A Study of the Nocturnal Migration of Songbirds at the Searsburg, Vermont, Wind Energy Facility: Spring 1997

Prepared for:

Vermont Department of Public Service

National Renewable Energy Laboratory

Green Mountain Power Corporation

and

VERA

Prepared by:

Paul Kerlinger, Ph.D.
31 Jane St. 14D
New York, NY 10014
(212) 691-4910, fax 989-3323
email: pkerlinger@aol.com

26 July 1997

Nocturnal Migration of Songbirds at the Searsburg,

Vermont, Wind Energy Facility: Spring 1997

A Report Prepared for the Vermont Department of Public Service, National Renewable Energy Laboratory, Green Mountain Power Corporation, and VERA

Executive Summary

A study of nocturnal songbird migration was conducted between 1 and 31 May 1997 at the Green Mountain Power Corporation 11 turbine (Zond Z-40, 190 foot), 6 megawatt wind energy facility, Searsburg, Vermont. The purpose of the study was to gather information on the flight behavior of songbirds migrating at night over the newly constructed wind turbines. The information gathered in this study will be compared with behavioral information gathered in the spring of 1994 and autumns of 1996 and 1997. The present study constitutes an "after construction" scenario that, when compared with "preconstruction" studies will provide a before and after analysis of migratory flight behavior. Migration was observed for 60 minutes per evening on 14 clear nights using a modification of the ceilometer and moonwatching techniques. A 400,000 candle power spotlight/ceilometer was directed vertically and birds were observed as they passed through the beam. Observations commenced about one hour after sunset.

A total of only 5 migrants was observed, an average passage rate of 0.36 birds per hour (maximum of 2 birds per hour, minimum of 0 birds per hour). The direction of migration was to the north of east, somewhat downwind of prevailing westerly winds. However, the small number of observations precluded the computation of a true mean direction.

The rate of passage as determined by ceilometer in this study for southern Vermont is much lower than reported for most other migration studies including studies in central New York, South Carolina, Louisiana, and coastal Massachusetts. The passage rate is also lower than autumn passage rates at the same location, as well as passage rate determined in spring 1994. Passage rate was similar to, thought slightly lower than, a study from northwestern Maine. Because so few birds were observed passing through the ceilometer during this study, it is likely that migration passage rate over the hilltops of southern Vermont in spring is small. For this reason and because birds generally migrate higher than 200-300 feet at night, it is unlikely that wind turbines on these hills will cause undue adverse impact on populations of songbirds migrating through this area.

Paul Kerlinger, Ph.D.
31 Jane St. 14D
New York, NY 10014
(212) 691-4910

26 July 1997

Introduction

The development of windpower as an alternative to traditional fossil fuel energy promises to provide clean, unpolluting energy for the future. However, though wind power may not generate chemicals that pollute the atmosphere, opposition from environmentalists has gained momentum since the first windpower projects in the United States went on-line. One of the leading concerns of environmentalists is the impact of wind turbines on birds, which has been debated for about a decade. On one side are those who feel that wind turbines do or might pose a risk to birds, and on the other are those who feel that wind power development does not constitute an undue adverse impact. The latter argue that the few individuals that are impacted at some wind energy facilities are inconsequential when compared to the numbers impacted by other methods of generating power.

Whether an impact on individual birds or populations occurs and, if it does, whether it is consequential has yet to be determined because the actual impact of wind turbines on birds is not yet known. Because of perceived problems and because mortality has been documented at a few operating wind power facilities, research projects have been conducted recently or are now being conducted to clarify whether wind turbines impact birds and how/if birds modify their behavior to deal with operating wind turbines. By studying bird mortality/fatalities and bird behavior and ecology at existing wind power stations, we will begin to develop a comprehensive picture of the risk involved with developing wind power. Particularly, we will come to understand the magnitude of the risk in comparison with other methods of energy production and with other forms of development.

