PHASE I AVIAN RISK ASSESSMENT

Groton Wind Project

Grafton County, New Hampshire

Report Prepared for:

Groton Wind, LLC

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Executive Summary

Groton Wind, LLC, proposes a wind-power project for Tenney Mountain in the Town of Groton in Grafton County, New Hampshire. It plans to construct about up to 20 wind turbines, each with a nameplate capacity of 2.0 megawatts (MW), for a total project capacity of about 22 - 20 MW at peak production. The wind turbines would have a hub height of about 78 meters (256 feet) above ground level (agl) and rotor diameters of about 87 m (286 feet). With the rotor tip in the 12 o'clock position, the wind turbines would reach a maximum height of about 120.5 m (398 feet) agl. At the 6 o'clock position, the rotor tip would be about 34.1 m (112 feet) agl. Turbines would be mounted on steel tubular towers and all or a subset of them 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 flashing lights (FAA type L-864) on the nacelle at about 80 m (262 feet) above the ground.

This report details a Phase I Avian Risk Assessment conducted for the Groton Wind 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.

Tenney Mountain rises to nearly 2,350 feet (715 m), but the wind farm area is on the northern part of the ridge below the summit. This ridgeline section is relatively short, measuring nearly 2.0 miles (3.2 km) , and ranges in elevation from about 1,900 to 2,137 feet (580 to 652 m). The Tenney Mountain Ski Area is located less than 0.5 miles (0.8 km) southeast of the wind farm area on Tenney Mountain. Groton Wind may expand the Project to adjacent Fletcher Mountain. Fletcher Mountain rises to 2,100 feet (640 m), but the area proposed for turbines is a 1.4-mile (2.2-km) ridgeline section below the summit to the north. This short ridgeline ranges between 1,850 and 2,070 feet (565 and 630 m) in elevation.

Land use on in the Project area is forestry and recreation (hunting). The mountain's lower slope forests on the western (Groton Hollow) side of the ridge are intensively harvested. The ridge has also been harvested, but there were no signs of recent activity except at the meteorological tower. Along the jeep trail to the summit, American beech, sugar maple, and yellow birch were the dominant tree species. On the ridge top, however, sugar maple was largely replaced by red maple. Deciduous woodland along the ridge ranged from dense, shrub-like patches to fairly mature woodland, with some fairly large yellow birch. The crowns of many of the larger trees showed evidence of ice storm damage. Where soils were thinner, where there were ledges, or where the ridge dropped off steeply, red spruce dominated, but its distribution was patchy, with no extensive spruce stands on the ridge). In these conifer patches, balsam fir and paper birch were mixed in, giving these patches a boreal forest-like appearance. Scattered red spruce was also evident in the understory of the deciduous woodland, with a few trees reaching the canopy.

Based on the site visit's evaluation of habitat and on Breeding Bird Atlas (BBA) and Breeding Bird Survey (BBS) data, the Groton Wind Project site has a diverse forest-interior breeding bird community. The site visit found Black-throated Blue Warbler and Ovenbird to be the most numerous species in deciduous woodland along the ridge. Blackburnian Warbler and Golden-crowned Kinglet were the signature species in spruce patches.

Among special-status species, the Peregrine Falcon, listed as endangered in New Hampshire, nests on ledges on Rattlesnake Mountain across the Baker River valley about 5.6 miles (~9km) from where turbines would be on the Tenney Mountain portion of the Project site. Cooper's Hawk, listed as threatened in New Hampshire, may nest in low densities on the slopes of Fletcher and Tenney Mountains. The threatened Common Nighthawk has been sparingly recorded in central New Hampshire; therefore, it is also unlikely to frequent the high elevation airspace at the Project site.

The *Yellow WatchList*[1] Wood Thrush was found to nest on the lower slopes of Tenney Mountain, but does not nest on the upper slopes, where it is replaced by Hermit Thrush. Based on habitat requirements Canada Warbler, a *Yellow WatchList* species, may occur below the ridgetop. The status of Olive-sided Flycatcher is uncertain, but it is probably an uncommon to rare breeder on the mountain. The *Red WatchList* Bicknell's Thrush does not breed on either Fletcher or Tenney Mountains as these mountain do not support high-elevation spruce/fir forests that are large enough in area for this species.

Regarding migration, there are no ecological magnets or barriers that would attract or concentrate migrating birds in large numbers at the Project site or nearby. For nocturnal-migrant songbirds, raptors, and waterbirds, migration will be broad front in nature and generally at altitudes above the sweep of the wind turbine rotors. It is unlikely that nocturnal songbird migrants would concentrate in fallout-type events on the Tenney Mountain ridge as there is abundant woodland habitat for these birds throughout the region.

Christmas Bird Count (CBC) data indicate that the Project site will have very few birds in winter, when wind exposure, cold temperatures, and abundant snow severely limit foraging opportunities.

The Groton Wind Project site does not overlap an Important Bird Area (IBA), and it lacks large, high-elevation conifer forest. However, its Northern Hardwood forest hosts a diverse community of forest-interior birds, many of which are Neotropical migratory species. This forest type is abundantly distributed in central New Hampshire, and the example of it on Tenney Mountain is not of high quality, given its history of timber harvest. Overall, the Project site is not discrete and distinguishable in character, habitat, or ornithological importance from surrounding areas in this part of New England.

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[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.

The construction of a wind farm on Tenney Mountain will have an impact on the site's forest-interior bird community, but it is expected that this effect will be small and limited mostly to the ridgeline. Nevertheless, the long-term maintenance of the forest-interior bird community probably depends most on how the forest is managed in the future for timber harvest regardless of a potential wind facility. In this regard, population levels of forest-interior birds could be monitored after turbine construction as a measure of forest ecosystem health.
Regarding New Hampshire endangered, threatened, and special-concern species, it appears unlikely that any nest in the vicinity of wind turbines and none are at risk of displacement. Regarding *WatchList* species, as noted above, the *Red WatchList* Bicknell's Thrush is unlikely to occur. Among *Yellow WatchList* birds, Wood Thrush is known to occur on the lower slopes of Tenney Mountain, but not at higher elevations near the summit. Canada Warbler, another Yellow WatchList species is unlikely to nest at turbine locations, but could nest nearby in small clearings in the forest. In addition, Prairie Warbler (Yellow WatchList) might be attracted to the early successional habitats resulting from construction, especially along the power-line connection to the electricity grid.

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 recent review of the literature on U.S. wind farms, mortality estimates were similar among projects, averaging 2.51 birds per turbine per year. Rates have been somewhat greater in the eastern U.S. than in the west, most likely because of denser nocturnal migration of songbirds in eastern North America. No federally listed endangered or threatened species have been recorded on the fatality lists at wind plants, 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 the species involved.

Fatality numbers and species impacted at the Groton Wind 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. Collision risk factors for raptors are minimal, as is risk to nesting and wintering birds. Collision risk to night-migrating songbirds is likely to be similar to other sites examined.

The following recommendations have been formulated to minimize avian risk:

Construction Guidelines

- Electrical lines within the project site should be underground between the turbines. Any new above-ground lines from the site and substations to transmission lines should follow Avian Power Line Interaction Committee (APLIC) guidelines for insulation and spacing.

- Permanent meteorological towers should be free-standing (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 be permitted or encouraged to regenerate as close to the turbines and roads as possible to minimize habitat fragmentation and disturbance/displacement impacts. To accomplish this, topsoil should be replaced, where removed, as a part of soil restoration as a means of encouraging good plant growth. Trees should be permitted to grow within cleared areas around turbines to the extent commercially practicable.

- 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 of study being contingent upon 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 rare species are involved, a second year of study should be undertaken. The design of the post-construction protocol should follow best practices now being used and refined at existing wind-power sites and approved by various government agencies.

- A study of displacement of nesting birds at turbine sites may be undertaken as a means of determining impacts to forest interior nesting species resulting from clearing forest for turbines and the presence of large infrastructure within the forest.

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Figure 1. Project Location in New Hampshire.

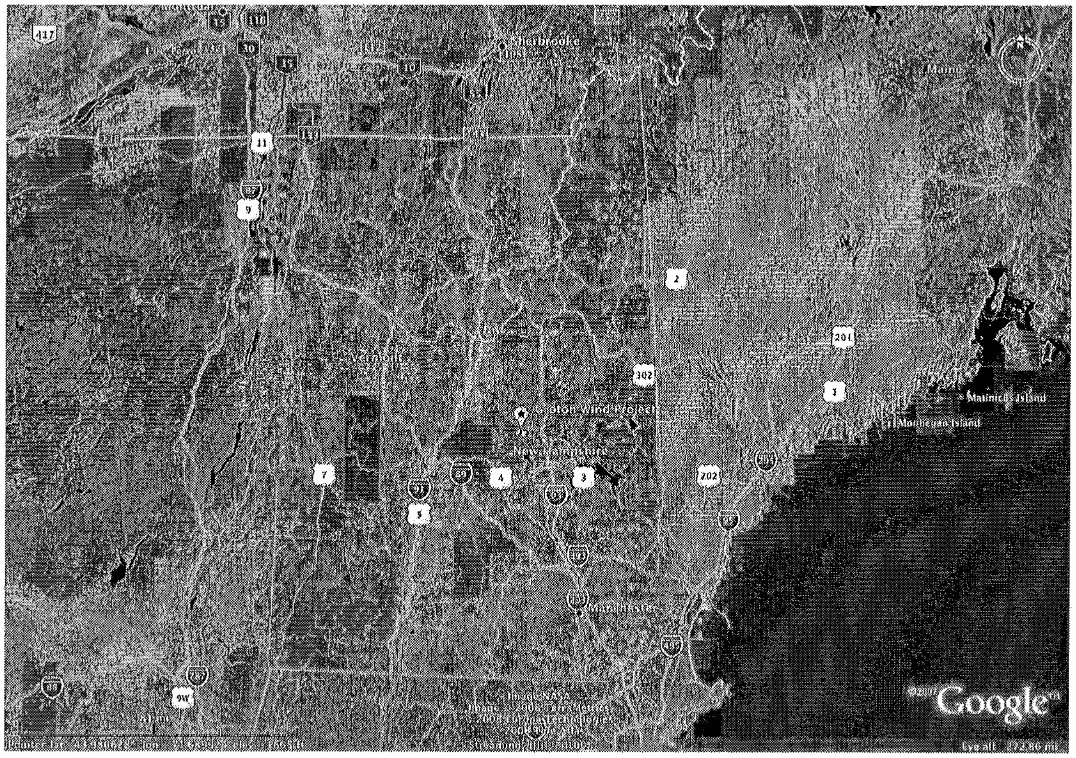


Figure 2. Project Location in Grafton County, New Hampshire.

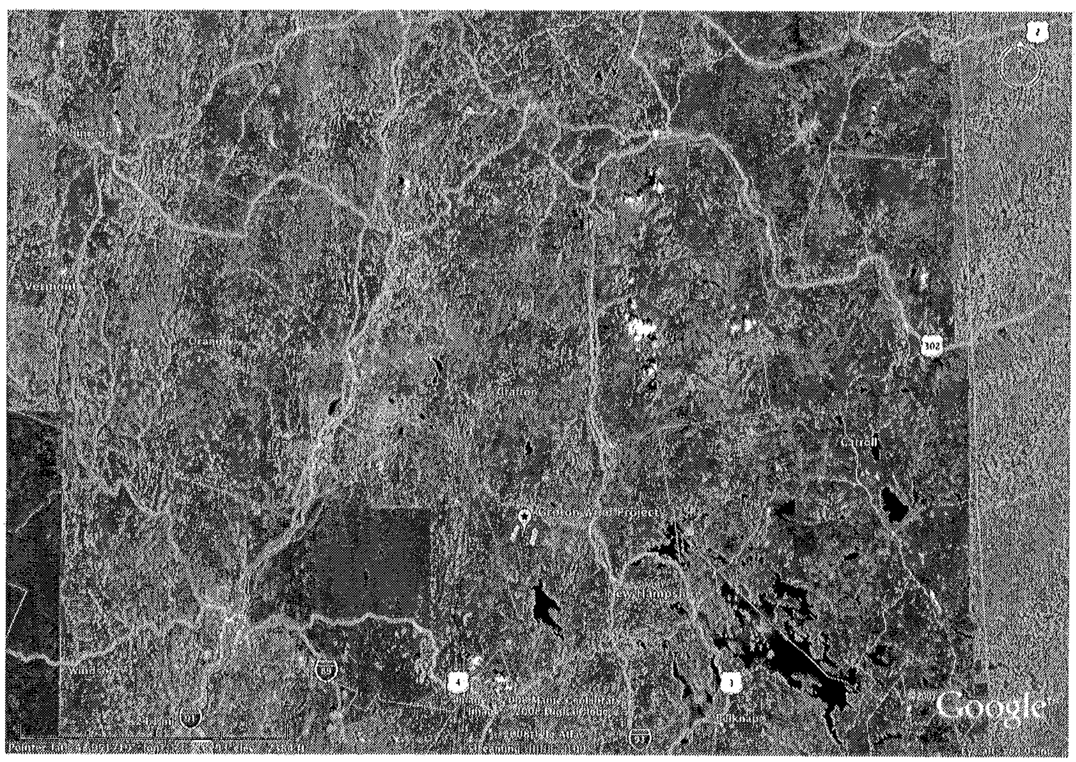


Figure 3. Satellite View of Project Site (boundary approximate), Grafton County, New Hampshire. Tenney Mountain, the focus of this report, is the polygon on the right. According to the developer, the Project may be expanded to adjacent Fletcher Mountain (polygon on the left). Note nesting site for Peregrine Falcon across the Baker River valley.

