Massachusetts Technology Collaborative

Community Wind Collaborative – Town of Wellfleet

SITE FEASIBILITY STUDY
B&V Project Number 135720.1200

Funded by the Community Wind Collaborative of the Renewable Energy Trust

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Notice

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Abstract

Black & Veatch reviewed the feasibility of developing a community wind energy project in Wellfleet, Massachusetts. The wind resource was estimated using wind data collected on site, as well as from nearby sources and the state wind resource map. Land use and operational issues were reviewed, specifically the proximity of the sites to coastal homes and its location within the Cape Cod National Seashore. The known electric infrastructure and loads in Wellfleet were reviewed to understand the feasibility of using some of the generated energy in a net metering scenario pursuant to the language S. 2768 (the Green Communities Act). Likely permitting requirements were also listed. The costs for two major development options were estimated, and the cash flows of the projects were reviewed. Black & Veatch found no obvious fatal flaws, although there are concerns regarding home proximity, impacts to tourism, and the Cape Cod National Seashore.

Keywords

Renewable Energy Trust
Massachusetts Technology Collaborative
Community Wind Collaborative
Town of Wellfleet
Cape Cod
Wind Energy
Wind Power
Black & Veatch
Feasibility Study

1.0 Executive Summary

The Massachusetts Technology Collaborative (MTC) has entered into a Work Order (WO08-3) with Black & Veatch to perform a wind project feasibility study for the Town of Wellfleet. This report provides the results from this study, and provides recommendations regarding further review of this project.

1.1 Study Results

The results of this feasibility study show many aspects of a potential project in Wellfleet that are favorable to development, as well as several that are unfavorable. Most of the unfavorable issues can be worked around, but it will take care and effort on the part of the Town and any consultants or contractors they choose to employ.

Aspects Favorable to Development:

- Based on data collected at the site and at the airport in Provincetown, the estimated long-term wind resource near White Crest Beach in Wellfleet is about 6.96 m/s (15.6 mph) at 49 meters above ground level, and about 7.69 m/s (17.2 mph) at 80 meters above ground. The wind shear component, α, was estimated to be about 0.27.
- The land west of White Crest Beach that is owned by the Town of Wellfleet could support up to three large wind turbines while maintaining required and recommended setbacks from homes and property lines. Construction and turbine equipment access is not expected to be an issue.
- There is a 115 kV transmission line directly west of the project area. The Town of Wellfleet owns land between the transmission line and project area that could be used for transmission access.
- Production estimates for the project and turbine options considered range from about 36 to 37 percent, which would generally be classified as "very good."
- Preliminary financial analysis indicates that a wind project in Wellfleet is likely to be financially viable for the Town, but might not meet required hurdle rates for a private developer. In general the economic payback is higher for the Town of Wellfleet than for a private developer.

Aspects Unfavorable to Development

- Current town bylaws include modern wind turbines in their definition of "windmills," and all utility-scale wind turbines are too large to meet the requirements set forth. These bylaws will need revising.

- Wellfleet is a seasonal community prized for its scenic view and recreational opportunities. There may be significant opposition to a wind project because of real or perceived threats to these aspects of the Town.
- There are potential issues with shadow flicker that could cause a nuisance to houses immediately to the east of the project site.
- The entire project area is located within the boundaries of the Cape Cod National Seashore, which will limit the ease of development and may make third party ownership or commercial operation impossible.
- Capital costs for the various project options are high, ranging from about $2,210 per kW for a three turbine project to about $2,670 per kW for a single turbine project.

