fall, or in both seasons. The number of sites studied in the spring (11) was fewer than those studied in the fall (17).

The amount of migration at all sites, in terms of numbers of birds passing through a one kilometer corridor during one hour (targets/km/hr, the standard of measurement), ranged from 135 to 661 targets/km/hr in the fall and from 42 to 473 targets/km/hr in the spring. It is important to note that these are mean seasonal rates. Within each season, there was significant variation from night to night.

While migration traffic rates at eastern U.S. sites appear to range widely, comparisons with radar study sites in the southeastern U.S. provide a dramatic perspective. Mean seasonal migration rates from Louisiana, Georgia, and South Carolina were in the thousands of birds per kilometer per hour in both fall and spring. Traffic rates in Louisiana averaged 9,000 to 10,000 targets/km/hr during fall, with some nights having on the order of 30,000-plus targets/km/hr. In spring, these sites registered flights averaging 3,000 to 50,000 targets/km/hr (Able and Gauthreaux 1975, Gauthreaux 1971, 1972, 1980). Similar, but slightly lower, migration traffic rates were reported by Able and Gauthreaux (1975) and Gauthreaux (1972, 1980) at a site near Athens, Georgia, and at a site in South Carolina. In Georgia during fall, the rate was between 1,500 and 3,250 targets/km/hr, and at both sites there were nights with tens of thousands of birds per kilometer per hour passing overhead.

In other words, migration traffic over the northeastern U.S. is less than along the Gulf Coast and southern U.S. region, where birds are concentrated before or after crossing the formidable ecological barrier presented by the Gulf of Mexico.

Mean migration altitude at northeastern U.S. sites surveyed ranged from 148 m (485 feet) to 583 m (1,912 feet) agl (above ground level) in the fall, and from 130 m (426 feet) and 528 m (1,732 feet) AGL in the spring. But, if radar measurements prior to 2000 are excluded, the range of mean altitudes for the sites in fall was 365 m to 583 m (1,197-1,912 feet) agl. For sites in the spring, it was 401 m to 528 m (1,315-1,732 feet) agl. This exclusion is important because the less powerful radar employed prior to 2000 was biased toward lower flying birds.

Another measurement routinely made by radar operators is the percentage of migrants below 125 m (~410 feet). This measurement is approximately equal to the height of turbines and is used to determine the potential for risk, although it has never been validated empirically as an indicator of the numbers of fatalities of night migrants at turbine sites. Excluding pre-2000 data, the fall percentage of migrants that fly below 125 m ranges from less than 4% of all migrants tracked with radar to about 13%. In spring, the percentage ranges between 4% and 12%. This means that between about 4% and 13% of migrants fly within the height of modern wind turbine rotors.

From the mean altitudes reported above, it is clear that most migration occurs well above the rotor-swept height of turbines. These measurements are consistent with the mean altitude of

nocturnal migrants reported by several authors who have reviewed radar studies from other parts of the United States, Canada, and Europe (Kerlinger 1995, Kerlinger and Moore 1989; Able 1970). These measurements are also similar to measurements from the southeastern United States taken with weather radar. From these studies, it does not appear that there is a great difference with respect to altitude of night migrating birds in diverse geographic settings or diverse topographies. This should also be the case in West Virginia.

Flight direction of migrants tracked with radar in the Eastern U.S. did not vary greatly among sites. The numerical means of the mean directions reported for fall and spring migration were 190° in fall and 38° in spring. These correspond to south-southwesterly migration in fall and northeasterly migration in spring. The standard deviations (actually angular deviations using circle-based statistics) around each site in the eastern United States are in the range of 40 to 80°. In other words, about 75% of all migrants tracked within 40° to 80° of the mean direction of migration. What is noteworthy is that in fall the mean migration directions reported from all of the eastern sites range between 219° and 175°, a range of 44°.

Young and Erickson (2006) have also reviewed radar studies at proposed and existing wind-energy projects in the Eastern U.S. (see NRC 2007). Based on 21 studies, they found similar mean passage rates in spring and fall (258 versus 247 targets/km/hr, respectively). Mean height of flight was 409 m agl in spring and 470 m agl in fall, with 14% of targets below 125 m (410 feet) in spring and 6.5% below that height in fall. Mean flight directions were NNE (31 degrees) in spring and SSW (193 degrees) in fall. These averages are in line with Kerlinger and Plissner's analysis.

In summary, nocturnal songbird migration above the Project site will be part of an extensive broad-front migration over central Massachusetts. Given that the site is located away from the Atlantic coast and other ecological barriers and magnets that tend to concentrate nocturnal migrants during fallout events, it is likely that the characteristics of migration above the site will be similar to those determined by radar studies at many other sites in the Eastern U.S. Those studies demonstrate that migration traffic is low to moderate and that most birds fly well above the rotor-swept area. Only a relatively small percentage of night-migrating songbirds may be expected to fly in the rotor-swept area.

4.2.2 Hawk Migration

The Hawk Migration Association of North America (HMANA; visit www.hmana.org) lists three active hawk watches within about ten miles (16 km) of the Project site. They are Mt. Wachusett, Mt. Watatic, and Barre Falls. All are active in fall, but Barre Falls is also active in spring. As may be noted in Table 4.2.2-1, the three sites average from about 5,000 to over 8,000 raptors passing from late August to late November-early December. A spring average for Barre Falls is not available, but in 2008, the total passage was 823 raptors. These figures indicate that raptor migration is greatest in fall in north-central Massachusetts.

As shown in Table 4.2.2-1 (thanks to information available at HawkCount.org), Broad-winged Hawk is the most common migrant, occurring in the thousands of birds. Broad-wing passage peaks in mid to late September, when large flocks ("kettles") of these soaring hawks migrate

southwestward over north-central Massachusetts in rising columns of air, known as thermals. Studies demonstrate that Broad-winged and other hawks using thermals generally migrate at altitudes ranging from 600 up to 1,500 feet (200 to 450 m) or even higher at midmorning, and up to altitudes up to 3,500 to 4,000 feet (1,100 to 1,200 m) or higher by mid-afternoon, when thermals reach their maximum (Kerlinger 1989). At such high altitudes, most hawks are not always perceptible to observers.

Table 4.2.2-1. Data from Nearby Hawk Watches

	Mt. Wachusett[1] 8.4 miles SE 8/20-11/20		Mt. Watatic[2] 8.6 miles NE 8/31-12/01		Barre Falls[3] 11 miles S 8/20-12/07	
Species[4]	**Average**	**High**	**Average**	**High**	**Average**	**High**
Black Vulture	-	-	-	-	1	1
Turkey Vulture	29	94	2	2	323	459
Osprey	107	140	123	162	304	454
Bald Eagle (MA-E)	19	38	16	26	60	102
Northern Harrier (MA-T)	18	34	10	19	56	90
Sharp-shinned Hawk (MA-SC)	275	426	146	224	1,117	1,769
Cooper's Hawk	25	35	29	45	103	170
Northern Goshawk	2	4	2	3	10	26
Red-shouldered Hawk	14	29	2	2	81	160
Broad-winged Hawk	5,049	9,059	4,488	12,117	5,409	17,322
Red-tailed Hawk	67	159	11	31	497	980
Rough-legged Hawk	1	1	-	-	3	5
Golden Eagle	3	5	1	1	4	5
American Kestrel	62	144	49	89	200	304
Merlin	13	17	9	18	48	90
Peregrine Falcon (MA-E)	3	4	3	9	12	16
Unidentified Raptor	18	30	63	108	64	106
	5,705		4,954		8,292	

[1] From http://hawkcount.org/siteinfo.php?rsite=228

[2] From http://hawkcount.org/siteinfo.php?rsite=229

[3] From http://hawkcount.org/siteinfo.php?rsite=181

[4] Massachusetts-listed species are in boldface: E = Endangered, T = Threatened, and SC = Special Concern.

At the three local hawk watches, Sharp-shinned Hawk, Osprey, and Red-tailed Hawk have averaged in the hundreds of birds. Except for the special-concern Sharp-shinned Hawk, none of the Massachusetts-listed raptors are common migrants at these sites, although average tallies of the endangered Bald Eagle and Peregrine Falcon and threatened Northern Harrier are a little more than double at Barre Falls than at Mt. Wachusett and Mt. Watatic.

It is worth noting that north-central Massachusetts lacks long, linear ridges that would concentrate migrating hawks on updrafts, such as occurs at Hawk Mountain, where about 20,000 raptors are tallied each fall (see http://hawkcount.org/siteinfo.php?rsite=109). Therefore, hawks migrating across Massachusetts rely mostly on thermals. Given the random nature of thermal development, the resulting migration pattern is broad front, with hawks dispersed over the landscape. This explains the moderate numbers of hawks recorded in fall at the Massachusetts sites when compared with a globally significant site such as Hawk Mountain. Given their height, Mt. Wachusett and Mt. Watatic are good vantage points for viewing hawk migration, especially of raptors that fly close to these monadnocks to take advantage of updrafts on their slopes.

Given that the Project site is not a monadnock, hawk migration above the site would be broad front at altitudes generally well above rotor height of wind turbines. Hawk migration in fall would be a magnitude greater than that in spring. In fall, Broad-winged Hawk would be the most common species, with peak passage in mid to late September.

4.2.3 Waterbird Migration

In his maps of waterfowl migration corridors, Bellrose (1980) shows between 5,000 and 25,000 geese migrating over New England between the east coast of Labrador and the Mid-Atlantic coastal region. Duck migration crossing New England between the Prairie Pothole region and the New England coastal region is bracketed at 50,000 and 225,000. These numbers are low compared with other U.S. regions. Comparable numbers are not available for shorebirds and other waterbirds. Nonetheless, the Western Hemisphere Shorebird Reserve Network (http://www.whsrn.org/google_map.php) does not list any significant shorebird stopover sites in north-central Massachusetts. The closest significant site is Great Marsh on the North Shore of Massachusetts, located about 60 miles (96 km) east of the Project site.

In the Project vicinity, there are no large lakes, marshes, mudflats, or other types of ecological magnets that would attract waterbirds, including geese, ducks, loons, grebes, cormorants, herons, rails, shorebirds, gulls, and terns in significant numbers. A small pond, however, abuts the Project site, but it would not attract more than small numbers of waterbirds to stopover.

Aviation reports from the Midwest indicate that most Canada Geese fly at about 2,000 feet above the ground in fall, with 52% of flocks between 1,000 and 3,000 feet and some flocks as low as 500 feet and others as high as 11,000 feet; spring aviation records show the average altitude even higher, at 2,500 feet (Bellrose 1980). Most migration of waterfowl and other waterbirds takes place at night, but some extends to daylight hours, depending on the distance traveled. Radar studies show altitudes of 500 to 1,000 feet (152 to 304 m) or more at many locations for ducks, geese, loons, and other birds (Kerlinger 1982, Kerlinger 1995, reviewed by Kerlinger and Moore 1989). It should be noted that migrating geese do make stopovers to feed on corn and other

seeds in agricultural fields during fall and spring migration, but there is no such habitat in the Project's vicinity.

4.2.4 Migratory Birds, Conclusions

There are no ecological magnets or barriers that would attract or concentrate migrating birds in large numbers at the Project site or nearby. The habitat on site is not suggestive of important stopover habitat for migrants. In the case of night-migrating songbirds, raptors, and waterbirds, migration will be broad front in nature and generally at altitudes above the sweep of the wind turbine rotors.

4.3 Wintering Birds

Audubon's Christmas Bird Count (CBC) provides an excellent overview of the birds that inhabit an area or region during early winter. Counts take place on a single day during a three-week period around Christmas, when dozens of birdwatchers comb a 15-mile (24 km) diameter circle (177 mi^2 [453 km^2] in area) to tally up all the bird species and individuals they see. In preparation for count day, participants also scout for birds during the "count week" period. While most of these birdwatchers are unpaid amateurs, they are usually proficient or highly skilled observers.

Available at http://audubon2.org/birds/cbc/hr/count_table.html, CBC data are used by scientists, wildlife agencies, and environmental groups to monitor bird populations. The results over the last ten years for the Westminster CBC have been examined to understand the winter bird populations likely to occur at the Project site. As noted in Table 4.3-1, this CBC overlaps the Project site and was active in each of the ten years sampled. Observer participation per count during the analysis period varied from a minimum of 6 observers to a maximum of 28.

Table 4.3-1. CBC Analyzed, 1998-2007

Count Name (Code)	Center County	Distance / Bearing from Site	Years Analyzed	# Participants	# Species Min-Max
Westminster (MAWE)	Worcester	0 mi SE	10	6-28	47-60

The number of species recorded in this count ranged between 60 and 47 species. Because this CBC included significant open-water and wetland habitat, it recorded waterfowl and other waterbirds that are unlikely to occur at the small pond present at the Project site. It also included a wide range of upland habitats, including no doubt high-quality representatives of some habitat types. Given its small size and low habitat diversity and quality, the Project site would be expected to have fewer species and lower bird abundances than this CBC.

To understand the winter bird profile in the Project region, Appendix F has been prepared. Sorted in taxonomic and abundance orders, this table displays the average frequency of birds, measured in birds/hour, for the Westminster CBC. Yearly abundances for species were

determined by dividing the number of individuals by the total number of party hours. These values were then averaged using the last ten years of available data (1998 to 2007).

A total of 85 species were recorded on the Westminster CBC over the last ten years. Of these birds, 20 species were recorded above 1 bird/hour and can be considered common. Individuals of these species made up 95% of all individuals recorded on the count. They were:

American Crow	19.63	American Goldfinch	4.31
Black-capped Chickadee	15.30	Great Black-backed Gull	2.76
European Starling	12.94	Mourning Dove	2.60
Herring Gull	12.46	Tufted Titmouse	2.41
Dark-eyed Junco	7.94	House Finch	1.97
Rock Pigeon	7.44	White-breasted Nuthatch	1.96
House Sparrow	7.29	American Tree Sparrow	1.55
Blue Jay	6.45	American Robin	1.50
Mallard	5.82	Canada Goose	1.25
Cedar Waxwing	5.64	Downy Woodpecker	1.19

Listed in Appendix F, the other 65 species were uncommon or rare.

Four of the commonest birds were waterbirds (out of 15 waterbird species recorded). Of them, Mallard is probably most likely to occur in winter at the pond adjacent to the Project site. Some of the commonest landbirds (e.g., European Starling, Rock Pigeon, and House Sparrow) were introduced species that thrive in heavily impacted landscapes. Many individuals of the Black-capped Chickadee, Dark-eyed Junco, Blue Jay, American Goldfinch, Mourning Dove, Tufted Titmouse, and others were probably recorded at bird feeders around houses. The high abundance of crows may represent a roost.

Eight species of raptors were recorded. Red-tailed Hawk (0.16) was the only relatively abundant species. All others were scarce, ranging from 0.03 to less than 0.005 birds/hour, including Sharp-shinned Hawk (MA special-concern), Cooper's Hawk, Northern Goshawk, Red-shouldered Hawk, Rough-legged Hawk, American Kestrel, and Merlin.

Table 4.3-2. CBC Records for Special-Status Species, 1998-2007

Species[1]	CBC	Percent Years Recorded	Range Number Recorded
Sharp-shinned Hawk (MA-SC)	**Westminster**	**80%**	**1-4**
Iceland Gull (*Yellow WatchList*)	Westminster	20%	1

[1] Massachusetts-listed species are indicated in boldface; see Table 4.1-1. *WatchList* species are indicated as *Red WatchList* or *Yellow WatchList*; see discussion in Section 4.1.

Regarding special-status species, the only Massachusetts-listed species registered was the special-concern Sharp-shinned Hawk, but it is likely that the individuals recorded did not originate from Massachusetts-breeding populations. It is significant that the endangered Bald Eagle was not recorded, which indicates that few Bald Eagles winter in north-central

Massachusetts. Among *WatchList* species, only the *Yellow WatchList* Iceland Gull was recorded infrequently.

In conclusion, Christmas Bird Count (CBC) data and the habitat present on site strongly suggest that the Project site will have limited bird use in winter. Outside of the Massachusetts special-concern Sharp-shinned Hawk, no listed or *WatchList* species appear likely to occur at the Project site in winter. In the case of the hawk, occasional individuals found to forage at the site would probably not be members of the Massachusetts breeding population.

5.0 Important Bird Areas, Reserves, and Sensitive Habitats in Project Vicinity

The avian risk analysis checks databases to see if Important Bird Areas (IBAs) or federal, state, or private protected areas overlap with the Project site or are in close proximity. The presence or proximity of such areas could indicate sensitive habitats and increased avian risk.

5.1 Important Bird Areas (IBAs)

A program of BirdLife International and Audubon, the Important Bird Area (IBA) Program seeks to identify and protect essential habitats for one or more species of breeding or non-breeding birds. The sites vary in size, but usually they are discrete and distinguishable in character, habitat, or ornithological importance from surrounding areas. In general, an IBA should exist as an actual or potential protected area, with or without buffer zones, or should have the potential to be managed in some way for birds and general nature conservation. An IBA, whenever possible, should be large enough to supply all or most of the requirements of the target birds during the season for which it is important.

According to information available at http://www.massaudubon.org/Birds_and_Birding/IBAs/, 79 IBAs have been approved in Massachusetts. Three are located within 10 miles (16 km) of the Project site.

Measuring 63,000 acres, the Ware River Watershed IBA reaches within 5 miles (8 km) of the Project site (to the south). It is considered significant for its breeding populations of Neotropical migrants, including vireos, thrushes, warblers, and tanagers. The Massachusetts endangered American Bittern and special-concern Sharp-shinned Hawk have been recorded as breeders. The area is also considered significant as a major stopover site for passerine migration.

Measuring 2,000 acres, the Wachusett Mountain IBA is located about 6 miles (9.6 km) southeast of the Project site. Considered significant for its hawk migration, it was discussed above in Section 4.2.2.

Measuring about 1,500 acres, the Mt. Watatic IBA is located about 8 miles (12.8 km) northeast of the Project site. Discussed above in Section 4.2.2, it is also considered significant for its hawk migration. Its spruce-covered summit hosts a number of northern breeding species, such as *Yellow WatchList* Olive-sided Flycatcher. The Massachusetts special-concern Sharp-shinned Hawk has also been recorded as a breeder.

The American Bird Conservancy (ABC) has published a directory of the 500 most important bird areas in the United States (ABC 2003). The closest IBAs to the Project site would be Crane Beach and the Parker River National Wildlife Refuge, located about 60 miles (96 km) east along the Atlantic Ocean. They are highlighted for their breeding Piping Plovers (Massachusetts endangered and *Red WatchList*) and migrating shorebirds.

5.2 Federal, State, County, and Private Protected Areas

A number of state forests and wildlife management areas (WMAs) are located within 10 miles (16 km) of the Project site. The closest is High Ridge WMA, located about one mile (1.6 km) east of the site.