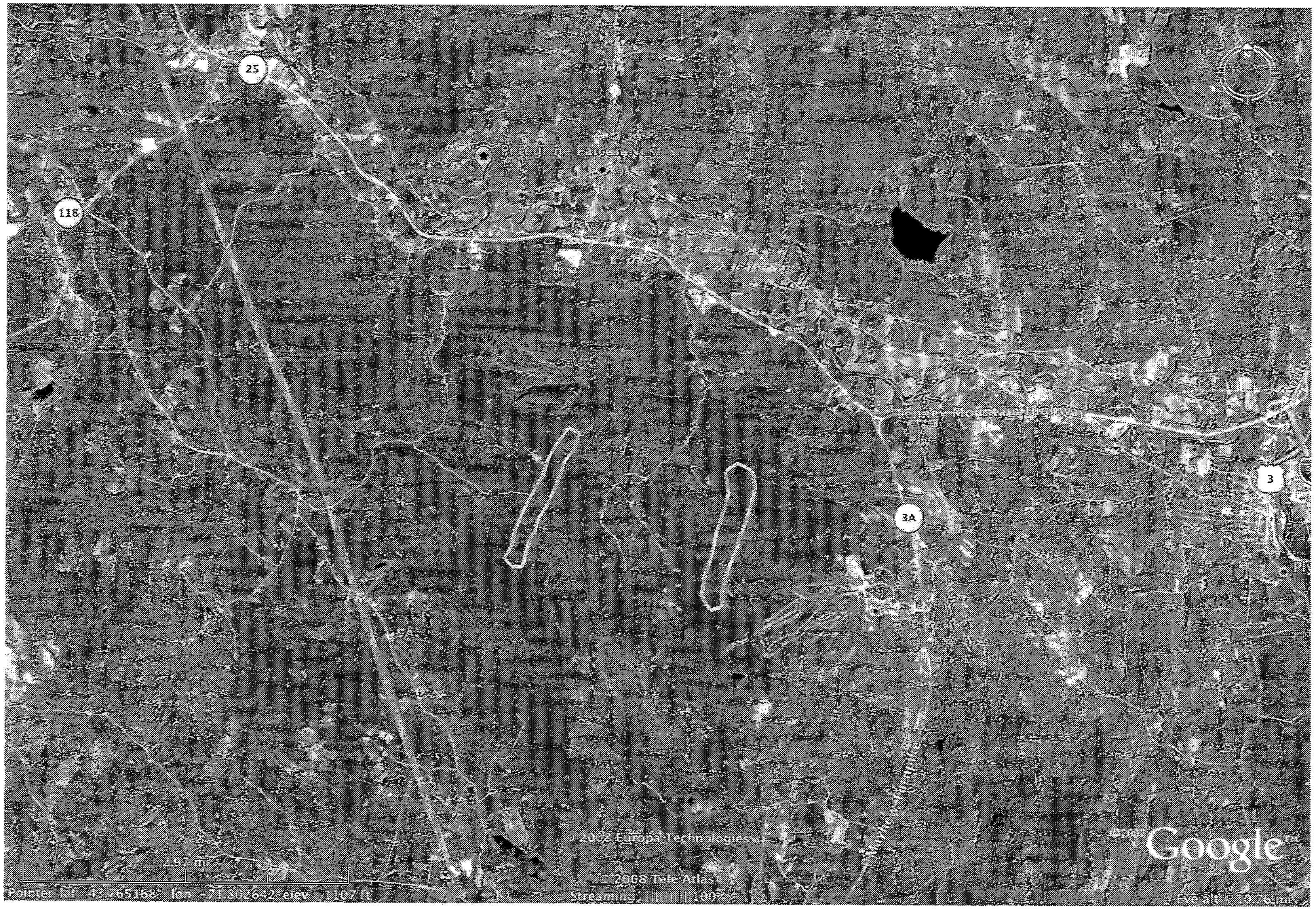
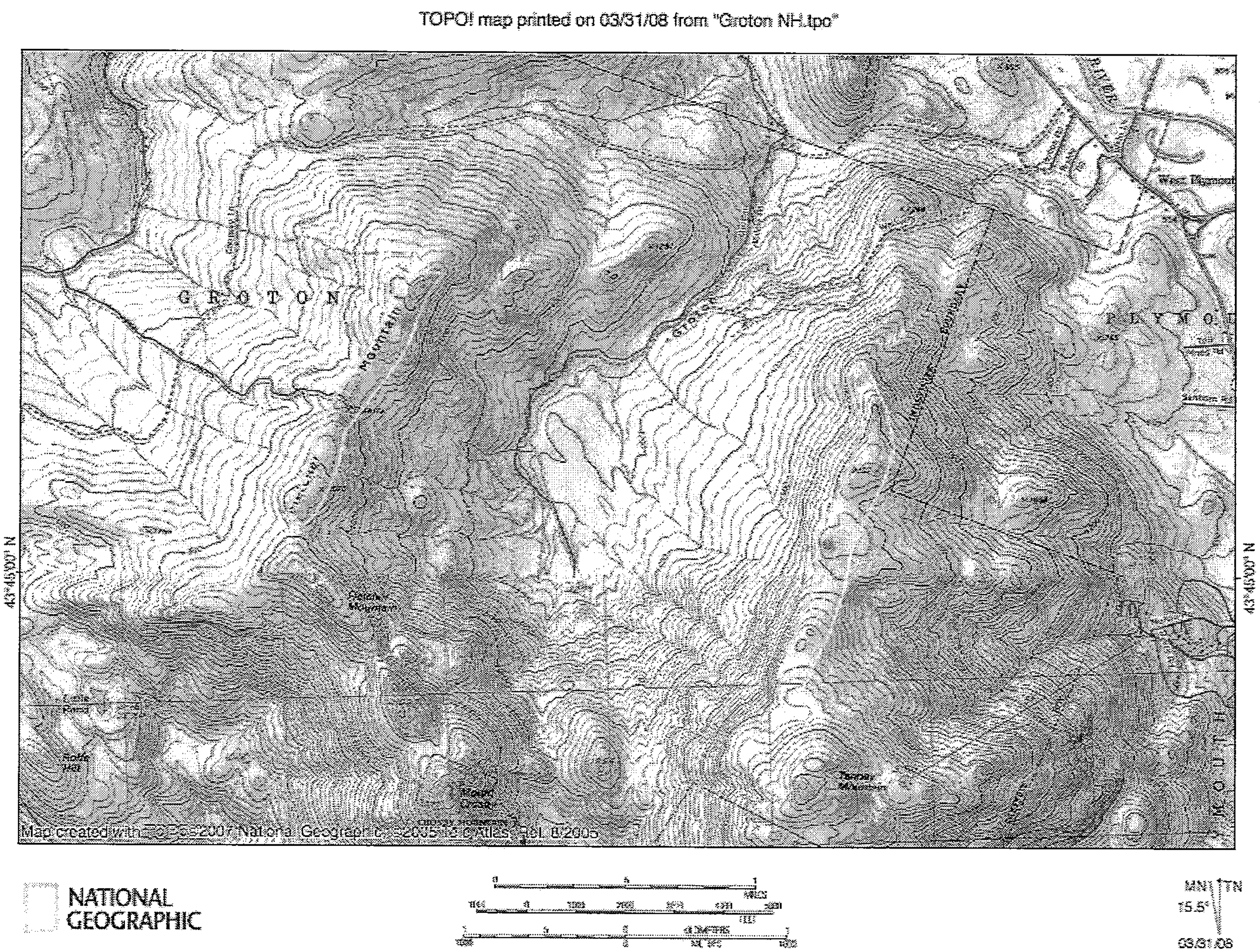


Figure 4. Topographic Map View of Project Site (boundary approximate). See note in Figure 3 about Tenney and Fletcher Mountains.



1.0 Introduction

Groton Wind, LLC, proposes a wind-power project for Tenney Mountain in the Town of Groton in Grafton County, New Hampshire. Its plans to construct about 11 to 13 wind turbines, each with a nameplate capacity of 2.0 megawatts (MW), for a total project capacity of about 22 to 26 MW at peak production. This report details a Phase I Avian Risk Assessment conducted for the Groton Wind 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 displacement by construction activities 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 (FWS) 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 to 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 habitats and landscape features 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 potential for risk to those birds assessed.

Avian literature and databases examined include records of the FWS and the New Hampshire Fish and Game Department (NHFGD), as well the New Hampshire Breeding Bird Atlas (BBA; 1981-1986), 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 important part of the literature search focuses on the empirical findings of studies that have determined empirical impacts to birds at wind power facilities.

Consultations are conducted via letter with wildlife agency biologists – in this case, NHFGD and FWS – 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: (i) summarizes known and likely bird use of the Project site's habitats, (ii) compares the Project site with wind-energy projects where risk has been determined empirically (with special consideration given to wind-power projects in the Eastern U.S.), (iii) determines the potential risks birds may face from the construction and operation of wind turbines at the site, and (iv) provides recommendations for further studies and mitigation, if indicated. Such recommendations and mitigation are provided in an effort to prevent and minimize risk to birds resulting from construction of the wind plant.

2.0 Project and Site Description

2.1 Project Description

The Groton Wind Project is proposed for one (perhaps two) short ridgeline site in west-central New Hampshire (see Figure 1), about 40 miles (64 km) north-northwest of Concord and about 4.5 miles (7.2 km) west of Plymouth. The Project would be located in the Town of Groton in southern Grafton County (see Figure 2).

Groton Wind, LLC, the Project proponent, proposes to construct wind turbines on Tenney Mountain. It may expand the Project to adjacent Fletcher Mountain. On Tenney Mountain, about 11 to 13 wind turbines would be constructed, each with a nameplate capacity of about 2.0 MW, for a total Project capacity of about 22 to 26 MW. A similar number of turbines may be constructed on Fletcher Mountain, if that area were to be included. The hub height of the wind turbines would be about 78 meters (256 feet) above ground level (agl) and have rotors with diameters of 87 m (286 feet). With the rotor tip in the 12 o'clock position, the wind turbines would reach a maximum height of about 121.5 m (399 feet) agl. At the 6 o'clock position, the rotor tip would be about 34.1 m (112 feet) agl.

Turbines would be mounted on steel tubular towers and all or a subset of them 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, flashing red LED's (FAA type L-864) on the nacelle at about 80 m (262 feet) above the ground. An electric substation for the purpose of connecting the Project to the electric power grid might be constructed somewhere on the Project site, if an existing substation is not suitable. .

2.2 Site Description

The New Hampshire Atlas & Gazetteer (DeLorme 2005), satellite imagery viewable through Google Earth Pro, USGS topographic maps viewable through National Geographic's TOPO! mapping software, and various literature sources and Internet sites were consulted in order to understand the Project site's topography, physiography, and habitat. This information was checked during a site visit conducted by an avian researcher on May 27 and 28, 2008.

The Groton Wind Project site is located at the northern end of the Southwestern Highlands physiographic region of New Hampshire. Hunt et al. (2004) describe this region as a mostly forested area between the Connecticut and Pemigewasset-Merrimack River Valleys. It begins at the Massachusetts border and ends just above the Project site at the Baker River valley. The White Mountains begin on the other side of the Baker River.

Richards (in Foss 1994) states that most of the Southwestern Highlands region is above 1,000 feet (305 m), much above 1,500 feet (460 m), with seven different peaks above 2,500 feet (760 m). Northern hardwoods (beech, sugar maple, and yellow birch) are the dominant vegetation type, but spruce grows on the higher elevations and in moist areas lower down. The bird fauna of the Southwestern Highlands is similar to that of southern New Hampshire, but more northerly species occur in the higher terrain areas. Examples are Yellow-bellied Flycatcher, Bicknell's Thrush, and Blackpoll Warbler.

Based on topographic maps and satellite images, the Project site is heavily forested. The only significant expanse of open land is found in the Baker River valley about 1.5 miles (2.4 km) to the north. The largest nearby water body is Newfound Lake, located about 3 miles (4.8 km) south of Tenney Mountain.