1.2 List of Recommendations

- The Town of Wellfleet should keep open communication of project plans with the community, and provide the community with important information such as visual simulations and analyses of noise, shadow flicker, environmental, and other impacts.
- Erosion is a possible issue. Although a project may not be directly affected by erosion during its lifetime, there may be significant peripheral impacts such as reduced site access or shifting of the soil. A formal erosion study should be performed during project development if a project moves forward.
- The addresses, ownership, and type of use of the houses affected by shadow flicker should be compiled so a better analysis of actual shadow flicker impacts can be performed.
- A more detailed noise study should be performed, including ambient noise measurement on-site.
- A more complete environmental review should be performed, preferably a formal review with on-site observations by a biologist.
- The project site should be mapped for wetlands at an early stage if project development moves forward.
- At least six months for permitting should be included in any project schedule, with the possibility that more time may be required to work with the Cape Cod National Seashore.
- The Town of Wellfleet will need to address the bylaws concerning windmills in the Town, and amend them to make the installation of large turbines in the town possible.

2.0 Introduction

2.1 Background

The Massachusetts Technology Collaborative and the Town of Wellfleet began working on a community scale (1 to 10 MW) wind project in Wellfleet about two years ago. The Renewable Energy Research Lab (RERL) at the University of Massachusetts at Amherst installed a 50 meter met tower near White Crest Beach, which was considered to be the most feasible location for a wind project in Wellfleet. The tower was installed in November of 2006, and is currently recording wind data.

Black & Veatch traveled to Wellfleet in January of 2008, and met with Town officials and members of the Alternative Energy Committee to discuss the work to date, this study, and how it would be performed. Black & Veatch visited the potential site as well as nearby areas that may be sensitive to visual impacts.

Based on the information obtained from MTC, RERL, the Town of Wellfleet, the site visit, and other public data sources, Black & Veatch produced this feasibility study, which attempts to capture the various aspects of a community wind project in Wellfleet.

2.2 Objective

The objective of this report is to assess the feasibility of building a community scale wind project in the Town of Wellfleet, on Cape Cod, adjacent to the coast and the Atlantic Ocean. Feasibility of a wind project at a location such as Wellfleet requires assessment of the wind resource, but also assessment of the various environmental, regulatory, political, and community issues that such a project will inevitably face.

2.3 Report Organization

This report is organized into the following sections:

- **Wind Resource:** This section looks at the wind resource data collected in Wellfleet, as well as long-term reference data from the Provincetown Airport, and makes an estimate of the long-term wind resource available at the site.
- **Site Physical Characteristics:** This section contains a general description of the potential project site, its current use, existing infrastructure, site access, and the overall suitability of the potential site for wind project development.
- **Site Electrical Infrastructure:** This section explores the known electrical infrastructure near the site, including potential interconnection points and overall interconnection feasibility.

- **Site Vicinity:** This section describes the general vicinity of the site, including possible visual and noise impacts, airspace impacts, telecommunications impacts, and the level of perceived overall community acceptance.
- **Potential Environmental Concerns:** This section outlines the various environmental concerns associated with the site, including known habitats of threatened or endangered flora and fauna, areas of critical environmental concern, wetlands, and overall environmental impact.
- **Permitting:** This section is an outline of the various permitting issues, including zoning and the possible impact of Wellfleet's windmill bylaws. It includes a list of likely permits and a general timeline.
- **Conceptual Design:** This section lays out a conceptual project design, including turbine choices, two project configurations, and a more detailed assessment of shadow flicker and noise impacts.
- **Project Development Considerations:** This section is an overview of ownership options, financing sources, operations and management of the project, and other development considerations.
- **Estimated Energy Production:** This section estimates net energy production from the chosen wind project designs and wind resource at the site.
- **Cost Estimate:** This section contains a general cost estimate.
- **Project Revenues:** This section attempts to quantify the revenue streams from the potential wind turbine projects, including energy savings, energy sales, and Renewable Energy Credit (REC) sales.
- **Financial Analysis:** This section shows the results of a simplified financial analysis.

3.0 Wind Resource

The wind energy resource of a project site is the most critical single aspect to understand, and is one of the few that cannot be overcome with technical solutions. This section discusses the various sources of wind resource information available for the region, and combines them into an estimate of the wind resource for Wellfleet.