The 772-acre Lake Wampanoag Reserve of Massachusetts Audubon is located about one mile northeast of the Project site. A description available at http://www.massaudubon.org/ does not mention any particular avian significance.

In conclusion, the Project site does not overlap an Important Bird Area (IBA), nor is its habitat distinct in character, habitat, or ornithological importance from surrounding landscape. Instead, the Project site is a small, isolated field on the outskirts of an urban center. Given these findings, no sensitive habitats and increased avian risk are indicated.

6.0 Review of Risk to Birds at Wind Power Plants in the United States and Europe

Assessing risk to birds at a prospective wind-energy site may be accomplished by comparing a site's avian use (abundance and behavior) with similar sites where avian risk has been determined through post-construction research. By comparing the types of species present or likely to be present, numbers of individuals, seasonality, and behavior of birds that nest, forage, migrate, or winter at a proposed wind-power site with existing facilities where risk has been determined, probabilistic assessments of risk can be made.

In this section, we review what is known about avian risk at existing wind-power facilities. Two general types of impacts have been documented: 1) disturbance and displacement of birds as a result of the construction and operation of wind turbines and related infrastructure, and 2) fatalities resulting from collisions with turbines, meteorology towers, and other infrastructure. These two types of impacts are detailed below.

6.1.1 Disturbance and Displacement

Disturbance and habitat alteration resulting from the construction and operation of wind turbines and other wind-farm infrastructure has sometimes been found to make a site unsuitable or less suitable for nesting, foraging, resting, or other bird use. Avoidance and displacement has been documented in some species, but subsequent habituation to wind power project infrastructure has also been demonstrated.

The footprint of turbine pads, roads, and other infrastructure required for a wind facility is generally a small percentage of a project site, often estimated at two to four percent. Therefore, in general, overall land use is minimally changed by wind-power development, and actual habitat loss is generally small. This is particularly true in agricultural landscapes. But, in forested landscapes, the construction of a large wind farm and its connection to the electricity grid may fragment habitat in a significant way, affecting wildlife populations (NRC 2007).

Despite the relatively small footprint of a wind facility, the true amount of wildlife habitat altered by a wind-power project sometimes extends beyond. This results from the presence and operation of the wind turbines and increased human activity to construct and maintain them. Various studies have examined the presence of tall wind turbines in landscapes to determine whether birds avoid or are displaced from an area as a result of these new features.

In the U.S., studies documenting disturbance, avoidance, and displacement have focused mainly on birds living in grassland and other open country habitats, including farm fields. At the Buffalo Ridge Wind Resource Area in southwestern Minnesota, Conservation Reserve Program (CRP) grasslands without turbines and CRP areas located 180 m (590 feet) from turbines were found to support higher densities of grassland birds than CRP areas within 80 m (260 feet) of turbines (Leddy et al. 1999). At the bases of turbines, mean bird density was measured at 58.2 males/100 ha; at 40 m, 66.0 males/100 ha; and at 80 m, 128.0 males/100 ha. At 180 m, mean bird density rose to 261.0 males/100 ha. In CRP control plots, it was calculated at 312.5 males/100 ha. Bobolinks, Red-winged Blackbirds, and Savannah Sparrows were the commonest

species in CRP grasslands with turbines, whereas Bobolinks, Sedge Wrens, and Savannah Sparrows were commonest in CRP grasslands without turbines. Other birds recorded were Common Yellowthroat, Clay-colored Sparrow, Grasshopper Sparrow, Le Conte's Sparrow, Dickcissel, Western Meadowlark, and Brown-headed Cowbird.

The Buffalo Ridge study appears to demonstrate that disturbance was greatest close to turbines and decreased with distance from turbines. This indicates that, after turbine construction, some birds either did not nest or forage near the turbines or did so at lower densities. Nonetheless, it should be noted that the Buffalo Ridge turbines are shorter than those proposed for the Project, and closer together. These characteristics may have greater impacts than larger, more widely spaced turbines. Furthermore, the Buffalo Ridge study was conducted in the first year after construction, when vegetation at turbine construction sites may not have been fully restored and birds had not had a chance to habituate to the project.

At the Foote Creek Rim Wind Plant in Wyoming, the numbers of nesting Mountain Plovers (a grassland-nesting species) declined after erection of turbines. Plover productivity also declined (Johnson et al. 2000), although successful nesting of Mountain Plovers was noted within 200 m (660 feet) of operating turbines. Thus, the area impacted extended beyond the actual footprint of the project.

O'Connell and Piorkowski (2006, reviewed in Mabey and Paul 2007) studied the effects of wind-power development on grassland and other bird populations at the Oklahoma Wind Energy Center, where 35 1.5-MW turbines were in operation. They measured breeding bird densities in native mixed-grass prairie, cropland (wheat), and Eastern red cedar-dominated habitats using 200-m (660-foot) point-count surveys along road transects at three distances: adjacent to turbines, intermediate (1 to 5 km away), and distant (5 to 10 km away).

Of the 66 species recorded in the point counts, 23 were common enough for analysis, including many grassland birds. In cropland, Killdeer was found to be most abundant at intermediate distances from turbines. Greater Roadrunner and Western Meadowlark were found to be most abundant at distant sites. These results are somewhat surprising because, in other studies (see Maple Ridge and Erie Shores below), Killdeers have been found to use turbine pads as nesting habitat. Paul Kerlinger (personal observation) has recorded apparent habituation in Western Meadowlarks that were perched on the lattice towers of older wind turbines in the Altamont Pass Wind Resource Area (APWRA) in California.

Returning to the Oklahoma study, Northern Bobwhite, Scissor-tailed Flycatcher, Horned Lark, Bewick's Wren, Cassin's Sparrow, Grasshopper Sparrow, Painted Bunting, Dickcissel, and Eastern Meadowlark showed no differences in breeding density in relation to proximity to wind turbines. The same was true of an analysis of all breeding birds combined. The authors concluded that most breeding grassland birds had experienced no negative effects that would translate into a reduction of breeding density. Nevertheless, Mabey and Paul (2007) point out that the sample sizes were low and the statistical power to detect differences was probably insufficient, but they consider this study one of the best efforts at controlled study of the population-level effects of wind turbines on birds.

At the Maple Ridge Wind Power Project in Lewis County, New York, an impact gradient study (Kerlinger and Dowdell 2008) was conducted to determine whether birds nesting in hay/grassland fields were displaced by wind turbines erected the previous year. Ten impact gradient transect/plots (100 m x 300 or 400 m; 3-4 ha) were established beneath turbines and five reference plots were established in fields between 400 and 1,600 m of turbines. Each plot was sampled three times prior to the first hay mowing.

Overall density of all birds (nine species) was 15.2/ha in turbine plots and 18.5/ha in reference plots. Savannah Sparrows and Bobolinks accounted for 57.1% and 40.6% of all birds observed within the turbine plots and for 47.8% and 48.9% of birds observed in the reference plots, respectively. Densities for Savannah Sparrow and Bobolink were similar to those reported for similar habitat at sites in New York, Michigan, Wisconsin, and Quebec, but they were greater than those reported at prairie sites.

There were marginally lower male Bobolink densities at turbine vs. reference plots. The pattern for Bobolink densities (all individual and males) revealed lower densities within 75 m of turbines. Bobolink densities from 0 m to 100 m increased exponentially, and from 100 to 400 m did not appear to change. Savannah Sparrow showed no difference in density between turbine and reference plots, and there did not seem to be an increase in density going out from the turbines. Killdeer were more abundant in turbine plots as opposed to reference plots, as they nested on the bare earth and gravel pads beneath the turbines, indicating that turbine construction actually created or enhanced habitat for them.

The authors of the study pointed out that habitat around the bases of turbines probably affected the results. Below many turbines, vegetation had not recovered to hay field; instead, there were bare earth and dirt piles out to 50+ m. This may have explained the lower Bobolink densities within 75 m of the turbines. For Savannah Sparrows, dirt piles serving as singing perches may have attracted males from nearby territories. Nevertheless, the data strongly suggested that densities of these birds beyond 75-100 m were not impacted by the presence of turbines. It was also likely that, beyond 100 m of turbines, these two species had habituated to the turbines. In other words, if displacement was occurring, it was only evident within 75-100 m of the turbines.

A second year of study will be conducted once habitat beneath turbines has fully recovered. Kerlinger and Dowdell (2008) also noted that hay mowing in the days after the gradient study eliminated all nests in hay fields where turbines were situated as well as reference fields. They concluded that impacts from turbines were orders of magnitude lower than displacement by turbines, if the latter occurred.

At the Erie Shores Wind Farm in Port Burwell, along the shore of Lake Erie in Ontario (James 2008), Killdeer nested at distances of 3 to 40 m (10 nests) from the bases of towers, Horned Larks at 15, 21, 37 and 40 m, Vesper Sparrow at 30 m, and Savannah Sparrow at 16 and 20 m. The author concluded that these species were more affected by the farming practices, including hay mowing and tilling, than by turbines.

A recent study from Europe (Devereux et al. 2008) has demonstrated that turbine locations did not affect the distribution of four functional groups of wintering farmland birds (seed-eaters,

crows and allies, gamebirds, and European Skylarks) at distances ranging from 0-150 m to 600-750 m. A further analysis of data collected at 0-75 m and 75-150 m from turbines found no evidence to suggest that farmland birds avoided areas close to wind turbines. This study appears to indicate that the present and future location of large numbers of wind turbines on European farmland is unlikely to have detrimental effects on farmland birds, at least for those species studied.

Curiously, at Tarifa, Spain, some songbirds nested at higher densities and with higher productivity on a ridge with wind turbines than on two other ridges without wind turbines (de Lucas et al. 2004). A sheltering effect from passerine predators (e.g., Booted Eagles) by wind turbines has been suggested, but the study did not analyze habitat differences between sites to exclude that possibility.

The Altamont Pass Wind Resource Area of California (APWRA) hosts very large numbers of raptors and grassland-nesting songbirds, which regularly perch on the lattice towers and guy wires of the site's older turbines. In a study in the APWRA, Red-tailed Hawks trained for falconry in Idaho were exposed to turbines in order to study their flight behavior near those structures. Upon first seeing the turbines at 100 feet (30 m), the birds would not fly. Within weeks, however, they appeared to habituate to the turbines in a manner comparable to resident Red-tailed Hawks (R. Curry, personal communication). Unlike most other wind power sites in the United States, turbines have been present in the APWRA for about 20 years, and resident birds have had ample time to habituate to them.

At Erie Shores Wind Farm (James 2008), construction activity in 2006 displaced a pair of Bald Eagles nesting 400 m (1,310 feet) of a proposed turbine location, but the pair established a new nest about 900 m (2,950 feet) away and successfully raised two young. This pair returned to the new nest in 2007, but the nest failed for unknown reasons. These adults and juveniles were seen perched within 200 m (660 feet) of active turbines, and on a few occasions they were observed flying closer than 100 m (330 feet) of rotating blades. Over the course of two years, Bald Eagles were noted flying past active turbines within 300 m (985 feet) of the towers on about 170 occasions. Most of these were along the Lake Erie shore, where they routinely soared past at less than 200 m (660 feet) away (137 times noted), but only 5 or 6 occasions were they seen less than 50 m (165 feet) of turning blades.

Also at Erie Shores Wind Farm (James 2008), a pair of Red-tailed Hawks nested within 135 m (215 feet) of a turbine under construction (!). The turbine was in operation about a month before the young had fledged, during which time the adults made hundreds of trips to the nest. They were observed on numerous occasions negotiating the airspace around the spinning rotors. In 2007, possibly the same pair returned to nest, but they moved to 265 m (870 feet) from the same turbine. This location was in the middle of a quadrangle of turbines instead of on the edge of the wind farm. Cooper's Hawk nests were found at 112 (367 feet) and 175 m (574 feet) away from the closest turbines.

Hötker et al. (2006) have reviewed studies conducted in Europe on displacement impacts. They found that 40 species have been analyzed in at least six studies each, allowing a statistical test as to whether their populations were affected negatively or positively (including no apparent effect)

by the construction and operation of wind facilities. Species analyzed for the breeding season included Mallard, Common Buzzard, two gamebirds, four shorebirds (including Black-tailed Godwit, Redshank, Oystercatcher, and Lapwing), and various songbirds (20 species). Negative population impacts could not be statistically verified for any breeding birds. Only shorebirds and gamebirds displayed reduced numbers in connection with wind facilities. Positive or neutral effects predominated in the other species. Interestingly, only two species showed statistically more positive or neutral reactions toward wind farms than negative reactions. Both were songbirds inhabiting marshes (Marsh Warbler and Reed Bunting).

When Hötker et al. looked at studies outside the breeding season, a different picture emerged. The suite of species analyzed was different, including various geese (analyzed together), three ducks, Grey Heron, three raptors, four shorebirds (Curlew, Oystercather, Lapwing, and Golden Plover), three gulls, and various songbirds (five species). Negative impacts predominated and were statistically more negative than positive in various geese, European Wigeon, Lapwing, and Golden Plover. The exception was Starling, for which effects were statistically more positive than negative. For most species, however, effects either way could not be statistically verified.

Regarding avoidance distance to wind facilities, Hötker et al. analyzed 28 species (mostly a subset of the previous analysis) for which data from at least five studies each were available. The data showed a wide range of values (i.e., some studies recording a species within 50 m of turbines, while others found the same species not approaching within hundreds of meters), but one trend was apparent, namely, avoidance distances during the breeding season were smaller than outside the breeding season. They found that birds of open habitats, such as geese, ducks, and shorebirds, generally avoided turbines by several hundred meters, but there were some notable exceptions, namely, Grey Heron, raptors, Oystercatcher, gulls, European Starling, and crows.

Hötker et al. also examined the relationship between the hub height of turbines and avoidance distance at four wind farms. Only in non-breeding Lapwings was there a statistically significant relationship, with avoidance distance increasing linearly with increasing hub height. Nonetheless, the authors noted clear tendencies, with breeding birds (particularly songbirds, but also Oystercatcher and Redshank) being less affected by tall turbines than by small ones. Lapwing and Black-tailed Godwit were exceptions. In non-breeding birds (with the exception of Grey Heron, diving ducks, Oystercatcher, and Common Snipe), the taller the turbines, the greater the avoidance distance. These differences may have more to do with the different suites of species analyzed in the two seasons, with larger species of open habitats predominating in the non-breeding season.

To gauge habituation (i.e., avoidance reactions decreasing over time), Hötker et al. examined 11 studies with at least two years of observation after wind farm construction. Each study analyzed several species, resulting in 122 data sets (ranging from 1 to 13 per species). Species included waterfowl, raptors, shorebirds, gulls, and songbirds. For breeding birds, 38 of 84 data sets (45%) indicated habituation. For non-breeding birds, 25 of 38 data (66%) indicated habituation. In other words, about half of the species analyzed demonstrated habituation. For individual species, sufficient data were available to analyze three. For Lapwing, two of eight studies during the

breeding season indicated habituation, while three of five during the non-breeding season did so. For breeding Skylarks and Meadow Pipits, three of six studies each indicated habituation.

Hötker et al. comment that the observed degree of habituation in most cases was small. They conclude that habituation cannot be ruled out, but it appears not to be a widespread or strong phenomenon.

Regarding specifics from European studies, in the Netherlands, shorebirds (mostly migrants) were displaced by 250-500 m (800-1,650 feet) from turbines (Winkelman 1990). In Denmark, some migrant shorebirds were displaced by up to 800 m (2,600 feet) by the presence of turbines (Pederson and Poulsen 1991). Other Danish studies have demonstrated species-specific differences in avian avoidance patterns near wind turbines (Larsen and Madsen 2000, Percival 1999, Kruckenberg and Jaene 1999). In general, Pink-footed Geese (Larsen and Madsen 2000) would not forage within 50 m (160 feet) of wind turbine rows and did not forage within 150 m (500 feet) of a cluster of wind turbines. Fewer of these geese foraged within 100 m (325 feet) of wind turbines than foraged farther from the turbines. Barnacle Geese, however, foraged within about 25 m (80 feet) of turbines, showing they are less sensitive than Pink-footed Geese (Percival 1999). Nonetheless, White-fronted Geese did not forage within about 400 to 600 m (1,300 to 1,950 feet) of wind turbines (Kruckenberg and Jaene 1999).

In contrast to some European studies, two years of post-construction studies at the Top of Iowa Wind Plant (Koford et al. 2005) revealed that Canada Geese were not displaced significantly by the construction of 89 turbines. That study, designed by Iowa State University and the Iowa Department of Natural Resources, was the first disturbance/displacement study of waterfowl in the United States. Anecdotal information from the Fenner Wind Power facility in New York State (Paul Kerlinger) suggests that Canada Geese forage in close proximity to large wind turbines.

At the Erie Shores Wind Farm (James 2008), Canada Geese appeared not to be inhibited from flying through the wind farm or from using fields and ponds within 200 m of operating turbines. Goose tracks were found within 25 m (80 feet) of turbines on five occasions, with some of the tracks within 10 m (33 feet) of a tower. Tundra Swans appeared to differentiate between operating and non-operating turbines. Of 280 swans seen flying less than 300 m (990 feet) from operating turbines at rotor height, only three got to within 100 m (330 feet). But, of 240 swans seen flying past non-operating turbines, just over 20% were less than 50 m (165 feet) from those turbines.

Drewitt and Langston (2006) speculate that some wind farms may create barriers for some species that alter migratory or local flight paths, increase energy expenditure, and disrupt linkages between feeding, roosting, molting, and breeding areas to such an extent that they may, under certain circumstances, lead indirectly to population-level impacts. This phenomenon is more of a concern in offshore and coastal wind projects, where significant changes in flight direction by waterbirds have, in some cases, been noted. Drewitt and Langston's review of the literature suggests that none of the barrier effects identified so far have had significant population-level impacts. They have also not noted whether birds habituate to turbines and are impacted less over a period of years following construction of new wind power projects.

Regarding evidence of barrier effect or lack thereof at coastal wind farms, Dierschke and Garthe (2006) have reviewed studies from five coastal wind farms in Europe.

At Bythe Harbor in northeastern England, nine, fairly short turbines (rotor diameter 25 m, total height 38 m) were constructed on a pier at 200 m intervals. Dierschke and Garthe report that, during a seven-year study (Still et al. 1995, Painter et al. 1999), large numbers of Great Cormorants, Common Eiders, Black-headed Gulls, Herring Gulls, and Great Black-backed Gulls were present for several months of the year. Great Cormorants were found to cross the turbine string regularly, with 10% flying at rotor height and the rest below. In the first years, eiders flew between the turbines to enter the harbor, but later, they entered the harbor only by swimming. Birds flying between turbines were mostly gulls (80%), but many more gulls flew along the turbine row (20-300 flights per ten minutes) than between them (0.7-1.5 flights per ten minutes). Great Black-backed Gulls and Herring Gulls crossed the turbines at rotor height 16% and 13% of the time respectively, with most crossing below rotor height and very few above. There were also anecdotal reports of Northern Fulmars, Black-headed Gulls, Black-legged Kittiwakes, and Sandwich Terns passing through the wind farm.