Tenney Mountain rises to nearly 2,350 feet (715 m), but the wind farm Project area is on the northern part of the ridge below the summit. This ridgeline section measures nearly 2 miles (3.2 km) and ranges in elevation from about 1,900 to 2,137 feet (580 to 652 m). The Tenney Mountain Ski Area is located less than 0.5 miles (0.8 km) southeast of the wind farm area on Tenney Mountain.

Fletcher Mountain rises to 2,100 feet (640 m), but the area proposed for turbines is a 1.4-mile (2.2-km) ridgeline section below the summit to the north. This ridgeline ranges between 1,850 and 2,070 feet (565 and 630 m) in elevation.

3.0 Results of Site Visit

An experienced field ornithologist visited Tenney Mountain on May 27 and 28, 2007. On both days, winds were fairly strong out of the west and northwest. Temperatures were judged to be seasonable on May 27 under partly cloudy skies, but the morning of May 28 was colder under clear skies, cold enough that there were no swarms of black flies.

The field researcher was able to drive from Route 25 up Groton Hollow Road to a parking area at about 1,350 feet (410 m) in elevation on the middle slope of Tenney Mountain. From the parking area, he hiked about one mile (1.6 km) up a logging trail to the ridgeline, ascending about 750 feet (230 m). This trail led to a wind-measuring (meteorology) tower (coordinates 43.74530, -71.79036).

Except at the meteorology tower, there were no trails along the ridge, but very faint signs of old logging roads were noticed in places. On two mornings, the ridge was walked from the communication tower above the ski area (43.73923, -71.79005) to the northern end of the ridgeline where it begins to descend steeply (at 43.76252, -71.78630). The straight-line distance between these points is 1.6 miles (2.6 km).

Photographs of Tenney Mountain and its habitats may be found in Appendix B. Land use at the Project site is forestry and recreation. The lower slopes of Tenney Mountain on the Groton Hollow side of the ridge are intensively harvested for timber. The ridge has also been harvested, but there were no signs of recent activity except at the meteorology tower.

Along the jeep trail up to the summit, American beech, sugar maple, and yellow birch were the dominant tree species. Up on the ridge, however, sugar maple was largely replaced by red maple. Deciduous woodland along the ridge ranged from dense, shrub-like patches to fairly mature woodland, with some fairly large yellow birch. The crowns of many of the larger trees showed evidence of ice storm damage. Judging from scat, moose make significant use of the ridge to feed on an abundant growth of striped maple and viburnum. Where soils were thinner, where there was ledge, or where the ridge dropped off steeply, red spruce dominated, but its distribution was best described as patchy (i.e., there were no extensive spruce stands on the ridge). In these conifer patches, balsam fir and paper birch were present. Scattered red spruce was also evident in the understory of the deciduous woodland, with a few trees reaching the canopy.

Regarding birdlife, song activity was judged to be low to moderate. The colder temperatures and fairly strong winds may have dampened song activity, but studies at the nearby Hubbard Brook Experimental Forest, about 10 miles (16 km) north of the Project site, show an overall decline in regional songbird populations (see http://www.hubbardbrook.org/research/animals/bird/holmes-intro03.htm). Nevertheless, 52 bird species were recorded on Tenney Mountain, with 32 of these species found along the ridge or heard calling from below the ridge crest. Black-throated Blue Warbler and Ovenbird were the most frequently encountered species in the deciduous woodland along the ridge. Blackburnian Warbler and Golden-crowned Kinglet were confined to spruce patches.

The only thrush heard calling along the ridge was Hermit Thrush. Tenney Mountain's high elevation and habitat are not appropriate for Bicknell's Thrush (*Red WatchList*) or even for Swainson's Thrush. Wood Thrush (*Yellow WatchList*) and Veery were heard on the lower slopes of Tenney Mountain. It appears unlikely that either would breed along the ridgetop.

Despite strong winds, little soaring activitiy was noted at Tenney Mountain either from the ridgeline or from scanning the ridge from a distance. Only one Red-tailed Hawk, one Turkey Vulture, and a small flock of Chimney Swifts were noted.

No New Hampshire-listed species was recorded on Tenney Mountain. The researcher also visited Rattlesnake Mountain where Peregrine Falcons (NH endangered) have nested for nearly 20 years, but did not see the birds. With regard to the Tenney Mountain Project, biologists from WoodLot Alternatives, Inc., investigated Peregrine Falcon nesting during summer 2006 (see letter of November 16, 2006, from Woodlot Alternatives to Wind Works, LLC). They observed falcon activity from a vantage point above the nest for seven hours a day on four days (June 23, July 18, July 19, and September 12, 2006). By mapping the birds' locations, they found their activity to be concentrated over the Baker River valley and not extending to the ridges of Fletcher or Tenney Mountains. This makes sense because Peregrines hunt birds from the air. Hunting opportunities would be concentrated over the Baker River valley with its rich mosaic of wetland, agricultural, and woodland habitats and more abundant bird life, not over the mountain slopes. Nonetheless, it is conceivable that Peregrines could infrequently visit the mountain ridges to soar in updrafts.

A reconnaissance of the Baker River valley did not reveal the New Hampshire endangered Bald Eagle, Northern Harrier, or Upland Sandpiper. The New Hampshire threatened Cooper's Hawk was not encountered on Tenney Mountain or elsewhere.

The only special-status species recorded was Wood Thrush, which is listed on the *Yellow WatchList* (discussed below). One bird was heard singing on the lower slopes of Tenney Mountain. It is not likely to breed on the ridge, where it appears to be replaced by Hermit Thrush.

Fletcher Mountain was not visited, but a habitat assessment conducted from a distance with binoculars indicated that its habitat mix was very similar to that of Tenney Mountain. Given that both mountains have similar elevations and are in close proximity, it is likely that the bird life of Fletcher Mountain is very similar to that found on Tenney Mountain.

4.0 Avian Overview of the Groton Wind Project Site

The North American Landbird Conservation Plan (Rich et al. 2004) locates the Groton Wind Project site in the Atlantic Northern Forest (Bird Conservation Region # 14) of the Northern Forest Avifaunal Biome, a region covering much of northern North America.

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 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 Southwest Highlands of New Hampshire, 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 Groton Wind Project site follows.

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

Species	NH (Federal) Status[1]	Recorded Site Visit?	Recorded BBA Block?[2]	Recorded BBS Route?[3]	Habitat Suitability at Site?[4]
Endangered/Threatened[5]					
Common Loon	T				NS
Pied-billed Grebe	E		+	+	NS
Osprey	T				NS
Bald Eagle	E				NS
Northern Harrier	E			+	NS
Cooper's Hawk	T		+		S
Golden Eagle	E				NS
Peregrine Falcon	E				NS
Piping Plover (*Red WatchList*)	E (E)				NS
Upland Sandpiper	E		+		NS
Roseate Tern (*Yellow WatchList*)	E (E)				NS
Common Tern	E				NS
Arctic Tern	T				NS
Least Tern (*Red WatchList*)	E				NS
Common Nighthawk	T		+	+	NS
Three-toed Woodpecker	T				NS
Purple Martin	E				NS
Sedge Wren	E				NS
Grasshopper Sparrow	T		+		NS

[1] E = Endangered, T = Threatened

[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, and ? = uncertainty in evaluation.

[5] From http://www.wildlife.state.nh.us/Wildlife/Nongame/endangered_list.htm (accessed 3/31/08). *WatchList* species are designated as *Red WatchList* or *Yellow WatchList* (see Section 4.1 discussion)

4.1 Breeding Birds

Table 4.1-1 (above) summarizes the NHFGD and FWS 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, Table 4.1-1 also grades the suitability of habitat for nesting on the Project site as suitable (S), marginally suitable (MS), or not suitable (NS). 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 and Least Tern on the New Hampshire list) and 2) *Yellow WatchList: Declining or Rare Species* (119 species, including Roseate Tern on the New Hampshire list).

Some *Watchlist* species not listed in Table 4.1-1 may also occur at the Project site. An example from the site visit was Wood Thrush (*Yellow WatchList*). The occurrence of *WatchList* species will be highlighted in the various data sources checked below.

FWS and NHFGD responses to our written inquiries about records of listed species in the Project vicinity would be in Appendix D and summarized here. Based on past agency consultations related to Eastern U.S. wind power projects, the extensive information and data sources checked for this report address most concerns of the wildlife agencies.

In the following sections, two data sources will be examined to determine the likely breeding bird community in and around the Groton Wind Project site. One is the New Hampshire Breeding Bird Atlas (BBA, 1981-1986), because its coverage partially overlapped the Project site. It will be checked for the occurrence of special-status species. The other source was the last ten years of available data from a nearby route of the Breeding Bird Surveys (BBS) of the U.S. Geological Survey (USGS). This route will be analyzed in detail to profile the breeding bird community.

If New Hampshire endangered or threatened species, or *WatchList* species, are indicated in these analyses, they were noted and discussed.

4.1.1 Breeding Bird Atlas (BBA) Analysis

A Breeding Bird Atlas (BBA) is a comprehensive survey that reveals the distribution of a region's breeding birds. New Hampshire conducted a BBA in 1981-86, the results of which were reported in 1994 publication, *Atlas of Breeding Birds in New Hampshire,* edited by Carol R. Foss.

The BBA project divided the entire state into over 1,000 Atlas blocks, each of which was one-sixth of a standard USGS 7.5-minute series topographic map. Each Atlas block measured 2.9 miles (4.6 km) north to south and approximately 3.2 miles (5.1 km) east to west, for an area of about 9.3 mi^2 (23.5 km^2). Because the state lacked the manpower to survey all Atlas blocks, 178 were selected randomly as priority blocks, and all of those were surveyed. In addition, 14 special areas were additionally surveyed because they contained habitats that were not well represented in the priority blocks. No special area overlapped or surrounded the Project site. If rare, endangered, or secretive species were recorded outside the priority blocks and special areas (i.e., in non-priority blocks), that data was accepted as well. The bird distributions resulting from this process were then mapped and published (see Foss 1994).

Blocks were assigned to volunteer birdwatchers, who, guided by detailed topographic maps, visited the various habitats within their blocks to record breeding evidence of the birds they saw. Evidence of breeding was graded as *Possible* (i.e., a species was simply observed in possible nesting habitat), *Probable* (i.e., a species exhibited certain behaviors that indicated breeding, such as territoriality, courtship and display, or nest building), or *Confirmed* (i.e., a species was observed nesting or engaged in behaviors associated with nesting, such as distraction display, carrying a fecal sac, carrying food for young, feeding young, etc.).

One priority block (7446) overlapped the northern half of the Tenney Mountain Project site. This report has checked it and the six priority blocks surrounding it (7513, 7525, 8514, 8432, 8411, and 7424) for the presence of special-status species. Records in adjacent non-priority blocks were also counted. Results are reported in Table 4.1.1-1. Species totals in these blocks ranged from 76 to 99 species, with 99 species recorded in the overlapping block. These totals indicate relatively high levels of effort in surveying the blocks.

Table 4.1.1-1. Special-Status Species Records in 1981-1986 New Hampshire BBA

Block	**Special-Status Species**[1]	**Breeding Status**
Overlapping	**Upland Sandpiper (NH-E)**	**Possible**
	Red-headed Woodpecker (*Yellow WatchList*)	Confirmed
	Wood Thrush (*Yellow WatchList*)	Confirmed
	Canada Warbler (*Yellow WatchList*)	Probable
Surrounding	**Pied-billed Grebe (NH-E)**	**Possible**
	Cooper's Hawk (NH-T)	**Confirmed**
	Common Nighthawk (NH-T)	**Probable**
	Olive-sided Flycatcher (*Yellow WatchList*)	Confirmed
	Willow Flycatcher (*Yellow WatchList*)	Possible
	Wood Thrush (*Yellow WatchList*)	Confirmed
	Prairie Warbler (*Yellow WatchList*)	Confirmed
	Canada Warbler (*Yellow WatchList*)	Probable
	Grasshopper Sparrow (NH-T)	**Probable**

[1] New Hampshire 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.

As noted in Table 4.1.1-1, one New Hampshire endangered species was found as a possible nester within the same block as the Project. That species is an obligate grassland nesting species

so will not be found within a mile of the turbine locations. The other four New Hampshire listed species were recorded in surrounding blocks. Grasshopper Sparrow, listed as threatened in New Hampshire, is an obligate grassland nesting species and will not be found at or near the turbines. Pied-billed Grebe, a New Hampshire endangered species, nests at the edges of open water in emergent vegetation. This species will not be found at the Project site or within a mile of the site. Common Nighthawk, New Hampshire threatened, requires grassland and savannah habitats, although it sometimes nests on the roofs of buildings. Thus, it will not be found close to the turbine sites. Finally, a New Hampshire threatened species, nests in forests, primarily at low elevations. It is highly improbable that this raptor will nest on the Project site.
There were also records of six *Yellow WatchList* species. Of them, only three are woodland species. Wood Thrush (recorded in 7 of 7 priority blocks) and Canada Warbler (6 of 7) appeared to be common based on the number of priority blocks in which they were recorded. Olive-sided Flycatcher (3 of 7) was less common. Only Wood Thrush was recorded in the site visit on the lower slopes of Tenney Mountain, but the other two species could breed on the mountain below the ridgeline. Red-headed Woodpecker (1 of 7 priority blocks), Willow Flycatcher (2 of 7), and Prairie Warbler (1 of 7) are unlikely to occur at the Project site because of their habitat requirements (open country with scattered trees for the woodpecker and brushy fields for the flycatcher and warbler; Foss 1994). Nonetheless, Prairie Warbler is known to colonize power-line cuts (Foss 1994), and it could colonize clear-cut areas below the ridge on Tenney Mountain.