3.1 Wind Data Reviewed

For Wellfleet, Black & Veatch reviewed several wind data sources, most of which were generated by the University of Massachusetts Renewable Energy Research Lab (RERL). These sources were:

- Wind data collected by RERL from a 50 meter meteorological tower sited in a parking lot near White Crest Beach, MA (November 2006 – February 2008)
- Wind data collected by RERL from the Highlands Center, Truro, MA 50 meter meteorological tower (March 24, 2006 through April 25, 2007)
- Wind Data Collected by the Provincetown Municipal Airport AWOS station (July 1990 – February 2008)
- *Wind Data Report: Wellfleet*, RERL, Fall 2006 Quarterly Report
- *Wind Data Report: Wellfleet*, RERL, Winter 2006-2007 Quarterly Report
- *Wind Data Report: Wellfleet*, RERL, Spring 2007 Quarterly Report
- *Wind Data Report: Wellfleet*, RERL, Summer 2007 Quarterly Report
- *Wind Data Report: Wellfleet*, RERL, Final Report
- *Eastham, MA: Sodar-Based Wind Resource Assessment*, RERL, July 10, 2007
- The New England Wind Map web site operated by TrueWind Solutions (http://truewind.teamcamelot.com/ne/)

The information available from each above resource is discussed in this section, and the resources are combined into a complete wind resource estimate for Wellfleet in Section 3.2.

3.1.1 Wellfleet Met Tower Data and RERL Reports

RERL installed a 50 meter (164 feet) tall meteorological (met) tower in Wellfleet to the west of White Crest Beach in November of 2006. The first data returned from the met tower was on November 20, 2006. The met tower is located at approximately 41°56’1.1” N, 69°58’51.7” W (WGS84) at an elevation of approximately 21 meters (68 ft) above sea level. The tower collected wind speed data and direction data from sensors located at 49, 38, and 20 meters (160.7 feet, 124.6 feet and 65.6 feet, respectively) above ground level, as well as temperature data at 2 meters (6.5 feet).

The tower is sited in the southwest corner of a parking lot along Ocean View Drive; approximately 200 meters from the shoreline. The tower itself is surrounded by dense shrubs and small trees on the north, south and west sides. This vegetation reaches an approximate height of 15 feet. There are no buildings or other large obstructions in the area save a small building on the opposite corner of the lot, about 80 meters (263 feet) away which is not expected to affect the wind resource measurement at this site. The terrain in this area consists of moderate rolling hills with elevation gradually increasing to the north-northwest; however, there is a significant drop-off (50 to 60 feet) to the east along the shoreline. The location of the Wellfleet tower is shown in Figure 3-1. The instrumentation on the tower is shown in Figure 3-2.

Because there was over a year of data available from this met tower, which was equipped and installed primarily for wind energy resource measurement, Black & Veatch concluded this to be the best source of data to base wind energy predictions upon. Also, the close proximity of these sites and similarity of the terrain features enables the resulting wind energy production estimates to represent the turbine performance at each site.

Figure 3-1. Wellfleet Met Tower Location.

Figure 3-2. Wellfleet Met Tower Instrumentation.

Black & Veatch reviewed each of the five *Wind Data Report: Wellfleet* RERL reports prepared quarterly on the met tower's data collection, as well as raw (or unfiltered) 10 minute data for November 20, 2006 through February 14, 2008. This information was obtained from the RERL web site and directly from RERL. The monthly average wind speeds are listed in Table 3-1 and shown in Figure 3-3. The values of wind shear were determined between the anemometers mounted at 49 meters and 38 meters above ground level; the results will be discussed further in Section 3.2. A cumulative power density wind rose based on the 49 meter level wind speed and 20 meter wind direction sensors is shown in Figure 3-4.

Table 3-1. Monthly Average Wind Speeds for Wellfleet.