At Maasvlakte wind farm in the Netherlands two rows of nine and 13 turbines were built on a seawall near a breeding colony of gulls and Common Terns. The turbines were at 130-m intervals with heights of 56.5 m and rotor diameters of 35 m. According to Dierschke and Garthe, van den Bergh at al. (2002) observed flight behavior of breeding birds in July of 2001. At both rows of turbines, 92% of seabirds at one turbine row and 62% at the other crossed below rotor height. Of those birds, 3.1% of gull flocks and 5.3% of Common Tern flocks exhibited a behavioral reaction, but only one gull turned back. Among gulls, this was about the same reaction rate as gulls flying above the turbines (3.0%). The authors concluded that there was no apparent barrier effect for foraging flights. They saw their results as showing a rapid habituation (or reduced sensitivity) to the presence of the turbines.

At Zeebrugge in Belgium, Everaert et al. (2003) studied flight behavior at 23 turbines of different dimensions (but all small in comparison with modern turbines) that were constructed on a pier. Thirteen turbines were located on the shoreline at close distance to a tern colony. The terns as well as gulls breeding elsewhere in the harbor regularly crossed the wind farm to forage at sea. According to Dierschke and Garthe's summary of the study, the majority of birds (54-82%) crossed the turbines below rotor height; only a small fraction (1-14%) crossed above. Depending on species and flight altitude, the percentage of avoidance reactions varied. We highlight the results for Common Tern, a species of special concern in many U.S. states. At 50-m tall turbines, 498 Common Terns were recorded passing. Of the 408 birds (81.9% of total) passing at 0-15 m, 15 (3.7%) showed an avoidance reaction. Of the 35 birds (7.0%) passing at 16-50 m (rotor height), 11 (31.4%) exhibited avoidance behavior. Of the 55 birds (11.0%) passing at 51-65 m, 6 (10.9%) exhibited avoidance behavior. Interestingly, very few Least Terns exhibited avoidance behavior at any height class (5 of 1860 birds [0.2%], including 4 of 828 birds [0.5%] at rotor height; none of the 1,010 flying below rotor height demonstrated avoidance).

At Den Oever in the Netherlands, a single turbine was constructed in the morning and evening flight paths of Black Terns and Common Terns. Dierschke and Garthe report a study during the 1997 breeding season (Dirksen et al. 1998a) in which visual and radar observation were employed to record the flight behaviors of up to 15,000 Black Terns and up to 6,500 Common Terns. These birds deviated their flight courses on both sides of the turbine, keeping a distance of 50-100 m from the turbine. Therefore, the direct vicinity of the turbine was used less than adjacent areas.

At Lely wind farm in the Netherlands, four turbines were constructed 800 m (0.5 miles) offshore in a freshwater lake. These turbines had a total height of 60 m, rotor diameters of 41 m, and spacing of 200 m. Dierschke and Garthe report that Dirksen et al. (1998b) used radar to study the flight paths of two diving ducks (Pochard and Tufted Duck) whose flight paths between diurnal roosts and nocturnal feeding grounds intersected the wind farm. On moonlit nights, the ducks could apparently perceive the wind farm, because a higher proportion of ducks flew close to the wind farm and included a low rate of flights between turbines. No birds turned back, but detour reactions were common. On moonless nights, these ducks avoided approaching the wind farm; instead, they flew parallel to it. The authors also found that resident birds, in contrast to migrants stopping over, habituated to the presence of turbines, even if they constituted a barrier to their regular movements. A second study (Dirksen et al. 2000, van der Winden et al. 2000) demonstrated the same results for Greater Scaup.

Hötker et al. (2006) have reviewed European studies examining barrier effect at onshore (including coastal) sites in a wide variety of birds, including waterfowl, storks, cranes, shorebirds, gulls, and songbirds. They assumed a barrier effect was operative if 5% of individuals or flocks showed a measurable reaction to wind farms. This was demonstrated in 104 of 168 data sets, covering 81 species. The authors found that geese, kites, cranes, and many small bird species were particularly sensitive to wind farms. But, some large birds (Great Cormorant and Grey Heron), ducks, some birds of prey (Sparrowhawk [an accipiter], Common Buzzard, and Kestrel), gulls and terns, European Starling, and crows were all less sensitive and less willing to change their original migration heading when approaching wind farms. These species and species groups also avoided wind farms less often and their local populations were less influenced by wind farms (Hötker et al. 2006).

Regarding forest-breeding species, a post-construction study of 11 turbines located on a ridgeline in Searsburg, Vermont, appears to be the only applicable study on disturbance and displacement impacts (Kerlinger 2000a, 2002b). Point count surveys for breeding birds done before and after the turbines were erected showed that some forest-nesting birds – such as Blackpoll Warbler, Yellow-rumped Warbler, White-throated Sparrow, and Dark-eyed Junco – appeared to habituate to the turbines within a year of construction. On the other hand, Swainson's Thrush, and perhaps some other species, appeared to be displaced by the turbines. This study could not document whether or not the former species nested close to the turbines, but it certainly demonstrated that they foraged and sang within forest edge about 100 feet (30 m) from the turbine bases. A visit to the site during the 2003 nesting season revealed that Swainson's Thrushes were singing (and likely nesting) within the forest adjacent to turbines, and many other species were present close to the turbines. It is not known if overall numbers of nesting birds were the same as prior to

construction, but letting the forest grow up to turbines and roadways may have reduced the fragmentation impacts at that site. It is also possible that habituation had occurred.

At Erie Shores Wind Farm (James 2008; John Guarnaccia, personal observation), some turbines are situated at the edge of woodlots, but resident woodland and woodland-edge birds appeared to habituate readily to their presence, including forest-interior species, such as Wood Thrush. Forest-edge birds lived as close as habitat allowed, including below the rotating turbine blades.

In a recent review of the literature on the ecological effects of wind-energy development (NRC 2007), the following conclusions and recommendations were made regarding effects on forest ecosystems (pg. 91):

1. Forest clearing resulting from road construction, transmission lines leading to the grid, and turbine placements represents perhaps the most significant potential change through habitat loss and fragmentation for forest-dependent species.
2. Changes in forest structure and the creation of openings may alter microclimate and increase the amount of forest edge.
3. Plants and animals throughout the ecosystem respond differently to these changes, and particular attention should be paid to species of concern that are known to have narrow habitat requirements and whose niches are disproportionately altered.

Nevertheless, the effects of wind-energy projects on ecosystem structure and bird habitats depend on the pre-construction conditions. For example, the influences of a project at a previously logged site will be different than those at a previously undisturbed site (NRC 2007).

Regarding migratory birds, there is a study of three ridges (one with turbines, two without) at Tarifa, Spain, where over 72,000 migrating birds (principally Black Kites, White Storks, House Martins, and Swallows) were recorded during nearly 1,000 hours of observation from fixed observation points (Janss 2000, de Lucas et al. 2004). Observations of flight behavior indicated that birds were aware of, and possibly avoided, the turbines. Changes in flight direction were recorded more often over the wind farm than over the other two areas. Migrants also tended to fly higher over the wind farm. Abundance also did not appear affected by the presence of wind turbines. These findings could indicate avoidance by migrating birds, but no comparable data were obtained prior to operation of the turbines. In contrast, resident Griffon Vultures were not observed to fly higher over the wind farm. Possibly they were more accustomed to the turbines.

Observations of autumn hawk migration in Vermont showed that the numbers of hawks that flew close to a hill with newly constructed turbines was less than in the year prior to turbine construction and operation (Kerlinger 2000a, 2002b). These migrants may have been avoiding the novel structures.

The Erie Shores Wind Farm in Ontario (James 2008) is located within two miles of Lake Erie in a well-documented, fall raptor migration corridor. Also located along the shore of Lake Erie, Hawk Cliff Hawk Watch is less than 20 miles [32 km] west of Erie Shores and averages 37,000 raptors per fall season (Zalles and Bildstein 2000).

The James study logged more than 2,300 observations of Sharp-shinned Hawks passing through the wind farm area, with 1,534 passing within 300 m (990 feet) of the turbines. Few birds, if any, hesitated to fly near an operating wind turbine, and there were only seven instances in which single birds got close enough to spinning rotors to be judged at risk. Indeed, just over 21% of birds made course changes that brought them closer to turbines. Most of these involved birds moving along a woodland edge or a "fencerow" of trees. Had birds not changed their headings, they would have passed turbine towers at distances greater than 100 m (330 feet), but shifting course to continue to follow tree lines brought them within 50 m (160 feet) of a turbine tower. Overall, there was nothing to indicate that the turbines were an impediment to the migration of Sharp-shinned Hawks. A concurrent mortality study found one Sharp-shinned Hawk carcass in two years of study.

Other autumn migrant raptors observed at Erie Shores flying within 300 m of wind turbines were Turkey Vulture (about 1,000 observations), Osprey (12), Bald Eagle (170), Northern Harrier (115), Cooper's Hawk (60), Northern Goshawk (6), Red-shouldered Hawk (4), Broad-winged Hawk (3), Red-tailed Hawk (300), Golden Eagle (4), American Kestrel (463), Merlin (21), and Peregrine Falcon (8). In all cases, the wind farm appeared to pose no impediment to migration, and birds appeared to negotiate the wind farm without hesitation or difficulty.

In summary, some types of birds appear to be disturbed and displaced more by wind turbine construction and operation than others. Differences between species are also evident, with some species being displaced farther than others, while others habituate to turbines. Disturbance and displacement effects have been documented in some grassland and prairie birds and in some (not all) waterfowl. Some European studies have demonstrated displacement of shorebirds, but a recent study suggests that large numbers of wind turbines on European farmland are unlikely to displace farmland birds. Forest birds, on the other hand, do not generally appear to be disturbed or displaced in a significant way by wind turbine operation; but forest fragmentation, as a result of wind facility construction, may impact forest-interior birds that are sensitive to edge effects and removal of forest canopy. Resident raptors may be displaced by construction activities during nesting season, but they appear to habituate to the turbines after the construction phase. In Spain, migrating raptors were shown to detect the presence of turbines and divert their course around them, because they changed their flight direction when they flew near them, but their abundance in the area appeared not to be affected. More research is required to fine tune understanding of displacement and habituation.

It should be noted that the vast majority of studies have been conducted on large utility scale wind farms. It would be reasonable to expect that the impacts of a small one or two turbine project on avian species would be considerably less than on a large scale project impacting large areas of habitat.

6.1.2 Collision Fatalities

6.1.2.1 Collision Mortality in Context

Collision mortality is well documented at wind-power sites in the United States. An estimated 20,000 to 37,000 birds were killed at about 17,500 wind turbines of 6,374 MW of total capacity in the United States in 2003 (Erickson et al. 2005), yielding on average mortalities of 2.11 birds per turbine per year and 3.04 birds per MW per year. To date, there have been more than 20 fatality studies at wind turbine facilities across the continent and a total of more than 25,000 individual carcass searches have been done at turbines in the United States. This research exceeds post-construction wildlife impact research at practically all other types of electrical generation (coal, natural gas, nuclear, hydro, etc.). From the large number of studies now available, fatalities were spread among dozens of species, revealing taxonomic differences in collision susceptibility. Studies from the Eastern United States reveal slightly greater fatality levels than farther west.

Erickson et al. (2005) have attempted to put this mortality in context. Based on various studies reviewed in their paper, they estimated that annual bird mortality from human-caused sources may easily approach one billion birds in the U.S. alone. Of this estimate, collisions from wind turbines amounted to <0.01%. The major mortality sources were buildings (550 million, 58.2%; Klem 1990), power lines (130 million, 13.7%; Koops 1987), cats (100 million, 10.6%; Coleman and Temple 1996), automobiles (80 million, 8.5%; Hodson and Snow 1965, Banks 1979), pesticides (67 million, 7.1%), and communications towers (4.5 million, 0.5%; M. Manville, personal communication). Erickson et al. did not, however consider hunting, which takes some 100 million birds in the U.S. and Canada annually. While the uncertainties in the estimates are large, the numbers are so large that they cannot be obscured even by the uncertainties (NRC 2007).

Based on best available estimates, Erickson et al. (2005) figure that human-caused mortality may take approximately 5% to 10% of the U.S. landbird population each year. The biological significance of this take to populations is as yet uncertain, but the best wildlife management practices routinely allow takes at or above these levels for waterfowl populations, including species of conservation concern. For example, some 20 million waterfowl are shot in the U.S. and Canada annually, apparently without significant impact to any species (Martin and Padding 2002).

Waterfowl and gamebird harvest rates are predicated on the theory of density-dependent population growth (Hilborn et al. 1995, cited in Johnson and Conroy 2005). This theory predicts a negative relationship between population growth and population density, because the members of a species compete for finite resources. When populations are harvested, they should respond by increasing reproductive output or decreasing mortality, because more resources are available per individual. Resource managers attempt to maximize sustainable harvest by adjusting population density to a level that maximizes population growth (Beddington and May 1977, cited in Johnson and Conroy 2005). However, if populations are below carrying capacity, compensatory mortality or reproduction are sometimes moot points.

The wildlife effects of wind power can be quantified with reasonable precision through mortality studies and other research. But, traditional forms of electric power generation also affect wildlife populations. Their impacts are different and, in many cases, indirect and difficult to quantify (e.g., effects of acid rain, mercury bioaccumulation, habitat fragmentation, and climate change). The reason is because impacts can occur at various stages in the life cycle of electric generation, aside from the actual generation process. In addition, the (life cycle) impacts extend hundreds (sometimes thousands) of miles outward from the point sources. Some documentation exists, however, to help link the indirect impacts of traditional electric power generation with wildlife losses. For example, acid rain from power plant emissions has been linked with extraordinary decreases in aquatic life in some lakes and streams (Likens and Bohrmann 1974), as well as with eggshell thinning in birds (Glooschenko et al. 1986). There are also direct impacts to bird populations, especially from forest removal from strip mining and stream subsidence from long-wall, underground mining, neither of which have been quantified by scientists or environmental agencies.

In the case of Wood Thrush, a forest-interior species that breeds in the eastern North America (downwind of Midwest power-plant emissions), a Cornell University study (Hames et al. 2002) has demonstrated a strong correlation between acid rain occurrence and decreases in Wood Thrush numbers. The suspected reason is decreased reproductive success as a result of eggshell thinning or scarcity of calcium in the diets of developing birds. Other major threats to the Wood Thrush include forest destruction and fragmentation on both the breeding (sometimes from strip mining) and wintering grounds, and increased nest predation and parasitism in fragmented breeding habitat (Roth et al. 1996). In migration, Wood Thrushes are also at risk of collision with wind turbines. With a global population of about 14 million birds (Rich et al. 2004) decreasing at 1.7 percent per year (Hames et al. 2002), some of the estimated annual loss of about 240,000 birds could conceivably be assigned to acid rain originating from Midwest power plants, mountaintop removal in Appalachia to supply power plants with coal, or collisions with wind turbines supplying consumers with electricity.

In other words, all electricity choices have wildlife implications. The Wood Thrush example strongly suggests that power plants are having a measurable impact on bird populations in North America. No one, including federal and state wildlife agencies, has attempted to calculate how a coal-based electricity choice compares with wind energy on a bird impacts (death and displacement) per MW basis, but it would hardly be surprising if the wildlife cost of coal exceeded wind (without considering global warming). The negative impacts of fossil fuel-based electricity on other wildlife taxa, such as fish, mammals, herps, plants, and invertebrates, are outside the scope of this study, but in all likelihood, they are immense. Unfortunately, there are few data available from which comparisons can be made, primarily because post-construction avian or other wildlife impact studies of fossil fuel-fired plants have not been required or have rarely been required by federal or state wildlife agencies, and such studies have not been requested by agencies when permitting such projects.

Table 6.1.2-1. Mortality Reported at U.S. Wind-Energy Projects (from NRC 2007)

Wind Project	# Turbines	Turbine MW	Project MW	All Bird Mortality Turbine per year	All Bird Mortality MW per year	Reference
Pacific Northwest						
Stateline, OR/WA[1]	454	0.66	300	1.93	2.92	Erickson et al. 2004
Vansycle, OR[1]	38	0.66	25	0.63	0.95	Erickson et al. 2004
Combine Hills, OR[1]	41	1.00	41	2.56	2.56	Young et al. 2005
Klondike, OR[1]	16	1.50	24	1.42	0.95	Johnson et al. 2003
Nine Canyon, WA[1]	37	1.30	62	3.59	2.76	Erickson et al. 2003b
Rocky Mountain						
Foote Creek Rim, WY, Phase I[2]	72	0.60	43	1.50	2.50	Young et al. 2001
Foote Creek Rim, WY, Phase II[2]	33	0.75	25	1.49	1.99	Young et al. 2003
Upper Midwest						
Wisconsin[3]	31	0.66	20	1.30	1.97	Howe et al. 2002
Buffalo Ridge, MN, Phase I[3]	73	0.30	33	0.98	3.27	Johnson et al. 2002
Buffalo Ridge, MN, Phase I[3]	143	0.75	107	2.27	3.03	Johnson et al. 2002
Buffalo Ridge, MN, Phase II[3]	139	0.75	104	4.45	5.93	Johnson et al. 2002
Top of Iowa[3]	89	0.90	80	1.29	1.44	Koford et al. 2004
East						
Buffalo Mountain, TN[4]	3	0.66	2	7.70	11.67	Nicholson 2003
Mountaineer, WV[4]	44	1.50	66	4.04	2.69	Kerns and Kerlinger 2004

[1] Agricultural/grassland/Conservation Reserve Program (CRP) lands

[2] Shortgrass prairie

[3] Agricultural

[4] Forest

Returning to collision impacts from wind turbines, the standard method for studying them requires systematic searches below turbines to record the bird and bat carcasses found. This number is then adjusted to include searcher efficiency (because searchers do not find all the carcasses) and carcass removal (because scavengers may remove some carcasses before searchers look for them). According to best practices (Anderson et al. 1999, NRC 2007), searcher efficiency and carcass removal tests should be regularly conducted to account for different habitats, seasonal changes in ground cover, and fluctuations in scavenger populations.

A criticism sometimes made is that mortality studies at wind-power projects underestimate mortality because searcher efficiency and carcass removal are not adequately determined or taken into account. The best answer to this criticism is the most recent survey of the environmental impacts of wind-energy development (NRC 2007). This survey found that data allowing accurate estimates of bird fatalities at wind-energy projects in the United States are limited, but fourteen studies have been conducted using a survey protocol for an annual period and incorporating searcher-efficiency and scavenging biases into estimates. Although the protocols used in these studies varied, all generally followed the guidance in Anderson et al. (1999).