No doubt, the distributions of some of New Hampshire's breeding birds have changed significantly since the 1981-1986 BBA. For example, as discussed above, Peregrine Falcon now nests on ledges on Rattlesnake Mountain across the Baker River valley from the Project site. Except for Cooper's Hawk, however, it is unlikely that any other threatened or endangered species would occur on the forested slopes of Fletcher and Tenney Mountains. Regarding *WatchList* species, the site visit confirmed the Wood Thrush's presence on the lower slopes of Tenney Mountain, but Canada Warbler would probably be found below the ridge with extended search effort. Olive-sided Flycatcher would be less likely to be found.

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.

One BBS route (Wilmot, #58011) surveys countryside as close as 5.5 miles (8.8 km) of the Project site (see Table 4.1.2-2). It 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. This route begins in Wilmot in northwestern Merrimack County and crisscrosses northward into southern Grafton County. Maps show the route crossing mainly forested terrain with some agricultural fields.

To profile the breeding bird community, Appendix E was prepared, listing the species recorded at least once from 1996 to 2005 (the most recent data available) on the Wilmot route. Species are listed both in taxonomic order and in order of their average frequency. To calculate average frequency, 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.

One hundred and one species were recorded on the Wilmot BBS route over the ten recent years sampled, of which eleven were recorded above 10 birds/hr and can be considered very common. They were (all in birds/hr):

Red-eyed Vireo	43.6	Chipping Sparrow	13.8
Ovenbird	27.5	Blue Jay	11.7
American Robin	23.7	Mourning Dove	11.6
Black-capped Chickadee	20.9	Common Yellowthroat	11.2
American Crow	16.8	Red-winged Blackbird	10.2
Cedar Waxwing	14.8		

Fifty-one species were recorded between 1 and 10 birds/hr and can be considered common. They included one *Yellow WatchList* species, Wood Thrush (all in birds/hr).

Veery	9.7	Blue-headed Vireo	3.5
Black-throated Green Warbler	9.7	Black-and-white Warbler	3.2
American Goldfinch	8.8	White-breasted Nuthatch	3.1
Hermit Thrush	8.7	Eastern Wood-Pewee	2.9
Eastern Phoebe	8.6	Pine Warbler	2.9
Song Sparrow	8.4	American Redstart	2.9
Black-throated Blue Warbler	7.7	Pileated Woodpecker	2.8
Myrtle Warbler	7.5	Least Flycatcher	2.8
Tree Swallow	7.4	Indigo Bunting	2.6
European Starling	7.4	Magnolia Warbler	2.4
Chestnut-sided Warbler	7.0	Hairy Woodpecker	2.3
Wood Thrush (*Yellow WL*)	6.8	Eastern Kingbird	2.3
Winter Wren	6.1	Alder Flycatcher	2.1
Swamp Sparrow	5.9	Brown-headed Cowbird	2.1
Common Raven	5.7	Purple Finch	2.1
Blackburnian Warbler	5.3	Yellow Warbler	2.0
White-throated Sparrow	5.2	Evening Grosbeak	2.0
Scarlet Tanager	4.9	Slate-colored Junco	1.7
Yellow-bellied Sapsucker	4.6	Bobolink	1.7
Common Grackle	4.4	Downy Woodpecker	1.5
Gray Catbird	3.9	Brown Creeper	1.5
Red-breasted Nuthatch	3.8	Northern Waterthrush	1.5
		Tufted Titmouse	1.4

Chimney Swift	1.3	Nashville Warbler	1.2
Baltimore Oriole	1.3	Rose-breasted Grosbeak	1.1
Great Crested Flycatcher	1.2	Killdeer	1.0

Together, individuals of these 62 species made up 97% of the birds recorded on the BBS route. Forty birds, on the other hand, were recorded below 1 bird/hr and can be considered uncommon to rare species (see Appendix E).

The breeding bird fauna in the Project region is noteworthy for the many forest-interior birds among the common species. It is indeed significant that the two commonest species were forest interior birds: Red-eyed Vireo (43.6 birds/hour) and Ovenbird (27.5). Other common forest-interior birds were Veery (9.7), Black-throated Green Warbler (9.7), Hermit Thrush (8.7), Black-throated Blue Warbler (7.7), Wood Thrush (*Yellow WatchList*; 6.8), Winter Wren (6.1), Blackburnian Warbler (5.3), Scarlet Tanager (4.9), Yellow-bellied Sapsucker (4.6), Blue-headed Vireo (3.5), and Pileated Woodpecker (2.8). Most other common species were birds of woodland edges, oldfields, thickets, and residential areas.

Obligate grassland birds were scarce, with Bobolink (1.7) and Northern Harrier (NH-E; 0.1) the only ones recorded. Waterbird diversity was somewhat high, but abundances were low: Wood Duck (0.6), Canada Goose (0.5), Mallard (0.5), Hooded Merganser (0.3), Wilson's Snipe (0.3), American Bittern (0.2), Great Blue Heron (0.2), American Black Duck (0.1), Pied-billed Grebe (NH-E; 0.1), and Spotted Sandpiper (0.1).

Four raptors were recorded, all at fairly low abundances: Broad-winged Hawk (0.5), Northern Harrier (NH-E; 0.1), Sharp-shinned Hawk (0.1), and Red-shouldered Hawk (0.1).

Regarding special-status species (see Table 4.1.2-1), the New Hampshire endangered Pied-billed Grebe and Northern Harrier and threatened Common Nighthawk were rarely recorded (one individual of each in ten years of surveys). None would breed on a forested ridge top. The grebe is a bird of ponds and marshes. The harrier is a grassland bird. The nighthawk prefers barrens.

Of the four *Yellow WatchList* species recorded, only Wood Thrush was common, Prairie Warbler was uncommon, and Olive-sided Flycatcher and Canada Warbler were rare. This indicates that Wood Thrush is most likely to breed in the vicinity of the proposed wind farm. This was confirmed in the site visit, but Wood Thrushes were only heard on the mountain's lower slopes.

4.1.3 Breeding Birds, Conclusions

Based on the site visit's evaluation of habitat and on Breeding Bird Atlas (BBA) and Breeding Bird Survey (BBS) data, the Groton Wind Project site has a diverse forest-interior breeding bird community. The site visit found Black-throated Blue Warbler and Ovenbird to be the most frequently recorded species in deciduous woodland along the ridge. Blackburnian Warbler and Golden-crowned Kinglet were the signature species in spruce patches.

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

Route Number	Route Name	County	Distance /Bearing from Site	# Years Surveyed	Species Min-Max	Special-Interest Species[1]	% Years Recorded	Range Birds per Year
58011	Wilmot	Merrimack -Grafton	5.5 mi S	10	71-52	**Pied-billed Grebe (NH-E)**	**10%**	**1**
						Northern Harrier (NH-E)	**10%**	**1**
						Common Nighthawk (NH-T)	**10%**	**1**
						Olive-sided Flycatcher (*Yellow WatchList*)	10%	1
						Wood Thrush (*Yellow WatchList*)	100%	1-11
						Prairie Warbler (*Yellow WatchList*)	40%	1-2
						Canada Warbler (*Yellow WatchList*)	10%	1

[1] New Hampshire 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.

Among special-status species, the New Hampshire endangered Peregrine Falcon is known to nest on ledges on Rattlesnake Mountain across the Baker River valley from the Project site, but it is unlikely to frequent airspace where the wind turbines would be constructed. The threatened Cooper's Hawk may nest in low densities on the slopes of Fletcher and Tenney Mountains. The threatened Common Nighthawk has been sparingly recorded in central New Hampshire; therefore, it is also unlikely to frequent airspace at the Project site.

The *Yellow WatchList* Wood Thrush was found to nest on the lower slopes of Tenney Mountain. Regarding other *Yellow WatchList* species, Canada Warbler no doubt occurs on Tenney Mountain below the ridge. The status of Olive-sided Flycatcher is uncertain, but it is probably rare. The *Red WatchList* Bicknell's Thrush does not breed on either Fletcher or Tenney Mountains as they are not high enough to support stunted spruce/fir forest.

4.2 Migratory Birds

This section sheds light on how migratory birds are likely to use the Groton Wind 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

Nocturnal songbirds and allies are the most numerous of birds migrating over New Hampshire. 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 New Hampshire is probably on the order of more than one hundred million birds per season. In New Hampshire, nocturnal songbird migration is concentrated from mid-late April to mid and late May (spring migration) and from mid August into November (fall migration).

General surveys of migration (Berthold 2001, Alerstam 1993, Eastwood 1967) strongly indicate that, if the nocturnal migration of individual songbirds over most of New Hampshire could be plotted on a map, the resulting pattern of roughly parallel movement that would be random or nearly uniform in dispersion. In the fall, this pattern would be oriented roughly southward (southeast to southwest). In the spring, the direction would be north-northeasterly. This pattern is "broad-front" migration. 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."

Radar studies conducted in the Eastern U.S. indicate that the night migration of songbirds, shorebirds, waterfowl and others is broad-front as opposed to concentrated in narrow corridors or at topographic features (Cooper et al. 1995, Cooper and Mabee 1999, Cooper et al. 2004b, 2004c). Perhaps the best evidence to support the contention that birds do not follow topographic features in the Eastern U.S. is a study by Cooper et al. (2004a) 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.

The evidence is overwhelming that most night-migrating songbirds are spread across broad fronts over most types of topography they encounter. Even migrants confronted by the Great Lakes do not turn when they encounter lakeshores at night (Diehl et al. 2003). Instead, they continue to cross the lakes as if they were not present. Nonetheless, some birds have been found to remain over lakeshores oriented in the direction of migration, rather than fly over the Great Lakes, resulting in higher densities of birds over land than over water. This pattern has been documented during spring migration along Lake Erie (Diehl et al. 2003).

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, their studies were 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.

J. Plissner, P.Kerlinger, 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 eastern U.S. is low to moderate when compared with 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 the 15+ eastern 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, of those surveys reviewed, 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 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.

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°. The mean migration direction at sites in western New York was almost identical to migration directions near the Adirondacks, Maine, and even Maryland, Virginia, and West Virginia. There is no apparent pattern for these variations in flight directions.

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 the analysis of Plissner, Kerlinger et al.

In summary, nocturnal songbird migration above the Groton Wind Project site will be part of an extensive broad-front migration over New Hampshire. Given that the site is located away from lakeshores 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 eastern U.S. sites. Those studies demonstrate that migration traffic is low to moderate, with the bulk of birds flying above the height of wind turbine rotors, and a relatively small percentage flying in the rotor-height zone.

4.2.2 Hawk Migration

The Hawk Migration Association of North America (HMANA; visit www.hmana.org) list four active hawk watches in New Hampshire. One is located about 12 miles (19.2 km) south-southeast of the Project site. According to information available at HawkCount.org, a database of hawk-watch results, the Little Round Top Migration Observatory (visit http://hawkcount.org/siteinfo.php?rsite=317) has been active since 1967. In recent years, observations have been limited to September, when about 100 hours of observations have been invested.

Over the past five years, the high seasonal count at Little Round Top was 4,082 hawks (42.6 hawks/hour) in 2004. The low was 675 (8.5 hawks/hour) in 2005. This variation is clearly tied to the Broad-winged Hawk migration, which peaks in mid September. 2004 was a high year for Broad-winged Hawks (3,736; see table below), whereas 2005 was a notable low (only 389 counted). For comparison, at the globally significant Hawk Mountain Sanctuary in Pennsylvania, the Broad-wing passage averages 8,628, ranging from 29,519 (in 1978) to 1,809 (in 1996).