Month/Year	Measured Wind Speed (m/s)			Wind Shear
	49 meters	38 meters	20 meters	
2006				
November	8.47	8.10	7.02	0.210
December	7.41	6.95	5.69	0.297
2007				
January	7.78	7.28	6.04	0.283
February	7.88	7.47	6.28	0.256
March	8.61	8.14	6.80	0.267
April	7.88	7.51	6.39	0.239
May	6.76	6.40	5.45	0.243
June	6.94	6.53	5.49	0.263
July	5.67	5.35	4.52	0.253
August	5.77	5.37	4.49	0.279
September	6.18	5.85	4.93	0.255
October	5.28	6.05	5.06	0.279
November		6.91	5.92	0.243
December		7.03	6.06	0.232
2008				
January		7.37	6.19	0.272
February		7.45	6.21	0.287
Annual Average	**7.06**	**6.78**	**5.71**	**0.267**

Source: RERL.

Notes: Months shaded in gray have less than a complete month of data available.
Wind shear values determined between anemometers at 49 and 38 meters above ground level.

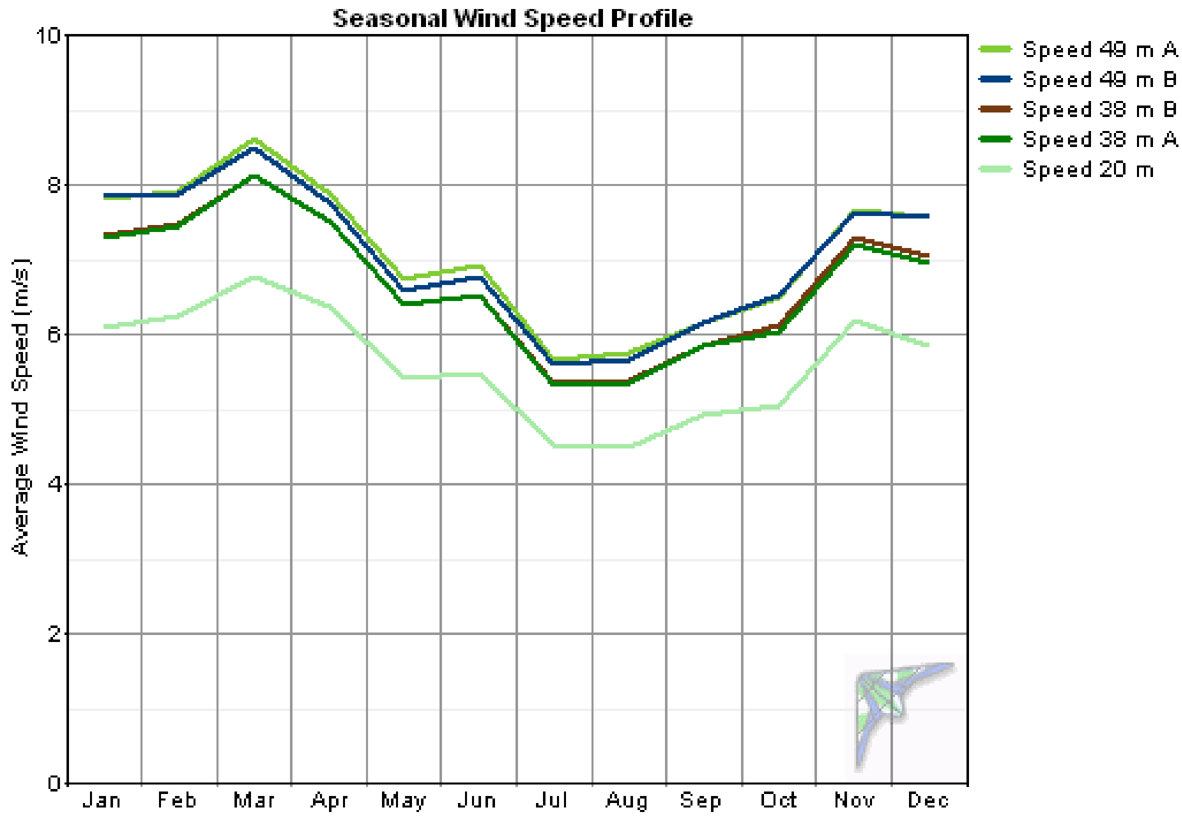

Figure 3-3. Wellfleet Seasonal Wind Speed Averages.