What has been found regarding wind turbine impact on birds has been summarized by Colson and Associates (1995). It seems that significant or undue impacts to populations of birds by wind power facilities occur at only a very few sites, if at all. It also seems that the impact is both site and season specific. That is, the degree of risk to birds is dependent upon where the facility is located and if birds migrate through a site or breed on the site. A review if the literature reveals that even within a large wind power field of thousands of turbines, there is variability, with some areas (and even individual turbines) having an impact while others do not.

A summary of the studies reveals that, to date, negative impacts on bird populations have not been documented (Kerlinger 1996a). Turbines do impact occasionally on individual birds, but these impacts have not been conclusively linked to a decline in a defined population. Definitive studies of population impacts are ongoing at several sites (Colson and Associates 1995), primarily to provide the information necessary to make intelligent decisions about future wind power development.

Birds are most vulnerable to potential impacts from turbines, towers, lighthouses, and other tall structures when they are flying in the same altitudinal strata as these objects. This occurs primarily when birds make foraging flights or when they are migrating. It can also happen during display flights, during which birds fly at 100 feet or more advertising their territory and attracting a mate.

During spring and autumn in North America, millions of songbirds undertake migrations between their breeding and wintering sites. Most, migrate during the night (Kerlinger and Moore 1989), along with other nocturnal migrants including waterfowl, herons and egrets, swifts and swallows, owls, and shorebirds (Kerlinger 1989, 1995a). Birds that use soaring flight during migration such as hawks, gulls, pelicans, and others migrate during daytime (Kerlinger 1989). Soaring flight is flight without flapping in which birds use updrafts to stay aloft. Nocturnal migrants like songbirds takeoff shortly after sunset, climb to their cruising altitude, fly for one to 12 hours, descend, and land. During this process migrants climb and descend through the first 200 feet above the ground. This occurs for only a small portion of their nightly flights. Most of the night is spent cruising at between 300 and 2,000 feet. Scientists who study migration are in agreement that a majority of migrants fly within this altitudinal band (Kerlinger 1995a).

To determine whether a given wind power project will impact upon migrants, planners need to know more about the numbers of migrants that pass through the project area and at what altitude they pass. In addition, the numbers collected at a proposed site must be compared with migration at other sites, particularly known migration hotspots. If large numbers of birds migrate at low altitudes in an area, the potential for adverse impacts to occur is greater than if small numbers of birds occur there. In addition to numbers of birds migrating over a site, planners also need to know more about behavioral responses of migrating birds when they are confronted by turbines. Do birds fly higher when they see turbines? Do they fly around windpower sites, or do change direction when they approach wind turbines? The answer to these questions will provide a more complete picture of the relationship between migrating birds and wind turbines.

A small wind energy project of 6 megawatts (11 wind turbines) has been constructed and is now being operated by Green Mountain Power Corporation in the hills of Searsburg, Vermont, a few miles west of Wilmington, Vermont. The wind turbines proposed will extend upwards to about 190+ feet above the ground. Because there is concern regarding the impact of wind turbines on birds, Green Mountain Power has commissioned breeding bird surveys (Capen and Coker 1994), surveys of endangered and threatened birds (Capen and Coker 1994), and hawk migration studies (Martin 1993, Martin 1994). To date, none of these studies has documented a scenario which would indicate undue adverse impact on birds.

The focus of the present study was to determine the amount of migration that occurs during nighttime in spring over the Searsburg site. In addition, the study examined the behavior of migrants encountering operating wind turbines. The data set described here will eventually be compared to studies conducted during spring 1995 and autumn 1996 and 1997. The birds that migrate over Searsburg at night are primarily songbirds, with some shorebirds, waterfowl, and other species mixed in. A large proportion of those songbirds are Neotropical migrants that fly to and from the Neotropics (Central and South America and the Caribbean Basin). These birds are now of particular interest because the populations of some species are declining. The types of

Neotropical and non-Neotroppical songbird migrants that fly over southern Vermont are summarized in Table 1. The numbers of birds migrating over the proposed windpower site will provide an indication as to the potential impact of the project on migrating songbirds, as will their behavior as they pass over or near the site.