Table 4.2.2-1. September Raptor Tallies at Little Round Top Migration Observatory[1]

Name	Avg	Max
Turkey Vulture	16	33
Osprey (NH-T)	**46**	**68**
Bald Eagle (NH-E)	**29**	**39**
Northern Harrier (NH-E)	**4**	**6**
Sharp-shinned Hawk	94	123
Cooper's Hawk (NH-T)	**22**	**41**
Northern Goshawk	2	3
Broad-winged Hawk	1543	3736
Red-tailed Hawk	20	36
Golden Eagle (NH-E)	**2**	**2**
American Kestrel	24	31
Merlin	3	4
Peregrine Falcon (NH-E)	3	5
Unidentified Raptor	48	83
Total	1856	

[1] From http://hawkcount.org/siteinfo.php?rsite=317

Table 4.2.2-1 presents the average and high tallies for individual species at Little Round Top. Based on average values, Broad-winged Hawks made up 83% of all hawks tallied. If hawk observations continued into October and November, seasonal totals for Turkey Vulture, Sharp-shinned Hawk, and Red-tailed Hawk would be greater, possibly in the low hundreds some years, as their peak passage occurs after September. The number of Golden Eagles would also be greater, possibly exceeding 10 birds in some years, as their peak passage is in November. Research using satellite transmitters shows that Golden Eagles nesting on the Gaspe Peninsula of eastern Quebec migrate through New England on their way south to winter in the central and southern Appalachians (see http://www.aviary.org/csrv/trackPA.php).

The topography in central New Hampshire lacks long, linear ridges that would concentrate migrating hawks on updrafts (such as occurs at Hawk Mountain). Therefore, hawks migrating across New Hampshire rely mostly on thermals. Ascending currents of air produced by sunlight warming the land, thermals allow hawks to gain height, which they use to sail for long distances on a downhill glide in search of the next thermal. Given the random nature of thermal development, the resulting migration pattern is board-front, with hawks dispersed above and across the landscape. This explains the low to moderate numbers of hawks recorded at Little Round Top when compared with a globally significant site such as Hawk Mountain. The same pattern would be expected at the Groton Wind Project site. That Little Road Top does not observe in October and November, or in spring, indicates that hawk passage is much less at those times. It is only when Broad-winged Hawks cross the state on thermals that impressive numbers of hawks may be seen.

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.

4.2.3 Waterbird Migration

In his maps of waterfowl migration corridors, Bellrose (1980) shows between 26,000 and 75,000 geese migrating over western New England between northern Quebec and the Mid-Atlantic coastal region. Duck migration crossing northern New England between the western Canada 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 New Hampshire. The closest significant site is Great Marsh on the North Shore of Massachusetts, located about 85 miles (135 km) southeast 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. Moreover, the Project site itself lacks any significant wetland habitat that would attract even 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. In all cases, migration will be broad front in nature and generally at altitudes above the sweep of the wind turbine rotors. It is unlikely that nocturnal songbird migrants would concentrate on the Tenney Mountain ridge as there is abundant woodland habitat for these birds in the Project region.

4.3 Wintering Birds

Winter in New Hampshire is famously cold and snowy, particularly in the mountainous areas and in the northern part of the state. Given the harsh winter climate, the state harbors relatively few birds in winter. Given that turbine locations on Tenney Mountains will be exposed to strong northwest winds, even fewer birds will be found at the Project site in winter. Most wintering birds are likely to avoid hilltops and settle in nearby valleys.

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 in order 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.

Table 4.3-1. CBCs Analyzed, 1998-2007

Count Name (Code)	Center County	Distance/ Bearing	Years Analyzed	Number Participants	Number Species
Baker Valley (NHBV)	Grafton	0 mi NW	10	6-15	29-33
Sandwich (NHSA)	Grafton	2 mi E	10	18-27	32-43
Hanover (NHHN)	Grafton	13 mi W	10	15-32	45-58

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 three CBCs within 15 miles (24 km) of the Project site (see Table 4.3-1) were examined in order to understand the winter bird populations likely to occur at the Project site. All CBC's survey an area of about 177 square miles (453 km^2); thus, the CBCs considered in this report covered a total area of 531 square miles (1,359 km^2). Observer participation per count during the analysis period varied from a minimum of 6 observers to a maximum of 32.

The number of species recorded in these counts ranged from a maximum of between 33 and 58 species to a minimum of between 29 and 45 species. All of the CBCs included some open-water and wetland habitat; as a result, they recorded waterfowl other waterbirds unlikely to occur at the

Project site. Because Fletcher and Tenney Mountains lack waterbird habitat, they would be expected to have fewer species than the CBCs examined.

To understand winter bird abundance at the Project site, Appendix F has been prepared. Sorted in taxonomic and abundance orders, this table displays the average frequency of birds, measured in birds/hr, for the nearby Baker Valley CBC, which just overlaps Fletcher Mountain. 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 61 species were recorded on the Baker Valley CBC over the last ten years. Of these birds, only 10 species were recorded above 1 bird/hr and can be considered common. Individuals of these species made up 80% of all individuals recorded on the count. They were:

Black-capped Chickadee	13.55	American Crow	1.53
Blue Jay	4.71	Rock Pigeon	1.41
American Goldfinch	3.28	House Sparrow	1.29
Mourning Dove	2.21	Evening Grosbeak	1.10
Common Redpoll	1.83	White-breasted Nuthatch	1.06

Listed in Appendix F, the other 51 species were uncommon or rare.

Only eight species of waterbirds were recorded on the Baker Valley CBC, but no species was common. Mallard (0.46 birds/hour) was most frequently recorded.

Six species of raptors were recorded, all at low very frequencies. Red-tailed Hawk (0.02) was most frequent. The other species were rare, ranging from 0.01 to less than 0.005 birds/hour, including the New Hampshire endangered Bald Eagle, threatened Cooper's Hawk, and unlisted Sharp-shinned Hawk, Northern Goshawk, and Rough-legged Hawk.

No open-country birds, such as Snow Bunting, were recorded. While some woodland birds (e.g., Black-capped Chickadee [13.55]) were common, their frequencies would be much lower at the Project site, because of wind exposure.

Regarding special-status species recorded on the three nearby CBCs (see Table 4.3-2), three New Hampshire endangered and two threatened species were recorded. The endangered Bald Eagle was only regular at the Hanover CBC, where the open waters of the Connecticut River would attract it. It was less regular at the Sandwich CBC, perhaps because waters of Squam Lake are sometimes frozen in December. It was irregular at the Baker Valley CBC. Northern Harrier and Peregrine Falcon were only recorded on the Hanover CBC. Agricultural lands along the Connecticut River attract harriers at apparently low frequency. Peregrine Falcon occurred in three out of ten years, probably attracted by ducks wintering along the river.

The threatened Common Loon was found infrequently on the two counts that had significant open water. The threatened Cooper's Hawk was found on all three counts, but it was only regularly recorded in the Connecticut River valley.

Rusty Blackbird (*Yellow WatchList*) was the only *WatchList* species recorded in the CBCs, with single birds found two years on the Hanover CBC.

These results indicate that most special-status species found in winter in central New Hampshire are unlikely to occur at the Project site. Perhaps most likely would be Cooper's Hawk, but the CBC results show that it is more common in the more moderate climate of the Connecticut River valley than in interior mountainous sections.

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

Species[1]	CBC	Percent Years Recorded	Range Number Recorded
Common Loon (NH-T)	**Sandwich**	**20%**	**1-7**
	Hanover	**10%**	**1**
Bald Eagle (NH-E)	**Baker Valley**	**10%**	**4**
	Sandwich	**40%**	**1-3**
	Hanover	**100%**	**1-4**
Northern Harrier (NH-E)	**Hanover**	**10%**	**1**
Cooper's Hawk (NH-T)	**Baker Valley**	**20%**	**1-2**
	Sandwich	**20%**	**1**
	Hanover	**90%**	**1-7**
Peregrine Falcon (NH-E)	**Hanover**	**30%**	**1**
Rusty Blackbird (*Yellow WatchList*)	Hanover	20%	1

[1] New Hampshire 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.

In conclusion, CBC data indicate that the Project site will have very few birds in winter, when wind exposure, cold temperatures, and snow severely limit foraging opportunities. Of the listed species, the New Hampshire threatened Cooper's Hawk is perhaps the likeliest to occur, but its abundance would be low.

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

As part of the avian risk analysis, databases were checked to see if Important Bird Areas (IBAs) or federal, state, or private protected areas (refuges, state/federal forests, parks, sanctuaries, etc.) overlap with the Project site or are in close proximity. The presence or proximity of such areas could indicate the presence of 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.

Described at http://www.nhbirdrecords.org/articles/V24N2S_ImportantBird.pdf, New Hampshire's IBA Program began in 2002 as a partnership among New Hampshire Audubon, NHFGD, and the University of New Hampshire Cooperative Extension. To date, 15 IBAs have been designated, but more sites will be named. Designated sites fall into three broad categories: 1) locations used by threatened and endangered species, 2) important habitats for species of conservation concern, and 3) places where large numbers of birds congregate during the non-breeding season.

No IBA overlaps the Project site, but two are located within 10 miles (16 km). Located about 5 miles (8 km) north, the High-elevation Spruce-Fir of the White Mountain National Forest (Site #5) was designated for its breeding population of Bicknell's Thrush and other high-elevation conifer/boreal species. The IBA map available on the Internet is not detailed enough to identify the nearest islands of high-elevation conifer forest, but they appear to be located at Stinson Mountain and Carr Mountain, across the Baker River valley from the Project site. The Project site is not high enough in elevation to have this habitat.

Located 9 miles (14.5 km) east, Squam Lake (Site #9) was designated for its breeding population of Common Loons, as a stopover site for migrating waterfowl, and as habitat for the New Hampshire endangered Bald Eagle.

The American Bird Conservancy (ABC) has published a directory of the 500 most important bird areas in the United States (ABC 2003). Organized by bird conservation regions, one of the sites in the Atlantic Northern Forest (BCR 14; see Section 4.0) is the White Mountain National Forest. It highlights this IBA for its nesting habitat for Bicknell's Thrush, Peregrine Falcon, and more than 70 Neotropical migratory bird species (ABC 2003). Rattlesnake Mountain, where the Peregrine Falcon nest is located, is part of the White Mountain National Forest. It is located about 3.5 miles (5.6 km) northwest of the Project site.

5.2 Federal, State, County, and Private Protected Areas

As already noted, the White Mountain National Forest, a federal protected area, is located as close as 3.5 miles (5.2 km) northwest of the Project site, but the high-elevation conifer areas are about 5 miles (8 km) distant. This national forest measures about 780,000 acres (ABC 2003).

A number of state forests are found within 5 miles (8 km) of the Project site. The Crosby Mountain State Forest and the adjoining Cockermouth Forest (administered by the Society for the Protection of New Hampshire Forests) are located a little more than a mile (1.6 km) southwest of the proposed turbine area on Tenney Mountain. The Cardigan Mountain State Forest is located about 4 miles (6.4 km) south. Mount Cardigan in the southern portion of this state forest was listed as a special area in the New Hampshire BBA. These state forests are no doubt prime habitat for a diverse community of forest-interior birds, many of which are Neotropical migratory species.

The Nature Conservancy in New Hampshire appears to have a reserve on Stinson Mountain, but details at its website are lacking. Audubon New Hampshire operates a wildlife sanctuary at Hebron Marsh on Newfound Lake, about 2.5 miles (4 km) south of the Tenney Mountain turbine area.

In its report on the Peregrine Falcon nest at Rattlesnake Mountain (see Section 3.0), Woodlot Alternatives reported two nesting areas within about 5 miles of the Project site. In addition to the traditional nesting site at Rattlesnake Mountain, about 1.5 miles north-northwest of the Project site, a single territorial individual was observed during the summer of 2006 on ledges at Bear Mountain in Hebron, about 5 miles (8 km) south of the Project site. Nesting cliffs are not likely to be a limiting factor for Peregrines in the vicinity of the Project site because there are many cliffs that are not occupied. Instead,, the limiting factor appears to be an adequate food supply to raise young. In this regard, the Baker River valley, as well as some lakes and marshes, are probably the only areas near the Project site that would concentrate enough prey for Peregrines to fledge young successfully. Therefore, it appears unlikely that other Peregrines will take up nesting at the Project site.

In conclusion, the Groton Wind Project site does not overlap an Important Bird Area (IBA), and it lacks high-elevation conifer forest, but its Northern Hardwood forest hosts a diverse community of forest-interior birds, many of which are Neotropical migratory species. This forest type is abundantly distributed in central New Hampshire, and the example of it on Tenney Mountain is not of high quality, given its use for timber extraction. Overall, the Project site is not discrete and distinguishable in character, habitat, or ornithological importance from surrounding areas.

6.0 Risk to Birds at the Proposed Groton Wind Project

6.1 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 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, a probabilistic assessment of risk can be made for different species and groups of species.