As can be seen in Table 6.1.2-1, there were some differences in the type and number of turbines at these projects, as well as in the geographic location, topography, and habitats where the projects were constructed. Mortality estimates were similar among projects, however, averaging 2.51 birds per turbine per year and 3.19 birds per MW per year, despite the differences in methodology, geography, and habitat. This suggests that the results of these studies were quantitatively robust. The values at the Tennessee site are slightly greater than other sites, but they do not suggest significant biological impacts at the regional, or local level (see human-caused mortality and waterfowl harvest discussions above).

Recently, however, 15 additional turbines were constructed at the Tennessee site. The new 1.8-MW turbines were larger than the three original 660-kW turbines, extending maximum height of the new turbines was 395 feet (120 m) AGL, versus 290 feet (88 m). A subset of the new turbines were equipped with red flashing strobes as opposed to white strobes that were on original turbines. Surprisingly, when all the wind turbines were recently studied, nine bird fatalities (all songbirds) were recorded in searches, yielding an overall adjusted mortality rate of 1.8 birds per turbine per year (Fiedler et al. 2007). This rate is significantly less than the 7.3 birds per turbine per year recorded in the previous study, and more in line with the 2.51 birds per turbine per year reported above.

6.1.2.2 Review of Avian Mortality Studies

What follows is a review of studies of avian mortality at wind farms (for a summary, see Appendix G). Except when noted, the numbers given are the numbers of carcasses found. As explained above, the number of fatalities would be higher when searcher-efficiency and the carcass-removal rates were factored in.

In Europe, collisions of birds with wind farms have been less comprehensively investigated than in the U.S. (Hötker et al. 2006). Dürr (2001, 2004), however, has assembled the most

comprehensive data set on collision victims at European wind farms, reporting data from eight European countries, including 14 wind farms in Germany. In reviewing Dürr's publications, Hötker et al. (2006) note that the highest mortalities have been recorded at wind farms along mountain ridges and at wetlands. At mountain sites, mortality has been notably high among resident birds of prey, especially Griffon Vulture (see below). At wetland sites, gulls and raptors have been notably affected.

Among raptors, Dürr's compilation shows that mortality has been particularly high among Griffon Vulture (133 victims, all from Spain), White-tailed Eagle (13, all from Germany), Red Kite (43, of which 40 from breeding populations in Germany), Common Buzzard (27), and Kestrel (29). According to ornithologist and wind-energy consultant Jan Blew (personal communication), Red Kite mortality occurs where wind turbines are placed in pastures and fallow fields, where birds hunt for rodents. Altering land-use around the turbines, such as by surrounding wind turbines with cropland, appears to be an effective method for reducing mortality. Montagu's Harrier, on the other hand, forages in the same grassland habitats, but it is barely affected (one collision victim reported by Dürr). According to Blew, the reason is that it usually flies low and does not enter the rotor-swept area.

Blew sees no easy solution for reducing White-tailed Eagle mortality in northeastern Germany, where there is a breeding concentration. He believes it is collision-prone because of it is a soaring bird that demonstrates no fear of wind turbines. White-tailed Eagle mortality has also been recently reported from the island of Smola in Norway. To date, its close relative, the Bald Eagle, has not been recorded in mortality studies.

Hötker et al (2006) find that species or species groups that show little avoidance reaction to wind farms are more likely to be collision victims than species that tend to avoid wind farms. In other words, birds of prey, gulls, and starlings are more frequently found as collision victims relative to geese and shorebirds, which avoid wind farms more. A notable exception, however, are crows, which do not avoid wind farms, yet they are rarely killed.

In a review, Dierschke and Garthe (2006) feature two mortality studies from coastal wind farms. For a ten-year study at the 23-turbine Zeebrugge wind farm in the Netherlands (Everaert et al. 2002), mortality rates ranged between 11 and 29 birds per turbine per year when corrected for recovery probability. In one year, 49 (89%) of 55 dead birds found were seabirds (44 gulls and 5 terns). The highest mortality was at a turbine row perpendicular to the main flight direction, where a maximum of 120 collision victims per year was recorded at one turbine (assumed corrected for recovery probability).

Dierschke and Garthe report that a six-year study (Painter et al. 1999) found that mortality at the nine turbines constructed on the pier at Blyth Harbor in the U.K. was six birds per turbine per year when corrected for recovery probability. Ninety-seven percent of mortality was of seabirds, including Common Eiders (12 carcasses). Most of the victims were gulls. The percent of local eiders (up to 3,200 birds) taken by turbine collisions (when corrected for recovery probability) was calculated annually. Values ranged from 0% to 1.3% (approximately 42 birds).

Fatalities of migrants have been relatively rare at most other European sites. Of particular interest is the relative lack of fatalities, given the migration traffic, at Tarifa, Spain, where several hundred thousand soaring birds, including more than 100,000 raptors, and millions of other birds, converge on the Straits of Gibraltar to cross between Europe and Africa (Marti Montes and Barrios Jaque 1995, Janss 2000, Barrios and Rodriguez 2004, and de Lucas et al. 2004). Not only have mortality studies recorded few migrants, but studies of birds exhibiting behaviors that put them at risk of collision (i.e., flying within 5 m [16 feet] of wind turbines) show that most migratory species do not exhibit these behaviors (Barrios and Rodriguez 2004). The birds that do exhibit these behaviors at Tarifa are resident raptors, particularly Griffon Vulture and Kestrel. In the case of the Griffon Vulture, mortality was concentrated in the fall and winter, when absence of strong thermals forced resident birds to use slopes for lift. Most mortality occurred during light winds, when birds probably could not maneuver as well. In the case of the Kestrel, most deaths occurred during the annual peak of abundance in summer and appeared to be related to wind turbine location in preferred hunting habitat (Barrios and Rodriguez 2004). Similar Griffon Vulture mortality did not occur at all Tarifa wind farms (de Lucas et al. 2004).

Elsewhere in Spain, significant Griffon Vulture mortality has been recorded at wind farms in the Pyrenees Mountains of Navarre. The causes for this relatively high mortality appear to be closely spaced turbine placements on ridges habitually used for soaring by a resident population (Lekuona 2001). Mortality was found to be higher under low wind conditions, when birds likely could not maneuver well.

In the United States, the Altamont Pass Wind Resource Area (APWRA) is the only wind-power site where risk to birds has been suggested to have been significant. Over 15 years of studies have shown that Golden Eagles, Red-tailed Hawks, American Kestrels, and other species collide with turbines in varying numbers. These findings suggest that raptors are the most collision-susceptible group of birds (Anderson et al. 2000), but fatalities at the APWRA have not impacted regional populations. A long-term study of the Altamont Golden Eagle population by Hunt (2002) concluded that, despite the high fatality rate, the population remains stable. Large numbers of gulls, ravens, vultures, grassland songbirds, and other species fly amongst the APWRA turbines and rarely collide with them.

The raptor fatalities in the APWRA appear to be an anomaly, because they have not been demonstrated elsewhere. Other studies conducted at U.S. wind power facilities outside of the APWRA have not revealed large numbers of raptor fatalities.

Several factors are believed to contribute to raptor risk in the APWRA, and some can be generalized to other species. These factors act alone or together to produce the collision mortality documented in the APWRA (Howell and DiDonato 1991, Orloff and Flannery 1992, 1996). They are:

- Large numbers of turbines (presently about 5,400, down from about 7,000 several years ago) concentrated in a small area and providing many obstacles to flight
- Closely spaced turbines (less that 10 m [30 feet] rotor-to-rotor distance) that may not permit birds to fly safely between them

- Extraordinary numbers of foraging raptors throughout the year, the result of a superabundant population of California ground squirrels
- Steep topography with turbines placed in valleys and along valley and canyon edges, where collision risk is greater
- Turbine rotors that sweep down to less than 10 m (30 feet) from the ground, affecting airspace where raptors forage extensively
- Turbines mounted on lattice-type towers that encourage perching and provide shade and cover from sun and rain
- Small turbine rotors that revolve at high rates (40-72 rpm) making the rotor tips difficult to see

Recent studies from Texas and Oklahoma, however, have demonstrated surprising mortality among Turkey Vultures, a species frequenting many U.S. wind farms, but which had been infrequently recorded in mortality studies. At the Buffalo Gap I Windfarm near Abilene, Texas, a study was conducted during 2006 of 21 of the 67 operating turbines. It recorded 21 avian casualties, including fifteen Turkey Vultures and one Red-tailed Hawk (Tierney 2007). Most of the Turkey Vultures that could be aged were juveniles, suggesting that younger birds may be more prone to collision. The author noted that Turkey Vultures were frequently seen flying near turbines, and that adult birds appeared to be quite adept at maneuvering around the rotating blades. When searcher efficiency and carcass removal were factored in, estimated fatality rates were 0.24 Turkey Vultures per turbine per year, 0.19 other raptors per turbine per year, and 1.94 small/medium birds per turbine per year. This yields an overall rate of 2.37 birds per turbine per year (Tierney 2007).

At the Blue Canyon II Wind Power Project in southwestern Oklahoma, a study was conducted during 2006 of 50 of 84 operating turbines. This study recorded 15 avian casualties, of which eleven were Turkey Vultures and two were Red-tailed Hawks (Schnell et al. 2007). The authors did not report the ages of the Turkey Vultures; therefore, it is uncertain whether the juvenile mortality pattern was evident there too. With searcher efficiency and scavenger removal factored in, mortality rates were reported as 0.27 small passerines per turbine per year and 0.25 raptors (including Turkey Vultures) per turbine per year. This yields an overall rate of 0.52 birds per turbine per year (Schnell et al. 2007).

West of the Rocky Mountains, avian mortality resulting from collisions with wind turbines has been studied at sites in California, Oregon and Washington State. With the exception of the APWRA, reported fatality numbers have been small. At San Gorgonio Pass and in the Tehachapi Mountains, relatively few birds were killed in two years of searches, including very low representation of raptors (Anderson 2000). One Golden Eagle has been found in the San Gorgonio Wind Resource Area in more than two years of study. At a new wind power site in Oregon, at which there are 38 turbines in farmland, a one-year study documented no raptor fatalities, eight songbird fatalities, and four game bird fatalities (three of which were alien species). The estimated number of actual fatalities was greater (N = 24 fatalities; 0.63 fatalities per turbine per year), when searcher efficiency and carcass removal (scavenging) estimates were factored in.

The State Line project on the Washington/Oregon border is one of the world's largest wind power facilities. As presented in Table 6.1.2-1, the fatality rate per turbine per year has been found to be slightly less than two birds per turbine per year (Erickson et al. 2002, 2003, 2004). That project now has 454 turbines. Among the fatalities were a variety of species, with Horned Larks (locally nesting birds) accounting for 46% of all birds found. Six raptors from three species were killed, and about 24% of fatalities were night migrating songbirds. The rates of avian fatalities at smaller wind power sites in Oregon (Klondike) and Washington (Nine Canyon) averaged slightly lower and higher, respectively. Birds killed were divided among night migrants, resident species, very few waterfowl, and small numbers of raptors. The rate of night migrants killed in the far west has been roughly one bird per turbine per year or less, which includes carcass removal and searcher efficiency correction factors

Most of the projects in the western United States discussed above were situated in tilled agricultural fields or pasture/prairie-like habitats. It should be noted that many of the turbines involved in California studies were less than 200 feet in height and did not have FAA lights. All turbines in Oregon and Washington were taller than 275 feet and a subset (perhaps one in three to one in four) of them had FAA lights (the presence or absence of lights is significant, because, as discussed below, lighting has been implicated in large-scale fatality events at communication towers). There has been no suggestion of population impacts at any of these facilities, nor have fatalities involved endangered or threatened species.

In the Rocky Mountain region, after five years of systematic searches at 29 modern turbines (expanded to 45 in the third year) in a short-mixed grass prairie/pasture land in northern Colorado, small numbers of fatalities were documented (Kerlinger, Curry and Ryder, unpublished). The fatalities were mostly Horned Larks, with fewer McCown's Longspur, White-throated Swifts, one teal, one American Kestrel, one Lark Bunting, and some other songbirds. The prevalence of Horned Larks on the fatality lists is likely a result of their aerial courtship flight during which they display and sing at the height of the rotors.

In Wyoming, at the Foote Creek Rim project (presented in Table 6.1.2-1), also in a short-mixed grass prairie habitat, 90 fatalities were recorded, 75 of which were at wind turbines and 15 of which were at meteorology towers with guy wires (Young et al. 2003). Thus about 20% of the fatalities resulted from collisions with guy wires at the meteorology towers and likely would have been avoided by using free-standing towers. This means the fatality rate per structure is about two to four times greater at the guyed meteorology tower than at the turbines. (Virtually no birds are known to be killed at free-standing meteorology towers.) Few raptors were found dead at the Foote Creek Rim project (three American Kestrels and one Northern Harrier) and 48% of the fatalities were night migrating birds. Of the migrants, no species accounted for more than five to seven individuals (including Chipping and Vesper Sparrows).

In the upper Midwest, a number of projects have been studied. In Kansas, Young (2000) noted no fatalities at the two turbines in the Jeffrey Energy Center in Pottawatomie County. In Minnesota, at the Buffalo Ridge wind power facility (approximately 400 turbines; see Table 6.1.2-1) near Lake Benton, relatively small numbers of fatalities have been reported (Johnson et al. 2002) during four years of searching at subsets of the turbines. The fatality rates per turbine ranged between about one bird per turbine per year to about four birds per turbine per year. The

species composition included a variety of birds, including one raptor (Red-tailed Hawk), very few waterbirds, and a number of night-migrating songbirds (about 70% of the 53 documented fatalities). Only about five ducks and coots were found during the study, despite their regular presence around the wind power site and the fact that the wind farm is within a major migration area for waterfowl (Bellrose 1970).

In Iowa, a study at a small wind plant reported no fatalities (Demastes and Trainor 2000). A two year study recently completed by Iowa State University and the Iowa Department of Natural Resources at the Top of Iowa Wind Power Project site revealed no fatalities to Canada Geese or other waterfowl (Koford et al. 2005). This study is important because the 89 turbines were located within one to two miles of three waterfowl management areas. Despite intense use of the turbine fields by waterfowl (>1.5 million duck and goose-use-days per year), none were killed. In addition, no shorebirds were killed, but one raptor (perhaps two) was recorded in the mortality study. As presented in Table 6.1.2-1, fewer than 1.5 birds per turbine per year were found to be killed at this site.

In Wisconsin, two years of carcass searches under 31 turbines situated in farm fields in the Kewaunee County peninsula found about two dozen songbird fatalities, mostly migrants. Perhaps six of the documented fatalities were night migrants. One Mallard and one Herring Gull were the only two waterbirds found dead at this site (Howe et al. 2002). The authors estimated that each turbine killed between one and two birds per year, when searcher efficiency and carcass removal rates were factored into the estimates. A study of two modern wind turbines at Shirley revealed one night migrating songbird fatality during a year-long study (Howe and Atwater 1999).

In the northeastern United States, where wind farms have been developed only since the late 1990s and early 2000s, there are fewer in depth studies of collision fatalities at turbines than in the west. But, there is information from eight wind power facilities in the eastern United States and one across Lake Erie in Canada that are relevant to the Project site, involving many of the same species and migration behaviors, especially among night migrants.

At the Meyersdale Wind Energy Center, located in southwest-central Pennsylvania, a total of 13 avian carcasses, representing six or more species, were found below 20 turbines during searches from July 30 to September 13, 2004. Two studies have been conducted at the Mountaineer Wind Energy Center on Backbone Mountain in West Virginia. This site has 44 turbines, twelve of which were lit with FAA-certified red strobes. In 2003, Kerns and Kerlinger (2004; see Table 6.1.2-1) found a mortality rate of about four birds per turbine per year, including about three night migrants per turbine per year. One duck and three raptors (two Turkey Vultures and one Red-tailed Hawk) were also found. In 2004, Arnett et al. (2005) found a total of 15 avian carcasses during a six-week period, with 13 of those individuals representing night-migrating songbirds or songbird-like species. The other two birds were a Turkey Vulture and a Sharp-shinned Hawk. Both these sites experience a fairly heavy fall raptor migration, but raptor mortalities have been minimal, limited apparently to mostly resident birds.

At a facility with eight modern turbines (four with red-flashing FAA lights approximately 280 feet [85 m] tall) located in farmland at Garrett, Somerset County, Pennsylvania, seventeen

rounds of fatality searches conducted from June 2000 through May 2001 revealed no avian fatalities (Kerlinger 2001).

In central New York State, the Madison and Fenner Wind Power Projects are located in cropland. The Madison site has seven modern turbines that reach a maximum height of about 120 m (390 feet) tall and are all lit with FAA red strobes (type L-864). Four collision fatalities have been recorded at the turbines, plus one at a guyed meteorological tower (Kerlinger 2002a). During the spring and fall migrations, each turbine was searched five and six times, respectively. If carcass removal and searcher efficiency rates at the Madison site were similar to those at other projects, the numbers of fatalities would likely be on the order of two to four-plus birds per turbine per year. Of these fatalities, most would be night-migrating songbirds and similar species. The Fenner project has 20 turbines. In mid 2004, the plant manager reported no fatality events for raptors or other large birds (Paul Kerlinger, pers. comm.). Nevertheless, biologists from the New York State Department of Environmental Conservation (NGPC) made a site visit during 2004 and found small numbers of dead bats.

In upstate New York, on the Tug Hill Plateau of Lewis County, several months of daily searches during spring and autumn migration beneath two unlit wind turbines (168 feet [51 m] tall) located in open fields revealed no carcasses (Cooper et al. 1995). At Searsburg in southeastern Vermont, searches done in June through December 1997 (nesting through fall migration) revealed no fatalities at eleven new, unlit turbines (192 feet [58 m] tall) situated on a forested hilltop (Kerlinger 2000a and 2002b).

As noted in Section 6.1.2.1, the greatest fatality rate found for birds at turbines in the United States was about close to eight birds per turbine per year under three turbines on a forested mountaintop in eastern Tennessee. The two-year study of the 290-foot (88-m) turbines equipped with white strobes revealed several dozen fatalities, mostly night migrating songbirds (Nicholson 2003). Lighting may have played an important role in these fatalities, but it is also possible that the larger rate of fatalities is the result of the more southerly latitude of this project, where migrants are more concentrated. But a recent study at this site has shown a much lower rate – 1.8 birds per turbine per year (Fiedler et al. 2007).

In coastal New Jersey, the Atlantic County Utilities Authority (ACUA) has erected a demonstration project of 5 turbines on a filled island surrounded by salt marsh with tidal creeks and channels. Avian use was very high at the site, as was noted one year of pre-construction studies. Eight carcasses were found at that site from July through December 2007, including two listed raptors (Osprey and Peregrine Falcon), two gulls, two shorebirds, and two night migrating songbirds (New Jersey Audubon 2008). Fatalities were not corrected for searcher efficiency and scavenging (carcass removal), but it appears that the fatality rate was low and not biologically significant, despite the fact that two listed species were killed.