Methods

The songbird migration study was conducted near Searsburg, Vermont in May 1997, at the site of the newly constructed windpower project. The actual study location was situated where turbine number 5 is situated at an elevation of about 2,700-2,800 feet asl (see Green Mountain Power Corporation Petition of Public Good, Vermont Public Service Board, 1995, for map of wind turbine locations). Dates of the study correspond to the peak of spring migration for Neotropical songbird migrants. At this time, songbirds are returning to New England from Central America, South America, and the Caribbean basin. In addition, many migrants are also returning from the southern and central United States, especially in the first week of the month.

To measure the numbers of migrants aloft and their flight direction, a standard ceilometer was used. A ceilometer is simply a very bright, narrow beamed spotlight. For the present study a 12 volt, 400,000 candlepower spotlight (Brinkman Q-Beam, "Black Max") was used. Power was supplied by a running automobile battery via a cigarette lighter converter. The ceilometer is aligned vertically with the aid of a bubble level. An observer reclines on his/her back and looks through a 22 power wide angle spotting scope that is also aligned vertically. By separating the spotting scope and the ceilometer by about 50 feet, insects that often fly in the lowest portion of the beam are not evident.

The ceilometer illuminates the underside of a migrant as it flies through the beam. Birds flying through a ceilometer beam are easily spotted. Their wings, tails, heads, and even breast spots at times are clearly visible. With the 400,000 candle-power ceilometer used in this study, birds the size of thrushes are visible to more than 600 feet and sometimes to more than 1,200 feet. Birds flying at higher altitudes are often missed, although these birds are not relevant to the present study because they cannot possibly be impacted. The ceilometer is ideal for examining low-level migration.

Flight direction is determined by recording clockface coordinates of the bird as it flies through the ceilometer beam. For example, with the observer looking upward in the prone position with head aligned to the north (12 o'clock), a bird seen flying from 6 o'clock to 12 o'clock is flying north. A bird seen flying from 3 o'clock to 9 o'clock is flying to the east and one flying from 9 to 3 is flying west.

When the moon was too bright for the Q-beam to be effective (three quarter and full moon in this study), moonwatching was substituted for ceilometer observations. Moonwatching for migrants is done by focusing a 22x spotting scope on the moon's disk. Birds can be seen crossing the moon in a fashion similar to crossing the ceilometer beam. Directions are read off a clockface that the viewer superimposes over the moon's disk. These clockface coordinates are calculated translated into actual directions (0-360°) by compensating for the moon's changing azimuth and angle above the horizon. This occurred on only three evenings during the study.

At about 60 minutes after sunset, ceilometer observations commenced. This period corresponds to the takeoff time and peak timing of migration for most night migrating songbirds. In addition, because it is so close to takeoff time, these birds would be flying at their lowest altitude and be readily visible. During observations short rest periods sometimes were taken. On all nights the total time for actual observations was 60 minutes. Operations were completed by a few minutes after 22:00 p.m. EDT.

Rudimentary weather data were gathered at the beginning of observations each evening and were noted if weather changed during an evenings work. Wind direction and speed, approximate temperature, and percent cloud cover were noted. In addition, precipitation was noted. Operations were terminated on the one evening when rain commenced prior to field work (although 14 nights of observations were completed).

Results and Discussion

Observations at Searsburg were conducted on 14 nights between 4 and 31 May, 1997 (Table 2). A total of 14.0 hours (840 minutes) of observations was logged. During the study, rain precluded observations on only one night (1 May).

During the 14 nights of observations a very small number of birds was observed. Migrants were noted on only about one-quarter of the nights of observation (4 of 14 nights). During 14.0 hours of observations only 5 migrants were seen, averaging 0.36 birds per hour. On only one night was more than 1 migrant seen; 2 on 17 May. Four of the five birds were seen in mid-month between 14 and 17 May and the remaining bird was observed on 25 May. The migration literature often states that most migration occurs on only a few nights and that migration occurs in waves. Each migration wave includes many thousands, or even millions of birds on the move. That 80% of the migrants occurred during the 4 day period in mid-month seems to agree with the literature and that this period is the peak of migration through southern Vermont. It also suggests that much of migration occurs on only a few days.