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 farm 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 habitat loss is generally small. This is particularly true in agricultural landscapes. But, in forested landscapes, the construction of a 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 farm, 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 areas located 180 m (590 feet) from turbines were found to support higher densities (261.0-312.5 males/100 ha) of grassland birds that areas within 80 m (260 feet) of turbines (58.2-128.0 males/100 ha) (Leddy et al. 1999). This study also found that the activities of many grassland-nesting birds were inhibited within about 80 m (260 feet) to nearly 200 m (650 feet) of turbines. An impact-gradient study demonstrated that disturbance was greatest within the first 100 m (325 feet) of a turbine and decreased at greater distances. This means that, after the construction of turbines, some birds either do not nest or forage close to the turbines or do so at lower frequencies. Nonetheless, it should be noted that the Buffalo Ridge turbines are shorter than those proposed, and closer together. These characteristics could have a considerable effect, not evident at larger widely spaced turbines. Furthermore, the study was conducted in the first year after construction, when vegetation at turbine construction sites may not have recovered, 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 (650 feet) of operating turbines. Thus, the area impacted extended beyond the actual footprint of the project.

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.

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. They were more affected by the farming practices, including hay mowing and tilling, than by turbines.

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. Local conservationists believe that, if construction had taken place outside of the breeding season, the eagle pair would not have abandoned the original nest (Peter Carson and Mary Gartshore, personal communication). 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.

In Europe, studies have shown that some waterfowl, shorebirds, and grassland songbird species avoid areas near turbines. For example, 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 studies have shown that some shorebirds and other birds can habituate to turbines to some degree (Ihde and Vauk-Henzelt 1999, Winkelman 1990). Studies have not yet been conducted to examine behavioral changes or habituation of birds to wind turbines over periods as long as five to ten years after construction. Therefore, it is not known if these species remain permanently displaced.

Other studies conducted in Denmark, 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). 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. Therefore, different species react differently to wind turbines. Nonetheless, research has not been conducted to determine if particular species will habituate to wind turbines and, if so, how long that process might take.

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.

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.

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 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, such as the Project 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 2000b). 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.

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 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.

In summary, limited research on bird disturbance and displacement suggests that some grassland and other open-country birds avoid turbines, or are displaced by them, at least to a greater degree than forest species. It is also evident that there are species-specific differences, with some species being displaced farther than others, while others habituate to turbines. More research is required, however, to fine tune understanding of displacement and habituation.

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) has 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 25 million waterfowl are shot in the U.S. and Canada annually, without significant impact to any species. Presently, the daily bag limit for duck hunters in Pennsylvania is six ducks, including one American Black Duck, which used to be a *WatchList* species. The overall annual harvest of this species is on the order of 10,000 birds per year (2002 and 2003) in Pennsylvania, and about 100,000 per year in the Atlantic Flyway.

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 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 Midwestern 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 electricity suppliers, mountaintop removal in Appalachia to supply power plants with coal, or collisions with wind turbines supplying consumers with electricity.

In other words, all of energy choices have wildlife implications. The Wood Thrush example strongly suggests that power plants are having a measurable impact on bird populations in eastern 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 they are 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.

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.

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

				All Bird Mortality		
Wind Project	# Turbines	Turbine MW	Project MW	Turbine per year	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

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, reported avian fatalities have generally been small at wind power plants. But, there are a few localities where greater numbers of fatalities have been found. At a wind power site with 18 turbines in the coastal Netherlands, dozens of songbirds and a variety of shorebirds were reported to have collided with wind turbines during a migration season (Winkelman 1995). At another wind plant in the Netherlands, where turbines were erected in a saltwater lake, about 65 waterfowl fatalities were noted in one winter (Winkelman 1995). These sites are adjacent to the North Sea, where migratory and wintering birds are densely concentrated. That several species were killed reduced the potential for significant population impacts on any one species. There are also higher fatality rates reported from Belgium, with respect to terns and gulls, at turbines located on harbors and adjacent to open water (Everaert 2002), and from Navarre in northern Spain (Lekuona 2001), where large numbers of resident Griffon Vultures have apparently been killed.

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-energy projects in the Pyrenees Mountains of Navarre. The causes for this relatively high mortality appear to be closely spaced turbine placements on habitual soaring ridges used by a resident population of habituated birds (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 seven wind power facilities in the eastern United States and one across Lake Erie in Canada that are relevant to the western Ohio lakeshore region, 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 between two and 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 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.

6.2 Avian Risk Assessment for the Groton Wind Project

6.2.1 Disturbance and Displacement Risk at the Groton Wind Project

As detailed in Section 6.1.1, some types of birds appear to be disturbed and displaced more by wind turbine construction and operation than others. It is important to also note that some species of birds benefit from habitat changes resulting from turbine construction. Disturbance and displacement effects have been documented among some songbirds at wind projects in grassland and prairie, as well as among some (not all) waterfowl. Some European studies have demonstrated displacement of shorebirds. 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 farm construction, may impact forest-interior birds that are sensitive to edge effects. 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.

On Tenney Mountain, turbines would be constructed on the ridgeline of a forested mountain that is intensively managed for timber harvest. The principal habitat effects would be a loss of forest-interior habitat and the creation of additional forest edge. These effects may occur through the construction of a road or widening and improvement of the existing road to accommodate equipment delivery, the clearing of a new road along the ridgeline to reach turbine locations, and the clearing of turbine construction areas. In addition, the clearing of a transmission line corridor, if needed, to connect the Project substation to the grid, may also impact forests.

Relative to the amount of forest on Tenney Mountain, wind farm construction would remove only a small percentage of forest-interior habitat. It should be noted, however, that timber harvest activities have previously and continue to remove forest-interior habitat on Tenney Mountain. In addition, the amount of forest edge created by the wind farm would also be small relative to the amount of edge that is created annually by timber-harvest operations. The habitat on the ridgeline appears not to be significantly different than the abundant habitat on the mountain slopes, so impacts would be similar to impacts of the logging that is currently being done downslope. In addition, the fact that there is a ski slope and a microwave tower on the east slope of Tenney Mountain, suggests that there are existing factors that contribute to forest fragmentation on the mountain.

Birds respond to forest removal in different ways. The removal of forest canopy and subsequent release of the understory can benefit shrub-nesting species, as has been demonstrated in timber-managed tracts (Duguay 1997, Duguay et al. 2000, 2001, cited in NRC 2007). Examples at Tenney Mountain would be Chestnut-sided Warbler and perhaps even Prairie Warbler, a *Yellow WatchList* species. On the other hand, habitat for Ovenbirds and Blackburnian Warblers is negatively correlated with understory density and positively correlated with the size and density of hardwood trees (Hagan and Meeham 2002, cited in NRC 2007). Territory densities of Ovenbirds were 40% less in edge areas (0 to 150 m from unpaved roads through forest) than within interior areas (150 to 300 m from roads; Ortega and Capen 1999). In other words, populations of shrub-nesting species may be expected to respond positively to Project construction, at least until the forest canopy fills in. Populations of forest-interior species, however, may be expected to respond negatively in the vicinity of cleared areas, with a reduction in density of territories.

The construction of a wind farm on Tenney Mountain will have some effect on the site's forest-interior bird community, but it is expected that this effect will be small, limited mostly to the ridgeline. Nevertheless, the long-term maintenance of the forest-interior bird community probably depends most on how the forest is managed by the landowner in the future for timber harvest. Such management is independent of the Project.
With respect to raptors, some disturbance impacts may occur if wind turbines are constructed near nesting sites. But, recent examples from the Erie Shores Wind Farm, cited above, show remarkable habituation to wind turbines on the part of Red-tailed Hawks, Cooper's Hawk (NH threatened), and even Bald Eagles (NH endangered). While Cooper's Hawk may nest at low density on Tenney Mountain, they would be more likely to nest at lower elevations, away from the ridgetop. Bald Eagle would not nest at the Project.

Regarding New Hampshire endangered, threatened, and special-concern species, it is unlikely that any nest in the vicinity of wind turbines would be at risk of displacement. This includes the threatened Cooper's Hawk., Regarding *WatchList* species, no *Red WatchList* species, such as Bicknell's Thrush, are likely. Among *Yellow WatchList* birds, Wood Thrush is occurs on the lower slopes of Tenney Mountain, and is replaced by Hermit Thrush on the upper slopes. Canada Warbler is unlikely to nest near turbine locations, but Prairie Warbler may be attracted to early successional habitats resulting from construction, especially along the power-line connection to the electricity grid.

Finally, some birds may be displaced temporarily during the construction phase, as heavy equipment passes through the site and as roads are constructed. This disturbance impact is expected to be temporary and decrease markedly after construction.

6.2.2 Collision Risk at the Groton Wind Project

Given that collision risk varies with bird type, we treat nocturnal migrant songbirds, raptors, waterbirds, and listed species separately.

6.2.2.1 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, as a percentage of total mortality, 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). At least six studies conducted after the NRC report basically confirm the above findings.

Most reports of night-migrant fatalities are of single birds, unlike the large-scale (sometimes called "mass mortality") 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 2000c) 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 with very few exceptions (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 2000c). 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. A few turbines at Buffalo Ridge in Minnesota have steady red lighting, as do all of the lighted turbines at the Erie Shores Wind Farm.

Research by Kerns and Kerlinger (2004) and Kerlinger (2004a, 2004b, Kerlinger et al. in review) has not demonstrated large-scale fatality events at wind turbines, nor has it shown a difference in numbers of fatalities at lit versus unlit turbines. Similar results from wind plants in Washington, Oregon, California, New York, Illinois, Pennsylvania, Tennessee, Minnesota, and Ontario 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 foggy night at an electrical substation involving mostly one turbine and the fences surrounding the substation. 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.

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 lit versus unlit wind turbines at sites across the United States, 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. Current FAA practice for wind turbine lighting requirements calls for lighting only on the 'ends' of a wind farm and selected turbines in the middle. Research by Gehring and Kerlinger (2007b) 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.

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 central New Hampshire would occur across a broad front mostly at altitudes above the sweep of wind-turbine rotors. A small percentage of migrants generally 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 descend to woodland and other habitats, where they feed to replenish the fat reserves that power their migration. On this descent, and on the evening ascent when they resume migration, these birds would be at higher 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 or isolated.

Overall, it is likely that collision mortality will be similar both in numbers and species composition of migrants killed to what has been recorded at other eastern wind power sites. This level of mortality is not likely to be biologically significant.

6.2.2.2 Raptors

Risk factors for raptors are well documented at the Altamont Pass Wind Resource Area (APWRA; see Section 6.1.2 discussion). Table 6.2.2.2-1 compares the APWRA risk factors with the project contemplated at the Project site. As will be seen, the known or suspected risk factors for raptors are minimal at the Project site.

Table 6.2.2.2-1. Comparison of Collision Risk Factors

Known or Suspected Risk Factors Altamont Pass Wind Resource Area (APWRA)	Comparison of Risk Factors Proposed Groton Wind Project
Large concentration of turbines (about 5,400 in 2002)	~11 to 13 turbines (possibly more)
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 on gently rolling/flat terrain
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 35 m (115 feet) above the ground
High raptor and susceptible species use of area	Generally low raptor use of area, some nesting likely

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.

At the Groton Wind Project site, the numbers of fatalities will probably be small and limited primarily to the species 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.

6.2.2.3 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 avian 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 do not appear 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).

At the Project site, there are no significant wetland habitats that would concentrate waterbirds at any time of the year.

6.2.2.4 Listed Species

Any listed species that transits the Project airspace at or near rotor height or, in the case of raptors, hunts at the Project site may be at risk of collision. Nevertheless, data sources indicate that no federal or New Hampshire-listed species appears likely to engage in these behaviors at a frequency that would lead to significant collision risk. This includes the Peregrine Falcon (NH endangered), which would concentrate its hunting mostly over the Baker River valley, . Cooper's Hawk (NH threatened) may nest on the lower slopes of Tenney Mountain, but it would hunt within the forest canopy and along forest edges, usually below the rotor swept area.

6.2.2.5 Collision Risk, Conclusions

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 2001 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 higher in the eastern U.S. than in the west, because of denser nocturnal migration of songbirds 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 Groton Wind 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. Again, these fatalities, when distributed among many species, are not likely to be biologically significant. Risk to nesting birds is likely to be minimal because most of these birds fly infrequently above the forest canopy. When compared with the Altamont Pass Wind Resource Area, collision risk factors for raptors are minimal. There is likely to be little or no risk to waterbirds because these birds will rarely, if ever, be on site. 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.

7.0 Recommendations

The following recommendations for the proposed Groton Wind 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. Any new above-ground lines from the site and substations to transmission lines should follow Avian Power Line Interaction Committee (APLIC) guidelines for insulation and spacing.

- Permanent meteorology towers should be free-standing (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, forested habitat should be permitted or encouraged to regenerate as close to the turbines and roads as possible to minimize habitat fragmentation and disturbance/displacement impacts. To accomplish this, topsoil should be replaced as a part of soil restoration as a means of encouraging good plant growth. Trees should be permitted to grow within cleared areas around turbines to the extent commercially practicable.

- 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 should be conducted during the first year after construction. If fatalities are recorded at levels that could be construed as biologically significant, or if significant numbers of rare species are involved, a second year of study should be undertaken. The study protocol should follow established designs approved by various government agencies, including the USFWS and NHFGD.