In Canada, at the Erie Shores Wind Farm in Ontario, (James 2008), a two-year mortality study included searcher-efficiency and carcass-removal trials. It estimated mortality to be between 2.0 and 2.5 birds/turbine/year, including a rate of 0.04 birds/turbine/year for raptors.

Some patterns of mortality were apparent. Mortality was higher at wind turbines within 200 m (660 feet) of the Lake Erie shore bluffs. Turbines even 250-400 m (820-1,310 feet) showed no elevated mortality. The steady red aviation-warning lights on a subset of the turbines also appeared to contibute to somewhat elevated mortality. Based on this finding, Environment Canada has requested that aviation-warning lights be changed to flashing red. In addition, the presence of woodlands at less than 50 m (165 feet) from turbine bases appeared to have some small effect on the mortality level, but beyond that distance, no effect was apparent. It was mainly the turbines near trees in near-shore areas that were most significant to bird mortality.

In future installation of wind farms in the Great Lakes area, James recommends that all turbines be kept at least 250 m (820 feet) away from shore bluffs or shores, aviation-warning lights should be flashing, and turbine bases should be kept at least 50 m (165 feet) of trees.

James conducted two other fatality studies at single wind turbine installations in Ontario. One was along the shore of Lake Ontario in a park in Toronto, and the other was adjacent to Pickering Marsh, a few miles inland from Lake Ontario. The turbines at both sites were tall, modern turbines. The two studies revealed mortality levels similar to the Erie Shores study.

In summary, studies at these and other sites have shown fatalities to be relatively infrequent events at wind farms. No federally endangered or threatened species have been recorded, and only occasional raptor, waterfowl, or shorebird fatalities have been documented. In general, the documented level of fatalities has not been large in comparison with the source populations of these species, nor have the fatalities been suggestive of biologically significant impacts to these species.

7.0 Avian Risk Assessment for the Mount Wachusett Community College Wind Energy Project

7.1.1 Disturbance and Displacement Risk at the Mount Wachusett Project

Disturbance and displacement impacts may occur at the Project site as a result of Project construction, habitat modification, and wind-turbine operation.

Construction: Some birds may be displaced temporarily during the Project's construction phase, as heavy equipment, trucks, and workers pass through the area. In addition, clearing for the road and turbine areas, may displace birds. This impact is expected to be ephemeral, decreasing markedly when construction ends. Such impacts would have a greater effect during the breeding season than in the non-breeding season. Effects would potentially be greatest on any federal or Massachusetts-listed species, because their breeding populations are small. Data sources, including letters from the MAFWD and USFWS indicate that such species are unlikely to breed or forage at the site.

Habitat Modification: The access road and one or two turbine-construction areas that will be created in a small field will reduce functional grassland by a small percentage. The Project will not fragment nearby woodlands, which are already heavily fragmented and degraded, nor will it modify shrubland, wetland, or other native habitat.

It should be noted that the habitat effects of Project construction would be minor in comparison with the effects of mowing or natural vegetation succession on grassland birds. Unless the field is managed appropriately for grassland birds, those birds are likely to disappear whether or one or two turbines are constructed. In addition, given that the grassland patch is so small and isolated, the presence of Bobolinks is already significantly threatened by succession to shrubland, as well as random events (Noss et al. 1997).

According to Rob Rizzo, MWCC Director of Operations (personal communication to the authors), the college is interested in following management recommendations that would enhance bird diversity at the site, especially since the development of the plan could involve the college's students. Two management options are possible. First, delaying mowing of the field until after Bobolinks have fledged their young (after July 15) is an obvious recommendation that should be followed. Such mowing would also ensure that the grassy field is protected from succession of grassland to shrub land and forest. Second, increasing the shrubland zone around portions of the pond merits serious consideration as a means of increasing the population of the *Yellow WatchList* Willow Flycatcher and possibly attract the *Yellow WatchList* Blue-winged and, or Prairie Warblers. This measure would increase the site's biodiversity and conservation value.

Turbine Operation: Research summarized in Section 6.1 indicates that displacement and disturbance of grassland birds by turbine placements and operation have not been consistently demonstrated. Where displacement has been demonstrated, densities of breeding birds were found to be lower within about 25-200 m (78-657 feet) of turbine placements. In the context of the Project, potentially affected species would be limited to Bobolink.

Because forest-interior birds, waterbirds, and raptors do not nest on site or within hundreds of meters of the turbines, displacement impacts to those species are unlikely. It is important to note that foraging raptors and waterfowl have been shown to habituate to turbines, regularly feeding in fields near these structures.

In summary, disturbance and displacement effects resulting from the Project are expected to be minor. Project construction will be of limited duration and unlikely to affect species of greatest conservation concern, which do not occur at the site. Habitat modification may affect the small Bobolink population, but there is reason to consider reducing the grassland further in favor of shrubland to provide habitat for *Yellow WatchList* species, such as Willow Flycatcher. Turbine operation could potentially displace breeding Bobolinks, but because studies in the northeast show that these birds will nest near turbines, this impact is unlikely.

7.2.1 Collision Risk at the Mount Wachusett Community College Wind Energy Project

Given that collision risk varies with bird type, we treat the various bird groups separately. These groups are nocturnal migrant songbirds, raptors, waterbirds. Listed species are not present at the site according to the MADFW and USFWS.

7.2.2.1 Nocturnal Migrant Songbirds

Table 6.1.2-1 provides the results of mortality studies where searcher-efficiency and carcass-removal rates were included (NRC 2007). At these fourteen projects, the percentage of night-migrating songbirds killed increased from west to east, presumably in response to migration traffic. At the Stateline, Washington, project in the West, the percentage of night migrants killed was 24%; at Foote Creek Rim, Wyoming, in the Rocky Mountains, 48%; at Buffalo Ridge in Minnesota, 70%; and at Mountaineer, West Virginia, in the East, 70.8%. At the Maple Ridge site in northern New York, the percentage of night migrants was about 80% (Jain et al. 2007). Finally, in Tennessee, nearly all birds killed in four years of study were night migrants (Fiedler et al. 2007, Nicholson 2002).

Most reports of night-migrant fatalities are of single birds, unlike the large-scale events documented over the past sixty years at communication towers greater than 500-600 feet (152-183 m) in height (Avery et al. 1980). That nocturnal migrants collide at a lower rate with wind turbines than with tall communication towers is related to the much greater height of the communication towers that were involved, as well as to the presence of guy wires (Kerlinger 2000b) and steady-burning FAA red lights (L-810 obstruction lights) on communication towers.

The communication towers that are responsible for the largest numbers of avian fatalities, including virtually all of those where large numbers have been killed in a single night, are almost entirely taller than 500-600 feet (152-183 m; from literature and recent unpublished studies). Such towers are much taller than the turbines proposed for the Project site. The most recent literature surveys conducted by the USFWS and the U.S. Department of Energy (Trapp 1998, Kerlinger 2000b, Kerlinger 2000c) reveal virtually no large scale mortality events at communication towers less than 500-600 feet in height. It should be noted that the few

communication towers less than 500 feet in height associated with reports of large-scale fatality events have been immediately adjacent to bright lights. At these sites, steady burning sodium vapor lights or other bright lights have been shown to be present (Kerlinger 2004a, b). Very attractive to birds, sodium vapor lights are very different from the lights stipulated by the FAA for wind turbines.

The fact that there are no guy wires on modern wind turbines is of critical importance, because it is the guy wires of tall communication towers that account for almost all of the collisions. The literature does not reveal many fatalities at free-standing communication towers that are as tall as 475 feet (Gehring and Kerlinger 2007a and 2007b). These studies were conducted at 400-475 foot tall unguyed communication towers revealed between about zero and two birds killed per tower per year. No published studies have revealed collision fatalities at freestanding towers, including freestanding meteorology towers at wind power sites (W. Erickson personal communication, Kerns and Kerlinger 2004).

The last risk factor that has been implicated in collisions of night migrating birds with tall structures is lighting (Kerlinger 2000b). The lights of communication towers and some other structures (smoke stacks, cooling towers, and tall buildings) have been demonstrated to attract migrants that then collide with the structures. On the 1,000-foot tall communication towers where large fatality events have occurred, all have been equipped with up to twelve steady-burning red L-810 obstruction lights as well as several flashing L-864 red flashing strobe-like lights (often incandescent lights that do not go entirely black between flashes).

The lighting on wind turbines is very different (see FAA Advisory Circular). Wind turbines almost never have the steady-burning red lights (L-810 obstruction lights) that are present on communication towers. Instead, a subset of turbines has single flashing L-864 red flashing strobes.

Research by Kerns and Kerlinger (2004) and Kerlinger (2004a, 2004b, Kerlinger et al. in review) has not demonstrated any large-scale fatality events at wind turbines, nor has it shown any difference in numbers of fatalities at lit versus unlit turbines. Similar results from wind plants in Washington, Oregon, and Minnesota have supported this finding. At the Mountaineer Wind Energy Facility in West Virginia, Kerns and Kerlinger (2004) reported a fatality event involving about 30 night migrating songbirds in May 2003. That event occurred on a very foggy night at an electrical substation involving mostly one turbine and the substation fencing. Birds were apparently attracted to four sodium vapor lamps on the substation and collided with the three closest turbines (mostly the closest turbine) and the substation infrastructure. Almost no birds were found at the 41 other turbines at that project, despite 11 of them being lit with red flashing, L-864 strobe-like lights.

There are two wind plants that are noteworthy because they have some steady burning, L-810 lights and have had slightly elevated fatality rates at turbines with those lights. At Buffalo Ridge in Minnesota, a smaller fatality event involving 14 migrants at two adjacent turbines (seven under each turbine) at Buffalo Ridge in Minnesota was probably the result of the steady burning red lights on one of the turbines. At Erie Shores, turbines with lighting (in all cases steady red) had more night migrant fatalities than unlit turbines. For this reason, Environment Canada has

requested that the lighting be changed to flashing red. This suggests that steady burning red lights (L-810) can attract birds.

The fact that no large scale mortality events involving night migrating birds have been documented at wind turbines anywhere, combined with the fact that there is no difference between the numbers of birds killed at turbines lit with L-864 red flashing strobes versus unlit wind turbines, strongly suggests that FAA obstruction lighting for wind turbines (red flashing, L-864 strobe-like lights) does not have the same attractive effect as the steady burning red lights (L-810) that are on communication towers (Kerlinger 2004a, 2004b). Furthermore, the FAA does not stipulate that all wind turbines be lit. Research by Gehring and Kerlinger (2007b) and Gehring et al. (in press - 2008) at communication towers in Michigan has provided the first evidence that L-810 lights are far more attractive to birds than flashing L-864 lights. Tower fatalities studied in Illinois and elsewhere have consistently been at towers in excess of 600-800 feet AGL, although some have exceeded 1,500 feet AGL (Seets and Bohlen 1977, Bohlen 2004, Graber 1958, Larkin and Frase 1988). These towers have all been equipped with guy wires and a combination of flashing red (L-864 type incandescent) and steady burning (L-810 type) lights. Some of these towers have been equipped with more than 12-15 lights, staggered at various levels from just above the ground to more than 1,000 feet above the ground. Overall, the structure and lighting of these communication towers is very different from that of wind turbines.

Conclusion

Wind turbines essentially lack the major risk factors implicated in large-scale mortality events involving nocturnal migrants at communication towers. In contrast, wind turbines: 1) are relatively low in height when compared with tall communication towers, 2) lack guy wires, and 3) have FAA obstruction lights that appear not to attract nocturnal migrants.

As explained in Section 4.2.1, studies strongly indicate that nocturnal migration above the Project site would occur on a broad front mostly at altitudes above the sweep of wind-turbine rotors. A small percentage of migrants would fly below 120 m (394 feet, roughly the height of a modern wind turbine) and be at risk of collision.

At dawn, nocturnal-migrant songbirds land in woodland and other habitats, where they feed to replenish the fat reserves that power their migration. During this descent, and during the evening ascent when they resume migration, these birds may be at greater risk of collision, particularly if birds are concentrated in the habitats adjacent to wind turbines. Nonetheless, concentrated migratory fallout is not anticipated at the Project site, as wooded habitats are abundant, not concentrated, in the Project region.

Overall, it is likely that collision mortality will be similar both in numbers and species composition of migrants to what has been recorded at other sites. The fact that there will be only one or two turbines at the MWCC site further suggests that collision mortality will not be great. It is important to remember that even if fatality rates at these one or two turbines is the highest rate yet reported (perhaps 7-9 per turbine per year), the absolute numbers of fatalities will not be great. In addition, fatalities at wind turbine sites generally are divided among many species, so if

7-9 birds are killed per turbine per year, this would amount to only one or two individuals of the most common of species. This level of mortality is not likely to be biologically significant.

7.2.2.2 Raptors

Risk factors for raptors are well documented at the Altamont Pass Wind Resource Area (APWRA; see Section 6.1.2 discussion). We use the Altamont Pass as a worst case scenario because that site is the only wind power facility with potentially significant risk to raptors. Table 7.2.2.2-1 compares the APWRA risk factors with the project contemplated at the MWCC site. As will be seen, the known or suspected risk factors for raptors are minimal at the Project site.

Table 7.2.2.2-1. Comparison of Collision Risk Factors

Known or Suspected Risk Factors Altamont Pass Wind Resource Area (APWRA)	Comparison of Risk Factors Proposed Mount Wachusett Project
Large concentration of turbines (about 5,400 in 2002)	1 or 2 turbines
Lattice towers that encourage raptors to perch	Tubular towers, no perching
Fast rotating turbine blades (40-72 rpm)	Slow rotating blades (12-18 rpm)
Closely spaced turbines (less than 30 m [100 feet] apart)	Widely spaced turbines (greater than 250 m [800 feet])
Turbines in steep valleys and canyons	Turbines in a flat, open field
Large prey base that attracts raptors	Small prey base
Turbine rotors sweep to less than 10 m (30 feet) from ground	Turbine rotors sweep down to about 40 m (131 feet) above the ground, although this will depend on the turbine make and model
High raptor and susceptible species use of area	Low raptor use of area, nesting unlikely

Risk factors aside, raptor mortality is generally low at U.S. wind farms. The combined average raptor mortality reported in fourteen U.S. studies analyzed by the National Research Council (NRC 2007; see Table 6.1.2-1) was 0.03 birds per turbine/year and 0.04 per MW/year.

Conclusion

At the Project site, few if any raptor fatalities are expected. Species most at risk would be those that nest or winter in the vicinity of the site and become habituated to the wind turbines, as opposed to migrating raptors that pass through the site or general area. In this regard, Red-tailed Hawk and Turkey Vultures (technically not a raptor) are probably the only species likely to become habituated to the Project. Raptor migration at the Project site is likely to be minimal and

take place across a broad geographic front at altitudes well above the sweep of wind-turbine rotors.

7.2.2.3 Waterbirds (Waterfowl, Shorebirds, Etc.)

Waterbird mortality at U.S. wind farms has been demonstrated to be relatively low. In a review of bird collisions reported in 31 studies at wind-energy facilities, Erickson et al. (2001, cited in NRC 2007) reported that 5.3% of fatalities were waterfowl, 3.3% waterbirds (mainly rails and coot), and 0.7% shorebirds. It is interesting that waterfowl and shorebirds are nocturnal migrants, but they appear not to be attracted to lights (FAA or other types). They are also known to migrate mostly at high altitudes (Kerlinger and Moore 1989, Bellrose 1980).

Conclusion

At the Project site, there are no significant wetland habitats that would concentrate waterbirds at any time of the year. The adjacent pond and wetland are too small to attract waterbirds in significant numbers, although Canada Geese and Mallards nest nearby and use the pond at times. Impacts to waterfowl are likely to be negligible and certainly not biologically significant.

7.2.2.4 Summary Collision Risk, Conclusions

The MWCC project is likely to result in similar numbers of fatalities as has been reported at other wind power facilities in the eastern United States. Those fatalities will consist of small numbers of night migrating songbirds and very few or no raptors, waterbirds, and other species. These fatalities will not likely result in biologically significant impacts to any species. In addition, impacts to listed species is highly unlikely.

Post-construction fatality studies, particularly those that have taken into account searcher efficiency in finding carcasses, as well as carcass removal by scavengers, have demonstrated that fatalities are relatively infrequent events at wind power projects. In a recent review of the literature on U.S. wind farms, mortality estimates were similar among projects, averaging 2.51 birds per turbine per year and 3.19 birds per MW per year. Rates have been slightly greater in the Eastern U.S. than in the West, presumably because of denser nocturnal migration of songbirds in eastern North America. No federally listed endangered or threatened species have been recorded in any of the studies undertaken, and only occasional raptor, waterfowl, or shorebird fatalities have been documented. In general, the documented level of fatalities has not been large in comparison with the source populations of these species, nor have the fatalities been suggestive of biologically significant impacts to these species.

Fatality numbers and species impacted at the Project site are likely to be similar, on a per turbine per year basis, to those found at Eastern and Midwestern U. S. projects that have been studied. These fatalities, when distributed among many species, are not likely to be biologically significant. When compared with the Altamont Pass Wind Resource Area, collision risk factors for raptors are minimal. Collision risk to night-migrating songbirds is likely to be similar to other sites examined because the altitude of migration is generally above the sweep of the wind turbine rotors.

8.0 Recommendations / Response to Wildlife Agency Comments

The following recommendations for the proposed Mount Wachusett Community College Wind Energy Project are based on: 1) an on-site examination of the habitat and birdlife, and 2) literature and database searches regarding the Project site's avifauna and what is known about the potential risks to birds from wind-power development in the United States and Europe.

Construction Guidelines

- Electrical lines within the project site should be underground between the turbines.
- Permanent meteorology towers should be freestanding (i.e., without guy wires) to prevent the potential for avian collisions.
- Size of roads and turbine pads should be minimized to disturb as little habitat as possible. After construction, any natural habitat should restored as close to the turbines and roads as possible to minimize habitat fragmentation and disturbance/displacement impacts. To accomplish this, topsoil or marsh should be replaced as a means of encouraging plant growth.
- Lighting of turbines and other infrastructure (turbines, substations, buildings) should be minimal to reduce the potential for attraction of night migrating songbirds and similar species. Federal Aviation Administration (FAA) night obstruction lighting should be only flashing beacons (L-864 red or white strobe) with the longest permissible off cycle. Steady burning (L-810) red FAA lights should not be used. Sodium vapor lamps and spotlights should not be used at any facility (e.g., lay-down areas or substations) at night except when emergency maintenance is needed.

Post-construction Studies

- A mortality study following best practices should ideally be conducted during a two-year period post-construction, with the second year contingent on what is found during the first year. If fatalities are recorded at levels that could be construed as biologically significant, or if significant numbers of special-status species are involved, a second year of study would be called for. The design of the post-construction protocol should follow the designs now being used and refined at existing wind-power sites and approved by various government agencies, including MADFW and USFWS. Such a study could be integrated into MWCC's environmental program. Students and faculty of MWCC would conduct the study with technical support from a biologist trained in conducting post-construction fatality studies.
- Results of the fatality study should be compared with impacts to birds from other types of power generation now supplying electricity in Massachusetts. This comparison would facilitate long-term planning with respect to electrical generation and wildlife impacts. The study should seek information from USFWS and MADFW on existing energy-generation impacts to wildlife. If information is not available, as our preliminary review

appears to reveal, these agencies should consider providing financial support for such studies. This project should be conducted by a team involving faculty, students, and a wind industry consultant.