All migrants seen during the 1997 season were flying on nights with winds that were not favorable for migration. Most migrants were flying with west to north winds, which are usually considered adverse for spring migrants. In fact, only one night of the 14 on which observations were made, were winds favorable for migration. On that night wind was from the southwest. On all other nights winds were from the west to north, and mostly from the northwest.

Direction of migrants was primarily correct for spring, with the mean direction being slightly east of north. One bird (20% of the sample) was observed flying south. The remaining 80% were distributed from NW to E, not a narrow band. The axis of migration (straight line direction between wintering ground and breeding ground) for spring migrating songbirds in the eastern United States is to the northeast, which is close to the direction found for migrants observed.

Prevailing west winds explain the fact that the average direction of migration was to the east of north. Birds like songbirds, capable of flying at airspeeds of only 15-25 mph cannot fly into or across strong winds. Maximum winds during the 14 nights of observation did not exceed about 20 miles per hour, which is difficult for small birds to orient in.

A comparison of the passage rate observed for spring migration at Searsburg with passage rates observed at other localities is instructive. Passage rates for spring migration at Searsburg was less than those reported in other studies. For example, a study conducted on hilltops in northwestern Maine reported an average of 2.15 birds per hour, which several times greater than the passage rate (0.36 birds per hour) found in the present study. The passage rate for spring 1997 was actually much lower than the 1.89 birds per hour reported from the same site in 1995 (Kerlinger 1995b) and lower than the 4.55 birds per hour reported from this site in autumn 1996

(Kerlinger 1996b).

Studies conducted in North Dakota (Avery et al. 1973) reported rates of about 1 to 18 birds per hour for an average of 5.3 birds per hour. This is more than 10 times the rate found in the present study. Farther south in Georgia, Able and Gauthreaux (1975) reported passage rates averaging more than 50 birds per hour, which is more than 150 times greater than found in southern Vermont. Even the highest one night passage rate (2 birds per hour) in southern Vermont was less than the lowest passage rates from Georgia. A range of 18-130 birds per hour was observed in Georgia, while during autumn the range was 21 to 503 birds per hour (Able and Gauthreaux 1975). In Louisiana, Gauthreaux (1969) and Able and Gauthreaux (1975) have reported autumn passage rates of more than 800 birds per hour. These migration passage rates are frequently one to two orders of magnitude larger than the 0.36 birds per hour found in the present study. Thus, the numbers of birds seen in Vermont were far fewer than reported farther south using the same methodology. This means that compared to these locations, the probability of wind turbines striking migrants is much lower than at almost any other location where migration has been studied.

Topographic features such as coastlines, rivers, and long, linear ridges are known to concentrate songbird migrants. There are few topographic features near the Searsburg site that act to concentrate migrants. A study in central New York near Albany showed that the Hudson River was a "leading line" for migrants when winds were strong from the west during autumn migration (Bingman et al. 1982). Ceilometer passage rates in this study (and unpublished data from these authors) were much greater than those reported from southern Vermont (this study). Passage rates of greater than 10 birds per hour are normal from the Hudson Valley near Albany and the surrounding area. Greater rates of passage, often exceeding 30-40 birds per hour were not uncommon.

Although no ceilometer data are available, it is likely that the passage rates are much lower than those in coastal areas of New England. This assessment is based on personal observations in coastal New York and Cape May, New Jersey. It is also based on radar studies conducted along the coast of Massachusetts (Nisbet 1963) and the Canadian maritime provinces (Richardson 1971). A regression technique developed by Able and Gauthreaux (1975) describing the relationship between numbers seen on radar and ceilometer yields insight as to how many birds would be seen on radar in Vermont. This compared with coastal radar studies of migration by Nisbet and his colleagues shows that the density of migrants over Vermont is much lower than along the Massachusetts coast. The reason for this is because inland migration occurs over a very wide area and is diffuse, whereas birds concentrate along the coast because they are reluctant to fly out over the Atlantic Ocean.