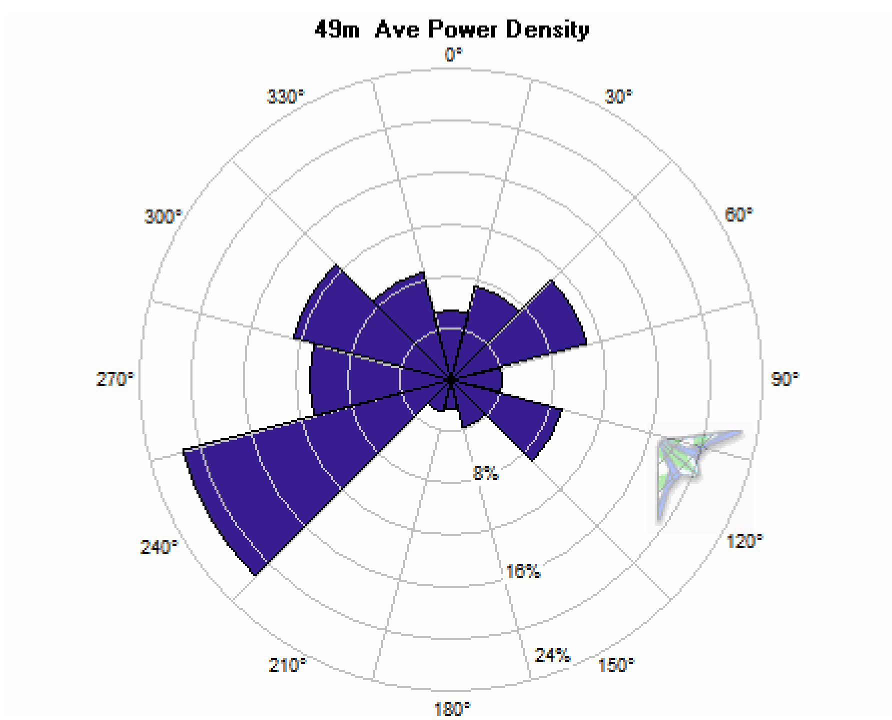

Figure 3-4. Wellfleet Power Density by Direction.

3.1.2 Highlands Center, Truro Wind Data

RERL operated a met tower in Truro, MA located at coordinates 42º 01’ 47.316” North, 70º 03’ 3.924” West (WGS84), about 8 miles from the Wellfleet met tower. This meteorological campaign utilized a standard 50 meter met tower to collect wind speed and direction data from sensors mounted at 50 meters, 38 meters, and 35 meters above ground level. RERL monitored wind conditions at this site from March 24, 2006 through April 25, 2007. This data set was used to validate the wind speed and shear profile for the Wellfleet met tower.

Black & Veatch reviewed the 2006/2007 RERL reports on the met tower’s data collection as well as 10 minute data from March 2006 through April 2007. This information was all obtained from the RERL website. The monthly average wind speeds are listed in Table 3-2 and shown in Figure 3-5. The values of wind shear were determined between the anemometers mounted at 50 meters and 38 meters above ground level. The percent energy wind rose for the 2006/2007 dataset is shown in Figure 3-6.

Table 3-2. Monthly Average Wind Speeds for Truro.