Habitat Enhancement

- The most significant breeding bird that presently occurs at the Project site is the *Yellow WatchList* Willow Flycatcher, which nests in the shrubland zone between the field and pond. We recommend developing a habitat management plan that would expand shrubland habitat to increase this flycatcher's population (presently at six territorial males). This step also has the potential to attract two other *Yellow WatchList* species to the site: the Blue-winged and Prairie Warblers, both of which were recorded regionally in the Breeding Bird Atlas and more recently in Breeding Bird Surveys. Ideally, MWCC students should be involved in the development and implementation of this plan. It should be noted, however, that increasing the shrubland zone will likely reduce habitat for the Bobolinks that presently display and possibly nest in the field. Nonetheless, the future of this Bobolink population is uncertain, given that it is so small and isolated. Furthermore, the flycatcher's status on the *Yellow WatchList* makes it of higher conservation concern. In any event, the field should not be mowed until about July 15, after Bobolink young have fledged (if they are nesting in the field).

Response to Agency Comments

This report helps to meet the recommendation of MADFW that potential impacts to birds be considered during the Project's design and permitting process.

Regarding the recommendation of the USFWS (Appendix D) to do three years of pre-construction radar study, we do not believe that such a study is warranted, because it will not improve on this risk assessment. As discussed in Section 4.2.1, the nocturnal migration pattern (in terms of traffic, altitude, percent of birds flying at rotor height, etc.) has been well documented at more than 20 (perhaps 30) sites across the northeastern U.S. These studies provide no suggestion that the migration pattern at MWCC would be substantially different at the Project site. In fact, these studies suggest a broadly diffuse migration across New England and the northeastern states, which is called a broad front migration. In addition, altitude of flight of these birds is similar among sites and there have been no sites found where the predominant altitude of nocturnal migration is even close to the rotor swept height of turbines. In other words, there is no reason to believe that migrants over the MWCC site are concentrated. Furthermore, as discussed in Section 6.1.2, all post-construction fatality studies at wind energy facilities have established that the average fatalities per turbine per year are relatively low (averaging perhaps three to five night migrants per turbine per year at wind farms in the northeastern US.). In addition, no mass or large-scale fatality events have ever been recorded at any wind turbines project. Therefore, detailed knowledge of night-to-night and year-to-year variation in nocturnal migration at a site will not improve on our mortality forecast. Radar has simply never been documented to be a precise or reliable predictor of risk, nor has it been validated as a research tool for assessing risk to birds.

USWFS has also recommended that the effects of habitat fragmentation at the MWCC site be considered. With regard to birds, we find that the creation of an unpaved access road and one or two turbine-construction areas in the field will reduce functional grassland by a small percentage. The Project will also not fragment woodland, which are not really on the Project site. Adjacent woodlands will not be impacted by the project and they are already heavily fragmented and degraded . Finally, the Project will not modify shrubland, wetland, or other native habitat, other than to improve such habitat through the voluntary efforts of the college.

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Appendix A. Conformance with U. S. Fish and Wildlife Service (USFWS) Guidelines

This addendum addresses the U.S. Fish and Wildlife Service's *Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines* (USFWS 2003). The Federal Register published these guidelines in July 2003, and USFWS briefed the National Wind Coordinating Committee on them on July 29, 2003. USFWS has emphasized that the guidelines are interim and voluntary. In April 2004, USFWS Director Williams sent a letter to the Service's state offices directing them regarding the implementation of the guidance document and its recommendations. The guidance document was posted on the Federal Register and a comment period was opened in July 2003 and closed in July 2005. Public and avian experts outside of the USFWS have now reviewed the guidance document, but the USFWS has not revised the document based on public comments, new scientific findings, and peer review. Currently, a FACA committee (Federal Advisory Committee Act) is being formed that would oversee the revision of the original 2003 draft guidance document. The role of a FACA committee is to ensure that advice from advisory committees is objective and accessible to the public.

It should be noted that the risk assessment conducted for the Project relied on methods similar to those presented in the USFWS voluntary and interim guidelines, as well as methods, many of which exceed what is requested in that document. For example, the breeding bird census we conducted is not called for by the guidance document. Also, we have reviewed the empirical literature on actual wind turbine impacts, whereas the USFWS approach does not rely on this detailed method of risk assessment. For many years, the standard Phase I Avian Risk Assessment process has incorporated many of the guidelines and recommendations made by USFWS, particularly those that have been shown to be scientifically valid. Therefore, the risk assessment presented above fulfills the intent of the guidance document and follows its recommendations to avoid or minimize impacts to wildlife, specifically birds and their habitats.

For background information, it is our understanding that the USFWS guidance document was written specifically for projects of five turbines and larger. This was made clear by Rob Hazelwood of USFWS, one of the authors of the USFWS guidance document, during a March 2004 meeting between that agency and the American Wind Energy Association. Hazelwood responded to a question about small wind projects stating that small projects, those less than about five turbines were exempt from the Service's guidance document. Thus, it would seem that for the MWCC project, the guidance document is not applicable to the MWCC project. However, this risk assessment does include many of the methods and procedures proscribed by that guidance document.

Specific Conformance to Guidelines

Teaming With Agencies. Letters have been sent to the Massachusetts Division of Fish and Wildlife (MADFW) and to USFWS requesting information on listed species and species of special concern, as well as other bird information. Agency response letters may be found in Appendix D. In addition, an in person meeting was held on site involving one of the authors of this report (Paul Kerlinger), principals from MWCC, Fred Unger from Heartwood Group, Inc., and Vernon Lang of the USFWS. Early coordination with the agency and the MADFW meets the recommendation by USFWS that developers should attempt to team with or involve such

agencies in the site evaluation process. Because this project is using federal funding, there is a federal permitting nexus (NEPA) for the Project with respect to wildlife. If work within wetlands is required for roads or turbine locations, a federal nexus may occur through the U.S. Army Corps of Engineers (USACOE), which often defers to USFWS with respect to wildlife issues.

Reference Sites. The Mount Wachusett Community College Wind Energy Project was compared to other wind power facilities in the United States, including projects in the East and Midwest, as well as projects in the western United States, Canada, and Europe. Selecting a worst-case scenario site for comparison with the Project site was not possible because choosing such sites would necessitate tenuous assumptions about high risk to birds at wind power projects that have not been demonstrated. Selection of a worst-case scenario site at this time cannot be based on biologically documented impacts. None of the other wind power projects in the United States, with the possible exception of the Altamont Pass Wind Resource Area (APWRA) of California, have resulted in biologically significant impacts to birds. In terms of collision risk to birds, on a per turbine or per megawatt basis, comparisons made suggest that risk at the Mount Wachusett site would be, in all likelihood, no greater than at other wind power facilities in the United States.

While it is not possible to compare the Project with a site that could be construed as worst-case scenario, comparisons to the APWRA and sites where risk has been documented to be negligible were made. Clearly, the Project does not have the collision risk factors present in the APWRA (see Table 6.2.2.2-1), although other potential risks are present.. Further comparisons were made to the impacts of communication towers of various sizes, lighting specifications, and construction types (guyed versus unguyed). This type of comparison is particularly important because there is a large body of research on communication towers, including towers in the Eastern and Midwestern U.S.

The potential for biologically significant fatalities at wind power facilities was assessed by comparing numbers of likely fatalities at the Project with the hundred-plus millions of bird fatalities permitted by the USFWS via depredation, hunting, and falconry permits. Some of the species permitted to be harvested have much smaller populations than those killed by wind turbines. In other cases, the harvested species have experienced long-term declines, yet the harvests are not considered to be deleterious (significant) to the populations of these species. This comparison strongly suggests that impacts of wind turbines are not biologically significant. These comparisons are relevant because they provide actual numbers of takings permitted by the USFWS and various state agencies.

With respect to habitat disturbance and displacement of nesting birds, comparisons were made with various sites where such disturbance has been determined to occur. Nonetheless, no significant disturbance or displacement effects are anticipated at the Project site.

Alternate Sites. This report has not considered alternate sites. It should be noted a NEPA review may require addressing an alternatives analysis. The Phase I Avian Risk Assessment did compare potential impacts at the Project site to other wind power projects.

Checklists. Instead of using the PII and checklists supplied in the USFWS guidelines, the Phase I assessment included detailed descriptions of the habitat and topography of the site and surrounding areas. For example, the risk assessment included determination of actual or potential migration pathways and the presence of ecological magnets and/or other attractive habitats located within or adjacent to the Project boundary. This included descriptions of the habitats, wildlife and natural areas, degree of habitat fragmentation, and degree of landscape alteration, by farming and other land use practices, within and around the site that could influence avian impacts potentially resulting from the proposed development.

Regarding other specific guidance and recommendations, in the area of site development, the Phase I Avian Risk Assessment addresses the following issues and concerns:

- Letters of inquiry were sent to USFWS and MADFW requesting records of listed species. In addition, habitat was examined to determine whether listed avian species are likely to nest or use the site.

- The Mount Wachusett site does not appear to be located on a known, specific migration corridor for raptors, songbirds, shorebirds, or waterfowl. In any event, wind turbines have not been shown to have biologically significant impacts on migrating birds. The Phase I assessment explains this.

- Raptor use of the area appears to be relatively low, and topography is moderate throughout much of the turbine area, so setbacks from soaring and updraft locations do not appear to be applicable. Raptor fatalities at wind power projects outside of the 5,400-turbine APWRA have totaled very few birds. Even in the APWRA, mortality does not appear to be biologically significant. It should be noted that none of the turbines at the Mount Wachusett site would be at the edge of steep terrain that could be used for soaring.

- The USFWS recommendation to configure turbines in ways that would avoid potential mortality has not been demonstrated empirically to reduce or prevent impact, because fatality numbers are small to begin with.

- Habitat fragmentation issues have been addressed in this risk assessment.

- Greater Prairie-Chickens are not present at the Mount Wachusett site. Disturbance or displacement effects on them and other grassland nesting species have been addressed in the Phase I assessment.

- Road areas and habitat restoration are addressed in this risk assessment.

- Carrion availability is not applicable at the Project site.

Regarding wind turbine design and operation, many of the USFWS recommendations are either covered in this risk assessment or routinely done at modern wind plants. Some USFWS recommendations, however, are incorrect or not applicable.

- Tubular (unguyed) towers will be used to prevent perching.

- Permanent meteorology towers have been recommended to be free-standing, without guy wires, in the risk assessment. However, no meteorology towers are planned.

- The USFWS recommendation that only white strobes should be used at night to avoid attracting night migrants is only partially correct. That red lights should be avoided is also only partially correct. There is strong evidence (Kerlinger 2004a, 2004b; Gehring et al. 2007, 2008) that, in the absence of steady burning red L-810 lights, red strobe-like Federal Aviation Administration (FAA) lights do not attract birds to wind turbines. Red strobe-like lights (L-864) are likely to be recommended by the FAA for the Mount Wachusett Project. This has been addressed in detail in the text of this risk assessment.

- Adjustment of tower/rotor height is problematic and cannot be addressed in this report. However, the turbines that are proposed are less than 500 feet in height and, therefore, unlikely to cause large-scale fatality events, such as those at tall communication towers. Such turbines have not been documented to cause biologically significant impacts to migrants.

- Underground electric lines and APLIC guidelines have been recommended in the risk assessment. Because all energy generated will be used on site, there will be no need for transmission lines at MWCC.

- Seasonal concentrations of birds are addressed in the risk assessment. The appropriateness of shutting down turbines or other mitigation is dependent on the level of demonstrated impacts, which cannot be determined during the pre-construction phase.

- The USFWS guidance document stipulates that radar or other remote sensing methodologies should be used if large concentrations of night migrants are suspected. A detailed discussion of the geographic and topographic patterns of migration is presented in this Phase I assessment. This discussion provides strong evidence that concentrated migration does not occur at the Project site. Thus, there is no scientific reason to suspect that there will be extraordinary concentrations of night migrants at the Project site. Therefore, radar or other remote sensing is not recommended. The radar issue is explored in detail in this report.

- Post-construction fatality monitoring would provide a means of determining the Project's impact to birds and has been recommended in this risk assessment.

Appendix B. Photographs of representative habitats at the proposed Mount Wachusett Community College Wind Energy Project site, Worcester County, Massachusetts. Upper photo: View of meadow from met tower. Lower photo: View of meadow toward met tower.

Appendix B. Photographs of representative habitats at the proposed Mount Wachusett Community College Wind Energy Project site, Worcester County, Massachusetts. Upper photo: Shrubland bordering pond. Lower photo: Pond with meadow in background.

Appendix C. Birds recorded during site visit on June 3, 4, and 5, 2008. For *WatchList* species, see Section 4.1 discussion. The list includes species nesting on and immediately adjacent to the Project site. Some species nest in the forests and fields that surround the Project. Others may nest miles away and forage onsite. Pr = Probable Nesting; Po = Possible Nesting; Co = Confirmed Nesting; On = Onsite (area within open field, surrounding pond, and along the tree edge surrounding site. Species that are not identified as nesting Onsite are likely to be nesting 200-400 m from the actual site.

Canada Goose – Pr
Mallard – Pr
Double-crested Cormorant
Great Blue Heron
Green Heron
Rock Pigeon
Mourning Dove – Po - On
Chimney Swift
Northern Flicker – Po - On
Willow Flycatcher (*Yellow WatchList*) – Co - On
Eastern Kingbird – Pr – On
Warbling Vireo – Po – On?
Red-eyed Vireo – Pr
Blue Jay – Pr - On
American Crow – Pr
Tree Swallow – Po – On?
Barn Swallow - Po
Black-capped Chickadee - Po
House Wren - Pr
Wood Thrush (*Yellow WatchList*) - Po
American Robin – Co - On
Gray Catbird - Co
Northern Mockingbird – Pr - On
European Starling – Co - On
Cedar Waxwing - Pr
Yellow Warbler – Pr-Co - On
Yellow-rumped Warbler - Po
Pine Warbler - Pr
Black-and-white Warbler - Pr
Ovenbird - Pr
Common Yellowthroat – Co - On
Chipping Sparrow – Co - On
Song Sparrow – Co - On
Northern Cardinal – Co - On
Bobolink – Pr-Co - On
Red-winged Blackbird – Co - On
Common Grackle – Pr - On
Brown-headed Cowbird – Pr-Co - On
Baltimore Oriole - Pr
Purple Finch - Po
House Finch – Pr - On
American Goldfinch – Pr - On
House Sparrow – Pr – On?

43 species

Appendix D. Letters from USFWS and MADFW commenting on the proposed Mount Wachusett Community College Wind Energy Project, Worcester County, Massachusetts.

Appendix E. Average Breeding Bird Frequency on N. Orange BBS Route (47017)

Taxonomic Sort[1]	Avg. birds/hr
Canada Goose	2.44
Wood Duck	1.78
Mallard	0.33
Hooded Merganser	0.11
Ring-necked Pheasant	0.11
Ruffed Grouse	0.22
Wild Turkey	3.33
American Bittern (MA-E)	**0.11**
Great Blue Heron	1.33
Turkey Vulture	0.11
Cooper's Hawk	0.11
Red-shouldered Hawk	0.22
Broad-winged Hawk	0.22
Red-tailed Hawk	0.11
Killdeer	0.44
Rock Pigeon	3.22
Mourning Dove	23.67
Yellow-billed Cuckoo	0.22
Barred Owl	1.00
Chimney Swift	13.33
Ruby-throated Hummingbird	0.78
Belted Kingfisher	0.11
Yellow-bellied Sapsucker	2.89
Downy Woodpecker	3.44
Hairy Woodpecker	2.56
Northern Flicker	1.56
Pileated Woodpecker	0.67
Olive-sided Flycatcher (*Yellow WatchList*)	0.11
Eastern Wood-Pewee	7.78
Alder Flycatcher	1.33
Willow Flycatcher (*Yellow WatchList*)	0.67
Least Flycatcher	2.89
Eastern Phoebe	10.00
Great Crested Flycatcher	2.78
Eastern Kingbird	2.78
Blue-headed Vireo	2.67
Warbling Vireo	0.44
Red-eyed Vireo	51.11
Blue Jay	27.22
American Crow	27.44

Frequency Sort[1]	Avg. birds/hr
Red-eyed Vireo	51.11
American Robin	37.11
Ovenbird	37.00
Black-capped Chickadee	30.56
American Crow	27.44
Blue Jay	27.22
Mourning Dove	23.67
Chipping Sparrow	23.33
European Starling	19.11
Chimney Swift	13.33
Common Yellowthroat	12.78
Scarlet Tanager	11.78
Black-and-white Warbler	11.67
Red-winged Blackbird	11.56
Tufted Titmouse	11.44
American Goldfinch	10.78
Tree Swallow	10.67
Cedar Waxwing	10.22
Eastern Phoebe	10.00
Gray Catbird	10.00
American Redstart	9.56
Wood Thrush (*Yellow WatchList*)	9.22
Chestnut-sided Warbler	8.56
Veery	8.22
Eastern Wood-Pewee	7.78
Myrtle Warbler	7.00
Bobolink	6.78
Song Sparrow	6.67
White-breasted Nuthatch	5.44
Common Grackle	5.33
Brown-headed Cowbird	5.33
Black-throated Green Warbler	4.78
Rose-breasted Grosbeak	4.56
Northern Cardinal	4.33
Pine Warbler	4.22
Baltimore Oriole	4.11
Hermit Thrush	3.89
Barn Swallow	3.78
House Wren	3.78
White-throated Sparrow	3.67

Common Raven	0.67
Tree Swallow	10.67
Barn Swallow	3.78
Black-capped Chickadee	30.56
Tufted Titmouse	11.44
Red-breasted Nuthatch	2.44
White-breasted Nuthatch	5.44
Brown Creeper	1.44
House Wren	3.78
Winter Wren	1.11
Eastern Bluebird	0.22
Veery	8.22
Hermit Thrush	3.89
Wood Thrush (*Yellow WatchList*)	9.22
American Robin	37.11
Gray Catbird	10.00
Northern Mockingbird	0.11
European Starling	19.11
Cedar Waxwing	10.22
Blue-winged Warbler (*Yellow WatchList*)	0.11
Nashville Warbler	1.11
Yellow Warbler	2.89
Chestnut-sided Warbler	8.56
Black-throated Blue Warbler	3.56
Myrtle Warbler	7.00
Black-throated Green Warbler	4.78
Blackburnian Warbler	0.44
Pine Warbler	4.22
Black-and-white Warbler	11.67
American Redstart	9.56
Ovenbird	37.00
Northern Waterthrush	1.33
Louisiana Waterthrush	0.22
Common Yellowthroat	12.78
Canada Warbler (*Yellow WatchList*)	0.22
Scarlet Tanager	11.78
Eastern Towhee	2.11
Chipping Sparrow	23.33
Song Sparrow	6.67
Swamp Sparrow	2.11
White-throated Sparrow	3.67
Dark-eyed Junco	1.11
Northern Cardinal	4.33
Rose-breasted Grosbeak	4.56
Indigo Bunting	0.78