At the Searsburg site, there are no rivers, lakes, or ocean coastlines, or ridges to act as leading lines, concentrating large numbers of birds into a small area. Instead, the landscape is dominated by hills and valleys that meander in directions that are seldom appropriate for migration. The data collected in this study do not document any concentrating effect at the study site. The migration passage rate from this study of less than 1 bird observed per hour indicates that there is a diffuse, broad-front migration that is most likely similar to the rate over hundreds or thousands of square miles of this portion of New England. Another possibility is that birds move through the valleys rather than crossing the higher ground where winds are stronger and would make migration more energetically expensive. In addition, prevailing westerly winds would tend to push or drift birds off course if they flew above the higher hills.

Before closing this section it is important to explore what is known about the altitude of nocturnal migration and bias inherent in the method used in this study. Ceilometers are biased to low altitude migrants. They are most effective for detecting birds below 1,500 feet so that birds above 2,000 or 2,500 feet are rarely seen. The reason for this is because the ceilometer beam cannot illuminate sufficiently birds that are more than 2,500 feet or more above the ground. Also, small birds are difficult to see at altitudes of more than 1,000 feet. It is possible that the actual passage rate of migrants over the Searsburg site is greater than the rate found in this study because of ceilometer bias. However, if birds are flying at altitudes beyond the range of the ceilometer they will not be impacted by turbines.

It should be remembered that ceilometer bias is inherent in <u>all</u> studies using this method. Therefore, the results of studies conducted in different parts of the world remain comparable, giving a relative estimation of the amount of migration that occurs at low altitudes. Because songbird migration at night proceeds mostly between 300 and 2,000 feet (Able 1970), ceilometers detect a goodly proportion of those migrants that are aloft.

Conclusions

Although we do not know a great deal about the impacts of wind turbines on songbirds migrating at night at specific sites, we have a great deal of general information about migratory behavior that will help us determine the potential for impacts. In addition, we are quickly gaining site specific information, as gathered in this study, that will help us make informed decisions as to potential impacts at proposed wind energy sites. Studies like the present one are important not only for the 11 turbine project now operating at Searsburg, but they are useful for siting wind projects in other portions of Vermont and New England.

From what was observed in 1995 before the turbines were erected and in 1997 after construction of the turbines, it seems unlikely that the Green Mountain Power Corporation wind energy facility at Searsburg, Vermont, will cause undue impact on populations of nocturnally migrating songbirds. This statement is based on the fact that the migration passage rates found in this study and in other studies at Searsburg and elsewhere in New England show that passage rate is very low. It is also based on what has been established regarding the altitude of migration in concert with the dearth of low flying migrants at Searsburg.

Simply put, the density of night migrating songbirds over the Searsburg site is lower than reported in virtually all previous ceilometer studies. Migrants flying over southern Vermont, and probably over most of inland New England, are dispersed over a very wide area. They are not concentrated, at least at Searsburg, where they could be impacted adversely by towers.

Just as important, except during takeoff and landing, migrants usually fly at altitudes that are well above the height of the wind turbines proposed for Searsburg. Considered in light of the scarcity of migrants observed at Searsburg, this means that only a small number of birds could potentially be impacted and only during a small portion of a night's flight. Together, these facts should discount fears that the Searsburg wind energy facility will unduly impact populations of night migrating birds.

Literature Cited

Able, K. P. 1970. A radar study of the altitude of nocturnal passerine migration. Bird-Banding 41:282-290.

Able, K. P., and S. A. Gauthreaux. 1975. Quantification of nocturnal passerine migration with a portable ceilometer. Condor 77:92-96

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

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

Capen, D. E., and D. R. Coker. 1994. Avian studies - proposed Green Mountain Power wind turbine project - Searsburg and Readsboro, Vermont, Summer 1994. Report to Green Mountain Power.

Colson & Associates. 1995. Avian interactions with wind energy facilities: a summary. Report for the American Wind Energy Association.

Gauthreaux, S. A. 1969. A portable ceilometer technique for studying low-level nocturnal migration. Bird Banding 40:309-320.

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

Kerlinger, P. 1995a. How Birds Migrate. Stackpole Books, Mechanicsburg, PA.