- Results of the fatality study should be contrasted with impacts from other types of power generation now supplying electricity in New Hampshire or are affecting New Hampshire forests (such as acid rain from coal-fired electricity generated in the Midwest). This comparison would facilitate long-term planning with respect to electrical generation and wildlife impacts. The study should seek information from USFWS and NHFGD 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.

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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.

It should be noted that the risk assessment conducted for the Project relied on procedures similar to those presented in the USFWS voluntary and interim guidelines, as well as other procedures, some of which exceed what is usually requested by USFWS. For many years, the standard Phase I Avian Risk Assessment process has incorporated most 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 in order to avoid or minimize impacts to wildlife, specifically birds and their habitats.

Specific Conformance to Guidelines

Teaming With Agencies. Letters have been sent to the New Hampshire Fish and Game Department (NHFGD) and to USFWS requesting information on listed species and species of special concern, as well as other bird information. Responses from both may be found in Appendix D. Approaching these agencies meets the recommendation by USFWS that developers should attempt to team or involve such agencies in the site evaluation process. There does not appear to be a federal permitting nexus 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 Groton Wind 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 APWRA of California, have resulted in biologically significant impacts to birds. In terms of collision risk to birds, comparisons made suggest that risk at the Project 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 Groton Wind 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 Groton Wind Project does not have the collision risk factors present in the APWRA (see Table 6.2.2.2-1). 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 United States.

The potential for biologically significant fatalities at wind power facilities was assessed by comparing numbers of likely fatalities at the Groton Wind Project with various data bases. Most important in our analysis were data from the one-hundred-plus million 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 – estimated at tens of thousands of bird fatalities per year nationally – 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. Because these types of impacts are likely to occur among some forest interior-nesting species at the Groton Wind Project site, further research has been recommended to prevent or mitigate impacts.

Alternate Sites. In the case of the Groton Wind Project, there are problems with requiring an alternative site analysis. No alternative sites were used for this study, because the habitat for several miles surrounding the Project is very similar and likely to support a similar avian community. In addition, it should also be noted that if no federal permits are necessary for this project, an alternatives analysis is not needed. Because a NEPA review is not triggered by this project, an alternative sites analysis is not likely to be required. The Phase I Avian Risk Assessment did, however, compare potential impacts at the Groton Wind Project 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 covers the following concerns:

- Letters of inquiry were sent to USFWS and NHFGD 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 Project site is not 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 Project 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 Project 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.

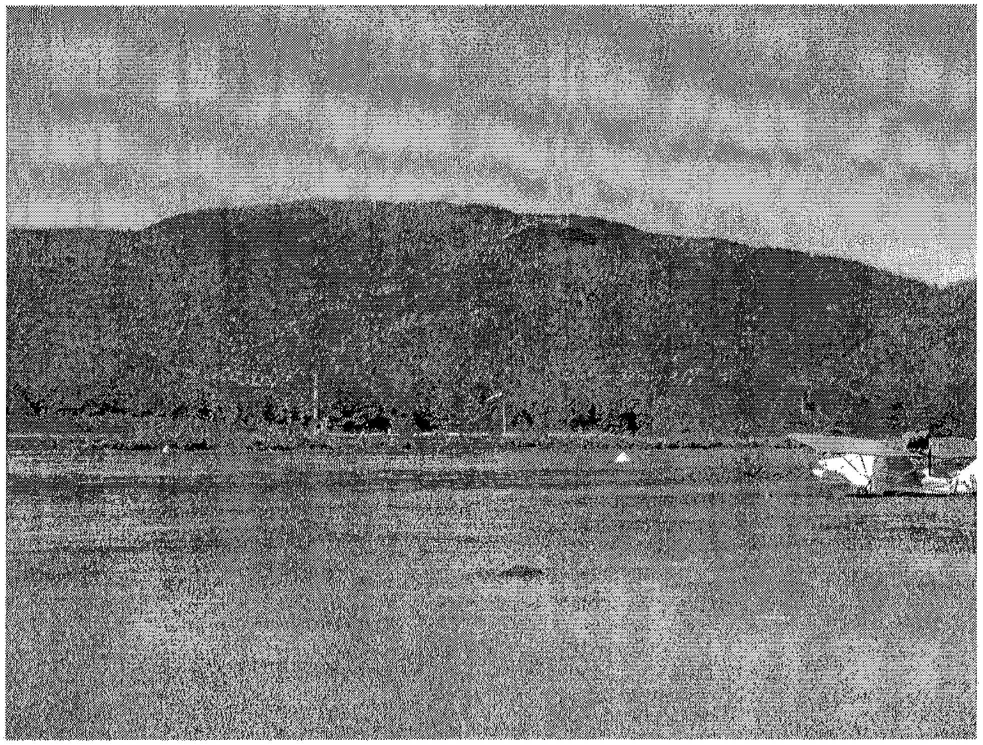
Regarding wind turbine design and operation, many of the USFWS recommendations are either covered in this risk assessment or routinely done at modern wind plants. Some USFWS recommendations, however, are incorrect or not applicable.

- 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.
- 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) 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 Groton Wind 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.

- 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 preconstruction 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. This will be checked in a radar study that the developer has already commissioned.
- Post-construction fatality monitoring would provide a means of determining the Project's impact to birds and has been recommended in this risk assessment.

If updated and revised, the USFWS's interim and voluntary guidance document promises to provide a means of evaluating wind power sites for wildlife impacts. Some of the guidance and recommendations are integral to adequately assessing risk, although some have not been substantiated or are only partially correct. There are also new scientific findings that need to be incorporated into the document. The guidance and recommendations set forth by USFWS are in need of a thorough peer review by the scientific community, industry, and environmental organizations prior to being required for wind power projects. Most importantly, there is need to validate the recommendations and protocols for ranking sites as to potential risk. Until such validation has been completed, it is difficult to determine how valuable the guidance and recommendations document is.

Appendix B. Photographs of representative habitats at the proposed Groton Wind Project site, Grafton County, New Hampshire. Upper photo: East side of Tenney Mountain. Lower photo: West side.



Appendix B. Photographs of representative habitats at the proposed Groton Wind Project site, Grafton County, New Hampshire. Upper photo: Deciduous woodland. Lower photo: Coniferous woodland.

Appendix B. Photographs of representative habitats at the proposed Groton Wind Project site, Grafton County, New Hampshire. Upper photo: Shrub habitat near center of project site. Lower photo: Habitat at met tower.

<u>Appendix C.</u> Birds recorded during site visit to the Groton Wind Project site, May 27-28, 2008.

This list only includes bird recorded on Tenney Mountain. Birds recorded on or just below the ridge are indicated with an asterisk.

Ruffed Grouse*
Wild Turkey
Turkey Vulture*
Red-tailed Hawk*
Mourning Dove
Chimney Swift*
Hairy Woodpecker*
Northern Flicker*
Pileated Woodpecker*
Alder Flycatcher
Least Flycatcher*
Eastern Phoebe
Great Crested Flycatcher
Blue-headed Vireo
Red-eyed Vireo*
Blue Jay*
Black-capped Chickadee*
Tufted Titmouse
Red-breasted Nuthatch*
White-breasted Nuthatch
Winter Wren*
Veery
Hermit Thrush*
Wood Thrush (*Yellow WatchList*)
American Robin
Cedar Waxwing*
Nashville Warbler*
Chestnut-sided Warbler*
Magnolia Warbler*
Black-throated Blue Warbler*
Yellow-rumped Warbler*
Black-throated Green Warbler*
Blackburnian Warbler*
Pine Warbler
Black-and-white Warbler*
American Redstart
Ovenbird*
Louisiana Waterthrush
Common Yellowthroat*
Scarlet Tanager*
Chipping Sparrow
Song Sparrow
White-throated Sparrow*
Dark-eyed Junco*
Rose-breasted Grosbeak*
Indigo Bunting
Common Grackle
Brown-headed Cowbird
Baltimore Oriole
Purple Finch*
American Goldfinch*
Evening Grosbeak*

52 species (32*)

Appendix D. Letters from USFWS and NHFGD regarding listed species at or near the proposed Groton Wind Project, Grafton County, New Hampshire.

Attachment 1

2004-0792

New Hampshire
Fish and Game Department

11 Hazen Drive, Concord, NH 03301-6500
Headquarters: (603) 271-3421
Web site: www.wildlife.state.nh.us

TDD Access: Relay NH 1-800-735-2964
Fax (603) 271-1438
E-mail: info@wildlife.state.nh.us

Lee E. Perry
Executive Director

November 2, 2004

Brian KillKelley
Wind Works LLC
PO Box 245
Charlotte VT 05445

Re: NHFG ID 2004-0792

Dear Mr. KillKelley:

The NH Fish and Game Nongame and Endangered Wildlife program has reviewed your request for information regarding state-listed species at the proposed Groton wind project. There are potential for impacts to a variety of wildlife species under the proposed project, including potential impacts to rare or endangered species. We have no known locations of state listed species found within the boundary of the project. However, we have several nearby locations of species that may potentially be impacted. In addition, although we have not documented the presence of endangered species at the proposed impact location, this area likely has not been sampled for rare species.

Of major concern are the potential effects on migratory birds and bats. U.S. Fish and Wildlife Service has authority over impacts to migratory birds through the Migratory Bird Treaty Act of 1918 and the NHFG has authority under the Endangered Species Conservation Act (RSA 212A). The state endangered peregrine falcon nests on the south face of Rattlesnake Mt. in Rumney, less than 2.5 mile from the project location. The impacts of wind turbines on foraging or migrating falcons are not known at this time and needs further consideration. Also, several bats of conservation concern could be potentially found in areas surrounding the proposed impact including Eastern red bat, Hoary bat, Silver-haired bat, Eastern pipistrelle and the state endangered small-footed bat. If spruce-fir habitat occurs on this site, it is possible that state-threatened pine marten and three-toed woodpeckers occur.

In addition to direct impacts to migratory birds and bats, we have concerns over the habitat loss and fragmentation that would occur as a result of clearing and construction of access roads. Wide ranging mammals may be particularly vulnerable to these fragmentation features, including marten, bobcat, black bear, and moose. The Natural Heritage Bureau should be contacted for potential impacts to rare plants or exemplary natural communities (Sara Cairns 603-271-3623 x 302).

Please contact me at 603-271-3016 for further assistance.

Conserving New Hampshire's wildlife and their habitats since 1865.

New Hampshire
Fish and Game Department

11 Hazen Drive, Concord, NH 03301-6500
Headquarters: (603) 271-3421
Web site: www.WildNH.com

TDD Access: Relay NH 1-800-735-2964
FAX (603) 271-1438
E-mail: info@wildlife.nh.gov

Glenn Normandeau
Executive Director

July 9, 2008

Michael Curry
Curry & Kerlinger, L.L.C.
1734 Susquehannock Drive
McLean, VA 22101

Dear Mr. Curry:

This letter is in response to your request for wildlife information from our Department regarding your proposed wind farm on Tenney Mountain in the Town of Groton. Our Department (primarily Michael Marchand) had previous discussions regarding this project and provided some details on areas of concern (see attachments). We do not know if studies previously recommended by NHFG and others (e.g., USFWS) have been initiated and/or completed. In addition to potential wildlife impacts, NHFG is interested in fisheries habitat, especially wild brook trout streams (if any are present within the project site), proposed impacts to wetlands including vernal pools, and any other rare habitats or communities that may exist on-site (e.g., rocky slides for small-footed bats).

For reference to previous select correspondences, please see attached:

1) NHFG November 2, 2004 letter to Brian Kilkelly identifying our initial concerns for wildlife and wildlife habitat.
2) A copy of an email (May 18, 2007) sent from Michael Marchand to Brian Killkelly and Derek Hengstenberg regarding the initial peregrine falcon survey that was conducted on-site (Woodlot summary report dated November 15, 2006) and recommendations for further survey work.

We appreciate the opportunity to comment on your proposed wind project and look forward to working with you in the future to minimize impacts on NH's wildlife resources. Our primary contact for this project is Michael Marchand (603-271-3016; Michael.Marchand@wildlife.nh.gov). Future meetings and discussions can be sent directly to him.

Sincerely,

Steven J. Weber

Steve Weber
Wildlife Division Chief

cc: Mike Marchand

United States Department of the Interior

FISH AND WILDLIFE SERVICE
New England Field Office
70 Commercial Street, Suite 300
Concord, New Hampshire 03301-5087
http://www.fws.gov/northeast/newenglandfieldoffice

August 6, 2008

Reference:	Project	Location
	Wind turbines	Groton, NH

Michael Curry
Curry & Kerlinger, L.L.C.
P.O. Box 453
Cape May Point, NJ 08212

Dear Mr. Curry:

This responds to Sharon Sharp-Harrison's recent correspondence requesting information on the presence of federally-listed and/or proposed endangered or threatened species in relation to the proposed activity(ies) referenced above.