Black-throated Blue Warbler	3.56
Downy Woodpecker	3.44
Wild Turkey	3.33
Rock Pigeon	3.22
Yellow-bellied Sapsucker	2.89
Least Flycatcher	2.89
Yellow Warbler	2.89
Great Crested Flycatcher	2.78
Eastern Kingbird	2.78
Blue-headed Vireo	2.67
Hairy Woodpecker	2.56
Canada Goose	2.44
Red-breasted Nuthatch	2.44
Eastern Towhee	2.11
Swamp Sparrow	2.11
House Finch	2.11
Wood Duck	1.78
Northern Flicker	1.56
Brown Creeper	1.44
Great Blue Heron	1.33
Alder Flycatcher	1.33
Northern Waterthrush	1.33
Purple Finch	1.22
House Sparrow	1.22
Winter Wren	1.11
Nashville Warbler	1.11
Dark-eyed Junco	1.11
Barred Owl	1.00
Ruby-throated Hummingbird	0.78
Indigo Bunting	0.78
Pileated Woodpecker	0.67
Willow Flycatcher (*Yellow WatchList*)	0.67
Common Raven	0.67
Killdeer	0.44
Warbling Vireo	0.44
Blackburnian Warbler	0.44
Mallard	0.33
Evening Grosbeak	0.33
Ruffed Grouse	0.22
Red-shouldered Hawk	0.22
Broad-winged Hawk	0.22
Yellow-billed Cuckoo	0.22
Eastern Bluebird	0.22
Louisiana Waterthrush	0.22
Canada Warbler (*Yellow*	0.22

		WatchList)	
Bobolink	6.78	Hooded Merganser	0.11
Red-winged Blackbird	11.56	Ring-necked Pheasant	0.11
Common Grackle	5.33	**American Bittern (MA-E)**	**0.11**
Brown-headed Cowbird	5.33	Turkey Vulture	0.11
Baltimore Oriole	4.11	Cooper's Hawk	0.11
Purple Finch	1.22	Red-tailed Hawk	0.11
House Finch	2.11	Belted Kingfisher	0.11
American Goldfinch	10.78	Olive-sided Flycatcher (*Yellow WatchList*)	0.11
Evening Grosbeak	0.33	Northern Mockingbird	0.11
House Sparrow	1.22	Blue-winged Warbler (*Yellow WatchList*)	0.11
95 Total Species		**Cumulative Frequency**	**585.7**

[1] Massachusetts listed species are indicated in boldface; see Table 4.1-1. *WatchList* species are indicated as *Red WatchList* or *Yellow WatchList*; see discussion in Section 4.1.

Appendix E. Average Wintering Bird Frequency on Westminster CBC (MAWE)

Taxonomic Sort[1]	Avg. birds/hr
Canada Goose	1.25
Wood Duck	0.00
American Wigeon	0.00
American Black Duck	0.76
Mallard	5.82
Northern Pintail	0.00
Common Goldeneye	0.02
Hooded Merganser	0.10
Common Merganser	0.08
Ring-necked Pheasant	0.04
Ruffed Grouse	0.05
Wild Turkey	0.64
Great Blue Heron	0.00
Sharp-shinned Hawk (MA-SC)	**0.03**
Cooper's Hawk	0.01
Northern Goshawk	0.00
Red-shouldered Hawk	0.00
Red-tailed Hawk	0.16
Rough-legged Hawk	0.00
American Kestrel	0.00
Merlin	0.00
Common Snipe	0.01
Ring-billed Gull	0.50
Herring Gull	12.46
Iceland Gull (*Yellow WatchList*)	0.00
Glaucous Gull	0.01
Great Black-backed Gull	2.76
Rock Pigeon	7.44
Mourning Dove	2.60
Eastern Screech-Owl	0.00
Great Horned Owl	0.02
Barred Owl	0.03
Northern Saw-whet Owl	0.01
Belted Kingfisher	0.02
Red-bellied Woodpecker	0.04
Downy Woodpecker	1.19
Hairy Woodpecker	0.27
Northern Flicker	0.01
Pileated Woodpecker	0.03
Northern Shrike	0.02
Blue Jay	6.45
American Crow	19.63

Frequency Sort[1]	Avg. birds/hr
American Crow	19.63
Black-capped Chickadee	15.30
European Starling	12.94
Herring Gull	12.46
Dark-eyed Junco	7.94
Rock Pigeon	7.44
House Sparrow	7.29
Blue Jay	6.45
Mallard	5.82
Cedar Waxwing	5.64
American Goldfinch	4.31
Great Black-backed Gull	2.76
Mourning Dove	2.60
Tufted Titmouse	2.41
House Finch	1.97
White-breasted Nuthatch	1.96
American Tree Sparrow	1.55
American Robin	1.50
Canada Goose	1.25
Downy Woodpecker	1.19
Northern Cardinal	0.88
American Black Duck	0.76
Wild Turkey	0.64
Common Redpoll	0.57
Ring-billed Gull	0.50
Golden-crowned Kinglet	0.49
Evening Grosbeak	0.49
White-throated Sparrow	0.29
Hairy Woodpecker	0.27
Red-breasted Nuthatch	0.24
Eastern Bluebird	0.22
Red-tailed Hawk	0.16
Northern Mockingbird	0.13
Brown Creeper	0.12
Song Sparrow	0.12
Hooded Merganser	0.10
Common Merganser	0.08
Purple Finch	0.08
Pine Grosbeak	0.07
Pine Siskin	0.07
Ruffed Grouse	0.05
Common Raven	0.05

Common Raven	0.05
Horned Lark	0.02
Black-capped Chickadee	15.30
Tufted Titmouse	2.41
Red-breasted Nuthatch	0.24
White-breasted Nuthatch	1.96
Brown Creeper	0.12
Carolina Wren	0.03
Winter Wren	0.00
Golden-crowned Kinglet	0.49
Ruby-crowned Kinglet	0.00
Eastern Bluebird	0.22
Hermit Thrush	0.01
American Robin	1.50
Gray Catbird	0.00
Northern Mockingbird	0.13
European Starling	12.94
American Pipit	0.00
Cedar Waxwing	5.64
American Tree Sparrow	1.55
Chipping Sparrow	0.00
Fox Sparrow	0.01
Song Sparrow	0.12
Swamp Sparrow	0.00
White-throated Sparrow	0.29
Dark-eyed Junco	7.94
Lapland Longspur	0.00
Snow Bunting	0.02
Northern Cardinal	0.88
Red-winged Blackbird	0.01
Eastern Meadowlark	0.00
Common Grackle	0.00
Brown-headed Cowbird	0.00
Pine Grosbeak	0.07
Purple Finch	0.08
House Finch	1.97
Red Crossbill	0.00
White-winged Crossbill	0.02
Common Redpoll	0.57
Pine Siskin	0.07
American Goldfinch	4.31
Evening Grosbeak	0.49
House Sparrow	7.29
85 Total Species	

Ring-necked Pheasant	0.04
Red-bellied Woodpecker	0.04
Sharp-shinned Hawk (MA-SC)	**0.03**
Barred Owl	0.03
Pileated Woodpecker	0.03
Carolina Wren	0.03
Common Goldeneye	0.02
Great Horned Owl	0.02
Belted Kingfisher	0.02
Northern Shrike	0.02
Horned Lark	0.02
Snow Bunting	0.02
White-winged Crossbill	0.02
Cooper's Hawk	0.01
Common Snipe	0.01
Glaucous Gull	0.01
Northern Saw-whet Owl	0.01
Northern Flicker	0.01
Hermit Thrush	0.01
Fox Sparrow	0.01
Red-winged Blackbird	0.01
Wood Duck	0.00
American Wigeon	0.00
Northern Pintail	0.00
Great Blue Heron	0.00
Northern Goshawk	0.00
Red-shouldered Hawk	0.00
Rough-legged Hawk	0.00
American Kestrel	0.00
Merlin	0.00
Iceland Gull (*Yellow WatchList*)	0.00
Eastern Screech-Owl	0.00
Winter Wren	0.00
Ruby-crowned Kinglet	0.00
Gray Catbird	0.00
American Pipit	0.00
Chipping Sparrow	0.00
Swamp Sparrow	0.00
Lapland Longspur	0.00
Eastern Meadowlark	0.00
Common Grackle	0.00
Brown-headed Cowbird	0.00
Red Crossbill	0.00
Cumulative Frequency	**129.23**

[1] Massachusetts listed species are indicated in boldface; see Table 4.1-1. *WatchList* species are indicated as *Red WatchList* or *Yellow WatchList*; see discussion in Section 4.1.

Appendix G. Annotated Review of Avian Fatality Studies in North America

The numbers of fatalities provided are, in most cases, recorded fatalities. Estimates of fatalities per turbine per year include searcher efficiency and carcass removal rates, thereby accounting for carcasses missed by searchers and carcasses removed by scavengers. Modern turbines ranged between about 58.5 m (192 feet) and about 122 m (400 feet) in height. Older turbines were less than 50 m (164 feet) in height. None of the turbines in these studies had guy wires.

Western States – Prairie and Farmland

- **California** - Altamont Pass Wind Resource Area (APWRA), 5,400 older turbines mostly on lattice towers in grazing and tilled land, many years, large numbers of raptor fatalities (>400 reported) and some other birds; Howell and DiDonato,1991, Howell 1997, Orloff and Flannery 1992, 1996, Kerlinger and Curry 1997, Thelander and Rugge 2000

- **California** – Montezuma Hills, 237 older turbines, 11 modern turbines in tilled farmland, two-plus years of study, 30-plus fatalities found (including 10 raptors, two songbirds, one duck); Howell 1997

- **California** - High Winds, 90 modern turbines in tilled farmland, two year study, 4,220 turbine searches, 163 (183 including incidental finds) fatalities found, 7 raptor species, one-third songbirds, few waterbirds, 2.0-2.9 fatalities per turbine per year; Kerlinger et al. 2006

- **California** - San Gorgonio Pass Wind Resource Area, thousands of older turbines, 120 studied in desert, two year of study, 30 fatalities, nine waterfowl, two raptors, four songbirds, <1 fatality per turbine per year; Anderson et al. 2000

- **California** - Tehachapi Pass Wind Resource Area, thousands of turbines, 100's of mostly older turbines studied, in Mojave Desert mountains (grazing land and scrub), two-plus years of study, 84 fatalities (raptors, mostly songbirds, few waterbirds); Orloff 1992, Anderson et al. 2000

- **Washington** – Nine Canyons, 37 modern turbines, prairie and farmland, one year, 36 fatalities, mostly songbirds, one kestrel, one Short-eared Owl, no diurnal raptors, 3.6 fatalities per turbine per year; Erickson 2003

- **Oregon-Washington** – Stateline Project, 124 of 399 modern turbines in farmland searched, 1.5 years of study, 106 fatalities, seven raptors, 28+ bird species, few waterbirds, 1.7 fatalities per turbine per year, 1.0 night migrant fatality per turbine per year; Erickson et al. 2003

- **Oregon** – Klondike, 16 modern turbines in rangeland and shrub-steppe, one year, eight fatalities, songbirds, including 50% night migrants, plus two Canada Geese, no raptors, 1.3 fatalities per turbine per year; Johnson et al. 2003

- **Oregon** – Vansycle, 38 modern turbines in farm and rangeland, one year, 11 fatalities, seven songbirds, including about four night migrants, and four game birds (no raptors or waterbirds); Erickson et al. 2000

- **Wyoming** – Foote Creek Rim, 69 modern turbines in prairie/rangeland, two years of study, 75 fatalities, songbirds, 48% night migrants, 4 raptors), 1.8 fatalities per turbine per year, 15 additional fatalities were at guyed meteorology towers; Young et al. 2003

- **Colorado** – Ponnequin, 29 (44 in 2001) modern turbines in rangeland, five years of study - 1999-2003, approx. two dozen birds per year, one duck, one American Kestrel fatality; Curry & Kerlinger unpublished data

Midwest - Farmland

- **Kansas** – St. Mary's, 2 modern turbines in grassland prairie adjacent to a coal-fired plant, 2 migration seasons; 33 surveys, 0 fatalities; Young 1999

- **Minnesota** – Buffalo Ridge near Lake Benton, 200+ modern turbines (some older turbines) in farm and grassland, four years of study (1996-1999), 53 fatalities, 2-4 fatalities per turbine per year (mostly songbirds and one Red-tailed Hawk); Johnson et al. 2002

- **Illinois –** Crescent Ridge, 33 modern turbines in farmland, fall and spring migration, 10 fatalities, ~1 fatality per turbine per year; 1,363 turbine searches, mostly night migrants, 1 Red-tailed Hawk; Kerlinger et al. 2007

- **Iowa** – Algona, 3 modern turbines in farmland, 3 migration seasons, zero fatalities; Demastes and Trainer 2000

- **Iowa** – Top of Iowa, 89 modern turbines (26 studied) in tilled farmland, 2 years of study, 7 fatalities, approx. 1 fatality per turbine per year, mostly songbirds, 2 Red-tailed Hawks, no shorebirds or waterfowl; Jain 2005, Koford et al. 2005

- **Wisconsin** – Kewaunee County Peninsula, 31 modern turbines in farmland, 2 years of study (four migration seasons), 25 fatalities, 1.3 fatalities per turbine per year, three waterfowl, 14 songbirds (including some night migrants), no raptors; Howe et al. 2002

- **Wisconsin** – Shirley, 2 modern turbines in farmland, 54 surveys, 1 year study (spring and fall migration seasons), 1 fatality (a night migrating songbird), no raptors or waterbirds; Howe and Atwater 1999

- **Texas** – Buffalo Gap I, 67 turbines (21 studied), one year, 21 avian casualties, including fifteen Turkey Vultures and one Red-tailed Hawk; adjusted mortality rate of 2.37 birds per turbine per year; Tierney 2007

- **Oklahoma** – Blue Canyon II, 84 turbines (50 studied), one year, 15 avian casualties, of which eleven were Turkey Vultures and two Red-tailed Hawks; adjusted mortality rate reported at 0.52 birds per turbine per year; Schnell et al. 2007

Eastern States – Farmland, Forest, and Salt Marsh

- **New York** - Tug Hill Plateau, 2 older turbines in farmland, 2 migration seasons, zero fatalities; Cooper et al. 1995

- **New York –** Maple Ridge Wind Farm (Tug Hill Plateau), 120 modern turbines in farmland adjacent to fragmented forest, June-November (2,244 turbine searches), ~2-9 fatalities per turbine, 80% songbirds, 1 American Kestrel, few waterfowl; Jain et al. 2007

- **New York** – Madison, 7 modern turbines in farmland, 1 year study, 4 fatalities, 2 migrant songbirds, 1 owl, and 1 woodpecker, no diurnal raptors or waterbirds; Kerlinger 2002

- **New Jersey –** Atlantic County Utility Authority, 5 modern turbines in filled marsh adjacent to waterways, July-December 2007, 8 fatalities noted (no extrapolation from searcher efficiency and scavenging), 2 raptors, 2 gulls, 2 night migrating songbirds, and 2 shorebirds; New Jersey Audubon Society 2008

- **Pennsylvania** – Garrett (Somerset County), 8 modern turbines in farm fields, 1 year study, 0 fatalities; Kerlinger 2001

- **Pennsylvania** – Meyersdale (Somerset County), 20 modern turbines on a forested ridge top, more than 20 searches of all turbines from July 30 to September 13, 2004; 13 avian carcasses found of 6 known species – mostly migrant songbirds, no raptors or waterbirds; Arnett et al. 2005

- **West Virginia** – Mountaineer Wind Energy Center, 44 modern turbines on forested ridge, one-year study in 2003 (22 searches of all turbines), 69 fatalities found, ~200-plus total fatalities when corrected for searcher efficiency and scavenging (4+ fatalities per turbine per year; ~3 night migrating songbirds per turbine per year, two Turkey Vultures and one Red-tailed Hawk); Kerns and Kerlinger 2004. In 2004, more than 20 searches from July 31 to September 11 found 15 avian carcasses of 10 known species (Arnett et al. 2005).

- **Vermont** – Searsburg near Green Mountain National Forest, 11 modern turbines on forested mountain top, studied during nesting and fall migration seasons, 0 fatalities; Kerlinger 2002

- **Massachusetts** - Hull, 1 modern turbine, open grassy fields adjacent to school and ferry terminal on island in Boston Harbor, informal searches for at least 1 year on dozens of occasions have revealed no fatalities; Malcolm Brown, personal communication, 2002

- **Tennessee** – Buffalo Mountain, 3 modern turbines on forested/strip-mined mountain, three years, approximately 7 fatalities per turbine per year (night migrating song and other birds) when adjusted for searcher efficiency and scavenger removal (Nicholson 2001, 2002, and

personal communication); studied again in 2005, after 15 taller turbines were added, adjusted mortality rate calculated at 1.8 fatalities per turbine per year (Fiedler et al. 2007), much less than previously.

Canada

- **Ontario** – Pickering Wind Turbine, 1 modern turbine near a marsh, 2 migration seasons, 2 fatalities (night migrating songbirds), probably about 4-5 fatalities per turbine per year; James, unpublished report

- **Ontario** – Exhibition Place, 1 modern turbine in Toronto on lakefront, 2 migration seasons, 2 fatalities, European Starling and American Robin; mortality projected at 3 fatalities per turbine per year; James and Coady 2003

- **Ontario** – Erie Shores Wind Farm, 66 modern turbines in farmland with woodlots, two migration seasons; overall mortality estimated at 2.0 to 2.5 birds/turbine/year, including 0.04 birds/turbine/year for raptors; James 2008

Appendix H. Resume and publication list of Paul Kerlinger, Ph.D. and resume of John Guarnaccia.

PAUL KERLINGER, Ph.D.
Curry & Kerlinger, L.L.C.
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Cape May Point, NJ 08212
(609) 884-2842, fax 884-4569
email: pkerlinger@comcast.net

PROFESSIONAL EXPERIENCE

Environmental Consultant and Principal, Curry & Kerlinger, L.L.C. (also Adjunct Professor, Collaborative Conservation Program, St. Francis University, Ebensburg, PA, 2005)	1994-
Director of Research - New Jersey Audubon Society and Director - Cape May Bird Observatory	1987-1994
Assistant Professor - University of Southern Mississippi	1985-1986
Postdoctoral Fellow - University of Calgary	1983-1985
Assistant Professor - Clemson University, South Carolina	1982-1983

EDUCATION

State University of New York at Albany	Ph.D., Biology	1982
	M.S., Biology	1981
State College of New York at Oneonta	B.A., Biology	1976

PROFESSIONAL AND POPULAR PUBLICATIONS: Outstanding publication record in scientific and popular literature - 50+ papers (published in 4 countries), 5 books, 40+ popular articles, 100s of technical reports. List and samples available upon request.