Kerlinger, P. 1995b. A study of the nocturnal migration of songbirds at the Searsburg, Vermont proposed wind energy facility: Spring 1995. Report prepared for the Green Mountain Power Corporation.

Kerlinger, P. 1996a. A literature survey of tower and wind turbine impacts on birds in the northeastern United States and the influence of ceilometers on bird flight. Vermont Department of Public Service, Green Mountain Power Corporation, National Renewable Energy Laboratory, and VERA.

Kerlinger, P. 1996b. Nocturnal migration of songbirds during autumn at Green Mountain Power Corporation's Searsburg, Vermont, windpower facility - 1996-1997. Interim Report. Vermont Department of Public Service, Green Mountain Power Corporation, National Renewable Energy Laboratory, VERA.

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

Martin, N. 1993. Hawk migration at Searsburg, Vermont - 20 September to 28 October 1993. Report prepared for Green Mountain Power Corporation.

Martin, N. 1994. Hawk migration at Searsburg, Vermont - 1 to 20 September 1994. Report prepared for Green Mountain Power.

Nisbet, I. C. T. 1963. Measurements with radar of the height of nocturnal migration over Cape Cod, Massachusetts. Bird-Banding 34:57-67

Richardson, W. J. 1971. Spring migration and weather in eastern Canada: a radar study. American Birds 25:684-690.

Table 1. Representative samples of Neotropical and non-Neotropical songbirds that migrate at night through southern Vermont, area during spring and autumn.

Neotropical Species	Non-Neotropical Species*
Least Flycatcher	Brown Creeper
Chimney Swift	Winter Wren
Blue-gray Gnatcatcher	Ruby-crowned Kinglet
Veery	American Robin
Swainson's Thrush	Hermit Thrush
Red-eyed Vireo	Pine Warbler
Canada Warbler	Palm Warbler*
Ovenbird	Yellow-rumped Warbler*
Blackpoll Warbler	Red-breasted Nuthatch
Black-throated Blue Warbler	Purple Finch
Magnolia Warbler	Song Sparrow
Bobolink	Northern Junco
Baltimore Oriole	Rufous-sided Towhee
Scarlet Tanager	White-throated Sparrow
Rose-breasted Grosbeak	
Indigo Bunting	

* Some individuals of these species, especially those with western populations, migrate to and from the Neotropics and some migrate, at times, during daylight hours.

Table 2. Summary of night migrating birds flying over the Green Mountain Power Corporation Searsburg, Vermont, wind energy site during spring 1997. Each day included one hour of ceilometer observations unless indicated by an asterisk, which indicates moon watch was used. Wind speed is given in miles per hour. Percentage is sky cover (clouds). Temperature is in degrees Fahrenheit.

Date/Time	Number of Birds	Direction of Birds	Weather
1 May	0		Thunderstorms/No Survey
4 May/2050-2200	0	na	0-5 NW, 0%, 39 F
5 May/2100-2200	0	na	0-5 N-NW, 10%, 38 F
8 May/2100-2230	0	na	5-10 NW, 10-25%, 41 F
11 May/2110-2220	0	na	12-15 NW, 5%, 45 F
14 May/2105-2200	1	S	10-20 W, 100%, 45 F
16 May/2115-2220	1	E	5-10 SW, 75%, 50 F
17 May/2115-2215	2	N,NNW	10-15 N, 85%, 53 F
19 May/2105-2210	0	na	10-25 NW, 100%, 50 F
*20 May/2100-2200	0	na	10-20 N, 5%, 45 F
*24 May/2100-2210	0	na	10-15 NW, 20%, 50 F
*25 May/2100-2200	1	E	5-10 NW, 30%, 55 F
27 May/2115-2220	0	na	5-10 NW, 5%, 40 F
28 May/2110-2210	0	na	5-15 W, 0%, 55 F
31 May/2105-2205	0	na	15-20 NW, 50%, 60 F
14 Surveys	5	N-NE	

Total Hours = 14+ Average = 0.36 birds per hour

Time in excess of one hour included rest periods such that net time observing was equal to one hour per evening.