Based on information currently available to us, no federally-listed or proposed, threatened or endangered species or critical habitat under the jurisdiction of the U.S. Fish and Wildlife Service are known to occur in the project area(s). Preparation of a Biological Assessment or further consultation with us under Section 7 of the Endangered Species Act is not required.

This concludes our review of listed species and critical habitat in the project location(s) and environs referenced above. No further Endangered Species Act coordination of this type is necessary for a period of one year from the date of this letter, unless additional information on listed or proposed species becomes available.

In order to curtail the need to contact this office in the future for updated lists of federally-listed or proposed threatened or endangered species and critical habitats, please visit the Endangered Species Consultation page on the New England Field Office's website:

www.fws.gov/northeast/newenglandfieldoffice/EndangeredSpec-Consultation.htm

In addition, there is a link to procedures that may allow you to conclude if habitat for a listed species is present in the project area. If no habitat exists, then no federally-listed species are present in the project area and there is no need to contact us for further consultation. If the above conclusion cannot be reached, further consultation with this office is advised. Information describing the nature and location of the proposed activity that should be provided to us for further informal consultation can be found at the above-referenced site.

Thank you for your coordination. Please contact us at 603-223-2541 if we can be of further assistance.

Sincerely yours,

Anthony P. Tur
Endangered Species Specialist
New England Field Office

Appendix E. Average Breeding Bird Frequency on Wilmot BBS Route (58011)

Taxonomic Sort[1]	Avg. birds/hr
Canada Goose	0.5
Wood Duck	0.6
American Black Duck	0.1
Mallard	0.5
Hooded Merganser	0.3
Ruffed Grouse	0.1
Wild Turkey	0.8
Pied-billed Grebe (NH-E)	**0.1**
American Bittern	0.2
Great Blue Heron	0.2
Northern Harrier (NH-E)	**0.1**
Sharp-shinned Hawk	0.1
Red-shouldered Hawk	0.1
Broad-winged Hawk	0.5
Killdeer	1.0
Spotted Sandpiper	0.1
Wilson's Snipe	0.3
Rock Pigeon	0.8
Mourning Dove	11.6
Black-billed Cuckoo	0.2
Yellow-billed Cuckoo	0.1
Barred Owl	0.1
Common Nighthawk (NH-T)	**0.1**
Chimney Swift	1.3
Ruby-throated Hummingbird	0.7
Belted Kingfisher	0.2
Yellow-bellied Sapsucker	4.6
Downy Woodpecker	1.5
Hairy Woodpecker	2.3
Yellow-shafted Flicker	0.8
Pileated Woodpecker	2.8
Olive-sided Flycatcher (*Yellow WL*)	0.1
Eastern Wood-Pewee	2.9
Alder Flycatcher	2.1
Least Flycatcher	2.8
Eastern Phoebe	8.6
Great Crested Flycatcher	1.2
Eastern Kingbird	2.3
Yellow-throated Vireo	0.1
Blue-headed Vireo	3.5
Warbling Vireo	0.6
Red-eyed Vireo	43.6

Frequency Sort[1]	Avg. birds/hr
Red-eyed Vireo	43.6
Ovenbird	27.5
American Robin	23.7
Black-capped Chickadee	20.9
American Crow	16.8
Cedar Waxwing	14.8
Chipping Sparrow	13.8
Blue Jay	11.7
Mourning Dove	11.6
Common Yellowthroat	11.2
Red-winged Blackbird	10.2
Veery	9.7
Black-throated Green Warbler	9.7
American Goldfinch	8.8
Hermit Thrush	8.7
Eastern Phoebe	8.6
Song Sparrow	8.4
Black-throated Blue Warbler	7.7
Myrtle Warbler	7.5
Tree Swallow	7.4
European Starling	7.4
Chestnut-sided Warbler	7.0
Wood Thrush (*Yellow WL*)	6.8
Winter Wren	6.1
Swamp Sparrow	5.9
Common Raven	5.7
Blackburnian Warbler	5.3
White-throated Sparrow	5.2
Scarlet Tanager	4.9
Yellow-bellied Sapsucker	4.6
Common Grackle	4.4
Gray Catbird	3.9
Red-breasted Nuthatch	3.8
Blue-headed Vireo	3.5
Black-and-white Warbler	3.2
White-breasted Nuthatch	3.1
Eastern Wood-Pewee	2.9
Pine Warbler	2.9
American Redstart	2.9
Pileated Woodpecker	2.8
Least Flycatcher	2.8
Indigo Bunting	2.6

Blue Jay	11.7
American Crow	16.8
Common Raven	5.7
Tree Swallow	7.4
Barn Swallow	0.8
Black-capped Chickadee	20.9
Tufted Titmouse	1.4
Red-breasted Nuthatch	3.8
White-breasted Nuthatch	3.1
Brown Creeper	1.5
House Wren	0.4
Winter Wren	6.1
Eastern Bluebird	0.3
Veery	9.7
Swainson's Thrush	0.2
Hermit Thrush	8.7
Wood Thrush (*Yellow WL*)	6.8
American Robin	23.7
Gray Catbird	3.9
Northern Mockingbird	0.1
European Starling	7.4
Cedar Waxwing	14.8
Nashville Warbler	1.2
Yellow Warbler	2.0
Chestnut-sided Warbler	7.0
Magnolia Warbler	2.4
Black-throated Blue Warbler	7.7
Myrtle Warbler	7.5
Black-throated Green Warbler	9.7
Blackburnian Warbler	5.3
Pine Warbler	2.9
Prairie Warbler	0.6
Black-and-white Warbler	3.2
American Redstart	2.9
Ovenbird	27.5
Northern Waterthrush	1.5
Common Yellowthroat	11.2
Canada Warbler (*Yellow WL*)	0.1
Scarlet Tanager	4.9
Eastern Towhee	0.3
Chipping Sparrow	13.8
Savannah Sparrow	0.2
Song Sparrow	8.4
Swamp Sparrow	5.9
White-throated Sparrow	5.2
Slate-colored Junco	1.7
Northern Cardinal	0.1

Magnolia Warbler	2.4
Hairy Woodpecker	2.3
Eastern Kingbird	2.3
Alder Flycatcher	2.1
Brown-headed Cowbird	2.1
Purple Finch	2.1
Yellow Warbler	2.0
Evening Grosbeak	2.0
Slate-colored Junco	1.7
Bobolink	1.7
Downy Woodpecker	1.5
Brown Creeper	1.5
Northern Waterthrush	1.5
Tufted Titmouse	1.4
Chimney Swift	1.3
Baltimore Oriole	1.3
Great Crested Flycatcher	1.2
Nashville Warbler	1.2
Rose-breasted Grosbeak	1.1
Killdeer	1.0
Wild Turkey	0.8
Rock Pigeon	0.8
Yellow-shafted Flicker	0.8
Barn Swallow	0.8
Ruby-throated Hummingbird	0.7
House Finch	0.7
Wood Duck	0.6
Warbling Vireo	0.6
Prairie Warbler	0.6
Canada Goose	0.5
Mallard	0.5
Broad-winged Hawk	0.5
House Wren	0.4
Hooded Merganser	0.3
Wilson's Snipe	0.3
Eastern Bluebird	0.3
Eastern Towhee	0.3
American Bittern	0.2
Great Blue Heron	0.2
Black-billed Cuckoo	0.2
Belted Kingfisher	0.2
Swainson's Thrush	0.2
Savannah Sparrow	0.2
House Sparrow	0.2
American Black Duck	0.1
Ruffed Grouse	0.1
Pied-billed Grebe (NH-E)	**0.1**

Rose-breasted Grosbeak	1.1	**Northern Harrier (NH-E)**	**0.1**
Indigo Bunting	2.6	Sharp-shinned Hawk	0.1
Bobolink	1.7	Red-shouldered Hawk	0.1
Red-winged Blackbird	10.2	Spotted Sandpiper	0.1
Common Grackle	4.4	Yellow-billed Cuckoo	0.1
Brown-headed Cowbird	2.1	Barred Owl	0.1
Baltimore Oriole	1.3	**Common Nighthawk (NH-T)**	**0.1**
Purple Finch	2.1	Olive-sided Flycatcher (*Yellow WL*)	0.1
House Finch	0.7	Yellow-throated Vireo	0.1
American Goldfinch	8.8	Northern Mockingbird	0.1
Evening Grosbeak	2.0	Canada Warbler (*Yellow WL*)	0.1
House Sparrow	0.2	Northern Cardinal	0.1
101 Total Species		**Cumulative Frequency**	**426.1**

[1] New Hampshire 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 Baker Valley CBC (NHBV)

Taxonomic Sort[1]	Avg. birds/hr
Canada Goose	0.08
Tundra Swan	0.01
American Black Duck	0.10
Mallard	0.46
Ring-necked Duck	0.00
Common Merganser	0.27
Ruffed Grouse	0.09
Wild Turkey	0.92
Bald Eagle (NH-E)	**0.01**
Sharp-shinned Hawk	0.01
Cooper's Hawk (NH-T)	**0.01**
Northern Goshawk	0.00
Red-tailed Hawk	0.02
Rough-legged Hawk	0.00
Herring Gull	0.01
Great Black-backed Gull	0.03
Rock Pigeon	1.41
Mourning Dove	2.21
Great Horned Owl	0.01
Barred Owl	0.02
Belted Kingfisher	0.01
Red-bellied Woodpecker	0.00
Downy Woodpecker	0.50
Hairy Woodpecker	0.43
Northern Flicker	0.01
Pileated Woodpecker	0.03
Northern Shrike	0.01
Blue Jay	4.71
American Crow	1.53
Common Raven	0.24
Black-capped Chickadee	13.55
Tufted Titmouse	0.56
Red-breasted Nuthatch	0.67
White-breasted Nuthatch	1.06
Brown Creeper	0.03
Golden-crowned Kinglet	0.24
Eastern Bluebird	0.01
American Robin	0.01
European Starling	0.56
Bohemian Waxwing	0.06
Cedar Waxwing	0.13
American Tree Sparrow	0.43

Frequency Sort[1]	Avg. birds/hr
Black-capped Chickadee	13.55
Blue Jay	4.71
American Goldfinch	3.28
Mourning Dove	2.21
Common Redpoll	1.83
American Crow	1.53
Rock Pigeon	1.41
House Sparrow	1.29
Evening Grosbeak	1.10
White-breasted Nuthatch	1.06
Wild Turkey	0.92
Red-breasted Nuthatch	0.67
Dark-eyed Junco	0.65
European Starling	0.56
Tufted Titmouse	0.56
Downy Woodpecker	0.50
Mallard	0.46
Hairy Woodpecker	0.43
American Tree Sparrow	0.43
Purple Finch	0.35
Northern Cardinal	0.27
Common Merganser	0.27
Common Raven	0.24
Golden-crowned Kinglet	0.24
Pine Siskin	0.18
House Finch	0.17
Cedar Waxwing	0.13
American Black Duck	0.10
Pine Grosbeak	0.10
Ruffed Grouse	0.09
Canada Goose	0.08
Red Crossbill	0.07
Bohemian Waxwing	0.06
White-winged Crossbill	0.04
Great Black-backed Gull	0.03
Brown Creeper	0.03
Pileated Woodpecker	0.03
Red-tailed Hawk	0.02
Barred Owl	0.02
Sharp-shinned Hawk	0.01
Bald Eagle (NH-E)	**0.01**
White-throated Sparrow	0.01

Chipping Sparrow	0.00
Fox Sparrow	0.00
Song Sparrow	0.01
White-throated Sparrow	0.01
Dark-eyed Junco	0.65
Northern Cardinal	0.27
Red-winged Blackbird	0.00
Brown-headed Cowbird	0.00
Pine Grosbeak	0.10
Purple Finch	0.35
House Finch	0.17
Red Crossbill	0.07
White-winged Crossbill	0.04
Common Redpoll	1.83
Hoary Redpoll	0.00
Pine Siskin	0.18
American Goldfinch	3.28
Evening Grosbeak	1.10
House Sparrow	1.29
61 Total Species	

American Robin	0.01
Cooper's Hawk (NH-T)	**0.01**
Belted Kingfisher	0.01
Tundra Swan	0.01
Herring Gull	0.01
Great Horned Owl	0.01
Northern Flicker	0.01
Northern Shrike	0.01
Eastern Bluebird	0.01
Song Sparrow	0.01
Northern Goshawk	0.00
Rough-legged Hawk	0.00
Red-bellied Woodpecker	0.00
Chipping Sparrow	0.00
Fox Sparrow	0.00
Brown-headed Cowbird	0.00
Hoary Redpoll	0.00
Ring-necked Duck	0.00
Red-winged Blackbird	0.00
Cumulative Frequency	**39.78**

[1] New Hampshire 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

<u>Midwest - Farmland</u>

- **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 and Forest

- **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

- **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