BOOKS PUBLISHED:

Kerlinger, P. 1989. *Flight Strategies of Migrating Hawks*. University of Chicago Press, Chicago, IL. pp. 374.

Kerlinger, P. 1995. *How Birds Migrate*. Stackpole Press, Harrisburg, PA. pp. 250.

Fowle, M., and P. Kerlinger. 2001. New York City Audubon Society Guide to Finding Birds in the Metropolitan Area. Cornell University Press, Ithaca, NY.

Blanchard, P., and P. Kerlinger. 2001. An Islanded Nature: Natural Area Conservation and Restoration in Western Staten Island including the Harbor Herons Region. Published by: Trust for Public Land and New York City Audubon, New York, NY.

Vezo, T., and P. Kerlinger. 2001. Wings in the Wild, Habits and Habitats of North American Birds. Stackpole Books, Mechanicsburg, PA.

HONORS/DISTINCTIONS: Letters of Commendation - Director of US Fish & Wildlife Service – 1995; Governor of New Jersey – 1996; Expert Witness for State of New Jersey Department of Environmental Protection and US Justice Dept. (Endangered Species and Wetlands) – 1988-1995; Reviewer for National Academies of Science National Research Council - wind power and wildlife report - 2007

MEMBERSHIP: National Wind Coordinating Committee – Wildlife Working Group (since 1996); U. S. Fish and Wildlife Service's Communication Tower Working Group – Research Committee (since 1999)

EXPERIENCE IN WIND POWER AND COMMUNICATION INDUSTRY (1993-2004)

Expertise: Provide expert advice to corporations and nonprofit organizations regarding avian and habitat issues related to windpower and communication tower impacts to birds in North America, Europe, the Caribbean, and Central America

- Design and conduct Avian Risk Assessments at proposed wind power and communication tower sites (initial siting issues and assessment of overall avian risks)
- Design and conduct postconstruction impact studies at wind turbine and communication tower facilities
- Design and conduct avian research prior to, during, and after construction of wind power facilities (monitoring)
- Consult on design of wind plants and communication towers for avian safety
- Provide expertise on reduction of risk at proposed and existing wind power and communication tower facilities
- Provide expertise regarding habitat management at proposed and existing wind power facilities

Serve as a liaison to conservation community and regulatory community for wind power developers
Provide expert testimony for permitting and other processes

** Consulting to nonprofit environmental organizations on wildlife, habitat, and conservation issues and research.

PUBLICATION LIST - BOOKS:

Kerlinger, P. 1989. *Flight Strategies of Migrating Hawks*. The University of Chicago Press. Chicago. 375 pp.

Kerlinger, P. 1995. *How Birds Migrate*. Stackpole Books, Mechanicsburg, PA. pp 240.

Dunne, P.J., R. Kane, and P. Kerlinger. 1990. *New Jersey at the Crossroads of Migration*. New Jersey Audubon Society. Franklin Lakes, NJ, 74 pp.

Fowle, M., and P. Kerlinger. 2001. *The New York City Audubon Society Guide to Finding Birds in the Metropolitan Area.* Cornell University Press.

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Vezo, T., and P. Kerlinger. 2001. Wings in the Wild, Habits and Habitats of North American Birds. Stackpole Books, Mechanicsburg, PA.

JOURNAL ARTICLES, CHAPTERES IN VOLUMES, REVIEW PAPERS – (Peer Reviewed)

Kerlinger, P. 1981. Habitat disturbance and the decline of dominant avian species in pine barrens of the northeastern United States. *American Birds* 35:16-20.

Kerlinger, P. 1980. The migration of Common Loons through eastern New York. *Condor* 84:97-100.

Bingman, V.P., K.P. Able, and P. Kerlinger. 1982. Wind drift, compensation and the use of landmarks by nocturnal bird migrants. *Animal Behaviour* 30:49-53.

Kerlinger, P. and P.H. Lehrer. 1982. Owl recognition and anti-predator behavior of Sharp-shinned Hawks. *Zeitschrift fur Tierpsychologie* 58:163-173.

Kerlinger, P. and P.H. Lehrer. 1982. Anti-predator responses of Sharp-shinned Hawks. *Raptor Research* 16:33-36.

Able, K.P., W. Gergits, V.P. Bingman, and P. Kerlinger. 1982. Field studies of avian nocturnal migratory orientation. II: Experimental manipulation in white-throated sparrows released aloft. *Animal Behaviour* 30:768-777.

Kerlinger, P., J. Cherry, and K. Powers. 1983. Records of migrant hawks from the North Atlantic Ocean. *Auk* 100:488-490.

Kerlinger, P. and S.A. Gauthreaux, Jr. 1984. Flight behaviour of sharp-shinned hawks during migration. I: Over land. *Animal Behaviour* 32:1021-1028.

Kerlinger, P. 1984. Flight behaviour of sharp-shinned hawks during migration. II: Over water. *Animal Behaviour* 32:1029-1034.

Kerlinger, P., V.P. Bingman and K.P. Able. 1985. Comparative flight behaviour of migrating hawks studied with tracking radar during autumn in central New York. *Canadian Journal of Zoology* 63:755-761.

Kerlinger, P. 1985. Water crossing behavior of migrating hawks. *Wilson Bulletin* 97:109-113.

Kerlinger, P. and S.A. Gauthreaux, Jr. 1985. Seasonal timing, geographic distribution, and flight behavior of Broad-winged Hawks during spring migration in south Texas: A radar and visual study. *Auk* 102:735-743.

Kerlinger, P., M.R. Lein, and B.J. Sevick. 1985. Distribution and population fluctuations of wintering Snowy Owls (*Nyctea scandiaca*) in North America. *Canadian Journal of Zoology* 63:1829-1834.

Kerlinger, P. and M.R. Lein. 1986. Differences in winter range among age-sex classes of Snowy Owls (*Nyctea scandiaca*) in North America. *Ornis Scandinavica* 17:1-7.

Moore, F.R. and P. Kerlinger. 1987. Stopover and fat deposition by North American wood-warblers (Parulinae) following spring migration over the Gulf of Mexico. *Oecologia* 74:47-54.

Kerlinger, P. and M.R. Lein. 1988. Causes of mortality, fat condition, and weights of wintering Snowy Owls. *Journal of Field Ornithology* 59:7-12.

Kerlinger, P. and M.R. Lein. 1988. Population ecology of Snowy Owls during winter on the Great Plains of North America. *Condor* 90:866-874.

Kerlinger, P. and F.R. Moore. 1989. Atmospheric structure and avian migration. *Current Ornithology*: 6:109-142. Plenum Press, NY.

Moore, F.R., P. Kerlinger, and T. Simons. 1990. Stopover on a Gulf Coast barrier island by spring Trans-Gulf migrants. *Wilson Bulletin* 102:487-500.

Bednarz, J. and P. Kerlinger. 1990. Monitoring hawk populations by counting migrants. pp. 328-342. *Proceedings of the Northeastern Raptor Symposium*, Rochester, NY. National Wildlife Federation Scientific and Tech. Series No. 13.

Kerlinger, P. and D.S. Wiedner. 1991. The economics of birding at Cape May, New Jersey. pp. 324-334, in *Ecotourism and Resource Conservation*, Vol. 1, J. Kusler, ed.

Russell, R., P. Dunne, C. Sutton, and P. Kerlinger. 1991. A visual study of migrating owls at Cape May Point, NJ. *Condor* 93:55-61.

Moore, F.R. and P. Kerlinger. 1991. Nocturnality, long-distance migration, and ecological barriers. *Proc. XXth Intern. Ornithol. Congr.*, pp. 1121-1129. New Zealand.

Wiedner, D.S., P. Kerlinger, et al. 1992. Visible morning flight of Neotropical landbird migrants at Cape May, New Jersey. *Auk* 109:500-510.

Duffy, K. and P. Kerlinger. 1992. Owl migration at Cape May, New Jersey. *Wilson Bulletin* 104:312-320.

Mabey, S.E., J. McCann, L.J. Niles, C. Bartlett, and P. Kerlinger. 1993. The Neotropical migratory songbird coastal corridor study, final report. A report of the Virginia Council on the Environment to the NOAA. pp. 72. (not peer reviewed)

Mabey, J.M., S.E. Mabey, L.J. Niles, C. Bartlett, and P. Kerlinger. 1993. A regional study of coastal migrtatory bird stopover habitat for Neotropical migrant songbirds: land management implications. Transactions 58th North American Wildlife & Natural Resources Conference, pages 358-407.

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McCann, J.M., S.E. Mabey, L.J. Niles, C. Bartlett, and P. Kerlinger. 1993. A regional study of coastal migratory stopover habitat for neotropical songbirds: land management implications. *Trans. 58th N. Am. Wild. and Nat. Res. Conf.*, pp. Wildl. Manage. Inst., Washington, DC.

Loos, G. and P. Kerlinger. 1994. Road mortality of Saw-whet and Screech Owls in southern New Jersey. *J. Raptor Res.* 27:210-213.

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Kerlinger, P., J. Gehring, and W.P. Erickson. In prep. Federal Aviation Administration obstruction lighting and night migrant fatalities at wind turbines in North America: A review of data from existing studies. Reviewed at **Wilson Bulletin** – now being revised for publication.

Gehring, J., P. Kerlinger, and A. Manville. 2008. Avian collisions and tower lights: The frequency of avian collisions with communication towers is determined by tower lighting systems. In press Ecological Applications (reviewed in 2007).

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1987. *The Migration of Hawks*. by D.S. Heintzelman. in *The Auk*.

1989. *Peregrine Falcon Populations, Their Manage. and Recov*. edited by T.J. Cade *et al*. in *BioScience*.

1991. *Rapaci in Volo*. by Luisella Carretta. in *Wilson Bulletin*.

2006. Hawks from Every Angle, by Jerry Liguori, in *Birding*.

RECENT ABSTRACTS AND PRESENTED PAPERS FOR PROFESSIONAL MEETINGS – Since 2003 (complete list dates to 1979)

Kerlinger, P., and J. Kerns. 2003. FAA lighting of wind turbines and bird collisions. Proceedings of the **National Wind Coordinating Committee** Meeting, November 18, 2003, Washington, DC.

Gehring, J., P. Kerlinger, and A.M. Manville. 2004. Avian collisions with communication towers: a quantification of the associated tower variables.

Kerlinger, P. 2004. Wind turbines and avian risk: lessons from communication towers. Presented at the **American Bird Conservancy-American Wind Energy Association** Meeting, May 18-19, 2004, Washington, DC.

Kerlinger, P. 2004. Attraction of night migrating birds to FAA and other types of lights. **National Wind Coordinating Committee – Wildlife Working Group** Meeting, November 3-4, 2004, Lansdowne, VA.

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Kerlinger, P. 2005. Appalachian ridge following by night migrating birds? A test of the hypothesis using marine surveillance radar in three states. Paper accepted for the joint **Wilson Ornithological Society/Association of Field Ornithologists** Meeting, April 2005, Laurel, MD.

Gehring, J.A., P. Kerlinger, and A. M. Manville, II. 2005. Avian collisions with communication towers: a comparison of tower support systems and tower height categories**. Wilson Ornithological/Association of Field Ornithologists** joint annual meeting, April 2005.

PUBLICATIONS AND REPORTS ON BIRDING ECONOMICS/ECOTOURISM STUDIES AS CONSERVATION TOOLS

The publications that follow represent a unique body of conservation research that has been used by numerous environmental organizations, government agencies, and citizens groups to promote open space conservation. Those noted by an asterisk have been peer reviewed and published in the journal or volume indicated.

*Wiedner, D. S. and P. Kerlinger. 1990. Economics of birding: a national survey of active birders. American Birds 44:209-213.

*Kerlinger, P. and D. S. Wiedner. 1991. The economics of birding at Cape May, New Jersey. In Ecotourism and Resource Conservation, A collection of papers. 2nd International Symposium Ecotourism and Resource Conservation, 1991, Miami, Florida, J. A. Kusler, Jr., ed., vol. 1, pp. 324-334.

Kerlinger, P. and D. S. Wiedner. 1992. Birding economics, or birders mean big bucks. Living Bird 11(1): 8-9

*Wiedner, D.S. and P. Kerlinger. 1992. Economic impact of birding in Cape May, New Jersey. Human Dimensions in Wildlife Newsletter 8(3):23-24.

*Kerlinger, P. 1993a. Birding economics as a tool for conserving Neotropical migrants. Transactions of the 58th N. Amer. Wildlife and Nat. Res. Conf. pp. 438-443. Washington, DC.

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*Eubanks, T., P. Kerlinger, and R. H. Payne. 1993. High Island, Texas: a case study in avitourism. Birding 25:415-420.

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Kerlinger, P., T. Eubanks, and R. H. Payne. 1994. The economic impact of birding ecotourism on the area surrounding the Santa Ana National Wildlife Refuge, Texas. Report to National Fish and Wildlife Foundation and the US Fish and Wildlife Service.

Kerlinger, P. 1994. The economic impact of birding ecotourism on the area surrounding The Nature Conservancy's Ramsey Canyon Preserve, Arizona. Report to National Fish and Wildlife Foundation and The Nature Conservancy.

Kerlinger, P. 1995. The economic implications and demographics of birding ecotourists in Trinidad and Tobago. Report to National Fish and Wildlife Foundation and New England Biolabs Foundation.

Kerlinger, P. 1995. The economic implications and demographics of ecotourists at the Chan Chich Lodge, Belize. Report to National Fish and Wildlife Foundation and the New England Biolabs Foundation.

Kerlinger, P. and J. Brett. 1995. Hawk Mountain Sanctuary: a case study of birder visitation and birding economics. pp. 271-280, in Wildlife and recreation: coexistence through management and research, R. L. Knight and K. J. Gutzwiller, eds. Island Press, Washington, DC.

Kerlinger, P. and T. Eubanks. 1995. Birds and bucks. Birding 27:21-23.

Kerlinger, P. 1995. Birders as ecotourists. Birders World (April):74-76.

Kerlinger, P. and T. Eubanks. 1995. The economic impact of birding ecotourism on the Corkscrew Swamp Sanctuary (National Audubon Society) area, Florida, 1993-1994. Report to National Fish and Wildlife Foundation and National Audubon Society.

Kerlinger, P., T. Eubanks, and R.H. Payne. 1995. The economic impact of birding ecotourism on the Sabal Palm Grove Sanctuary (National Audubon Society) area, Texas, 1994-1995. Report to National Fish and Wildlife Foundation and National Audubon Society.

Kerlinger, P. 1995. Preliminary report on the economic impact of ecotourists on the communities surrounding Mohonk Preserve, New York. Report to the Mohonk Preserve, Inc.

Kerlinger, P. 1995. Paying our fair share, birders should back the Wildlife Diversity Funding Initiative. Living Bird 14(4):8-9.

*Kerlinger, P. 1998. Establishing an economic basis for protecting bird habitat at the local level. eds. R. Bonney, L. Niles, and D. Pashley. 1996 Partners in Flight Workshop volume from Cape May, New Jersey 1995 meeting volume.

PUBLICATIONS - TECHNICAL REPORTS FOR NONPROFIT ORGANIZATIONS

Kane, R., P. Kerlinger, and R. Radis. 1990. Arthur Kill Tributary and Greenway Project: Wildlife and Habitat Inventory. pp. 88. New Jersey Audubon Society, Franklin Lakes, NJ.

Kerlinger, P. and J. Palumbo. 1990. Raccoon Creek Tributaries Greenway Project (1990). pp. 68. New Jersey Audubon Society, Franklin Lakes, NJ.

Kane, R., P. Kerlinger, and K. Anderson. 1992. Delaware Bay and River Tributaries Greenway Project (1991-1992). pp. 112. New Jersey Audubon Society, Franklin Lakes, NJ.

Kane, P. and P. Kerlinger. Raritan Bay Habitat and Wildlife Inventory, 1992-1993. pp. 74. New Jersey Audubon Society, Franklin Lakes, NJ.

(Many others)

PUBLICATIONS - POPULAR LITERATURE/MAGAZINES

Natural History - 1995, 1996 (American Museum of Natural History)
Birders' World - 1994, 1995; 2000-2006 (Birds on the Move – a regular column)
Wild Bird - 1993, 1994, 1995, 1996
Atlantic Coast - 1993
New Jersey Outdoors 1995, 1997
The Conservationist (NYS Dept Envior. Conservation)
Birding (American Birding Association
Kingbird (NY State Federation of Bird Clubs)
New England Bird Observer (Mass Audubon Society)
Peregrine Observer (Cape May Bird Observatory)
Newsletter of the Hawk Migration Assoc. of North America
New Jersey Audubon Magazine
Records of New Jersey Birds (1988-1994)
Bird Watcher's Digest
Cape May Bird Report - 1987 - by David A. Sibley (Kerlinger published this book)
Winging It (ABA Newsletter)
The Living Bird - 1998, 1995, 1992 (Cornell Lab of Ornithology)
The Eyas (Raptor Research Society)

Geographic Extent of Projects and Consulting: Vermont, New Hampshire, Maine, Massachusetts, New York, New Jersey, West Virginia, Ohio, Virginia, Maryland, Pennsylvania, Illinois, Michigan, Iowa, Colorado, Wisconsin, Kansas, Oklahoma, Kentucky, Nevada, Montana, Washington, Texas, New Mexico, California, Newfoundland, Puerto Rico, Mexico, Spain (Andalucia, Galicia)

Companies: Zilkha Renewable Energy, PPM, Horizon, FPL Energy, Invenergy, Illinois Wind Power, Midwest Wind Energy, SeaWest Inc., Kenetech Windpower Inc., Atlantic Renewable Energy Corporation, Green Mountain Energy, Green Mountain Power Corporation, Vermont Deparment of Public Service, Public Service Company of Colorado, Excel, enXco, Distributed Generation Corporation, Cape Winds, US Cellular, Sprint, AT&T Wireless, KRKO Radio, Superior Renewable Energy, US Wind Force, PPM, RES, AES, Cape Wind, Gamesa, Babcock & Brown, Community Energy, etc.

Nonprofit Clients: U. S. Fish and Wildlife Service, Conservation Law Foundation, New York City Audubon Society, New York City Department of Parks and Recreation, Michigan State Police and Attorney General's Office, US DOE - National Renewable Energy Laboratory, Federal Aviation Administration, St. Francis University, Texas Parks and Wildlife, Fermata Inc., Cape May County Municipal Utility Authority, etc.

REFERENCES: A list of references from industry, academia, and, or the nonprofit conservation sector (including agencies) are available upon request