Month/Year	Measured Wind Speed (m/s) 50 Meters	38 Meters	35 Meters	Wind Shear
2006				
March				
April	7.90	7.28	7.05	0.305
May	7.68	7.10	6.87	0.314
June	6.84	6.32	6.10	0.305
July	6.94	6.37	6.16	0.325
August	5.88	5.40	5.23	0.322
September	6.47	5.96	5.74	0.328
October	8.12	7.48	7.22	0.318
November	7.42	6.86	6.58	0.329
December	8.18	7.49	7.24	0.322
2007				
January	8.72	8.04	7.76	0.304
February	8.63	8.00	7.74	0.279
March	9.15	8.44	8.17	0.309
April				
Annual Average	**7.75**	**7.16**	**6.92**	**0.309**

Source: RERL.

Notes: Months shaded in gray have less than a complete month of data available.
Wind shear values determined between anemometers at 50 and 38 meters above ground level.

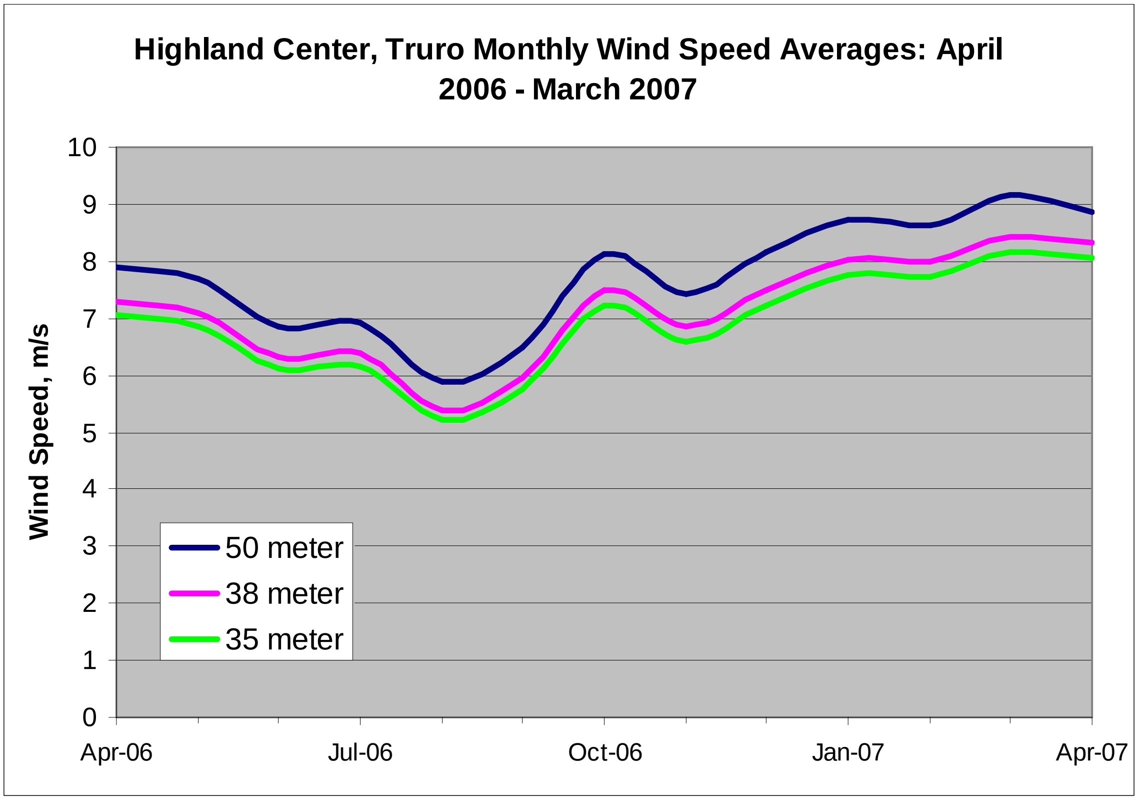

Figure 3-5. Highlands Center, Truro Monthly Wind Speed Averages.

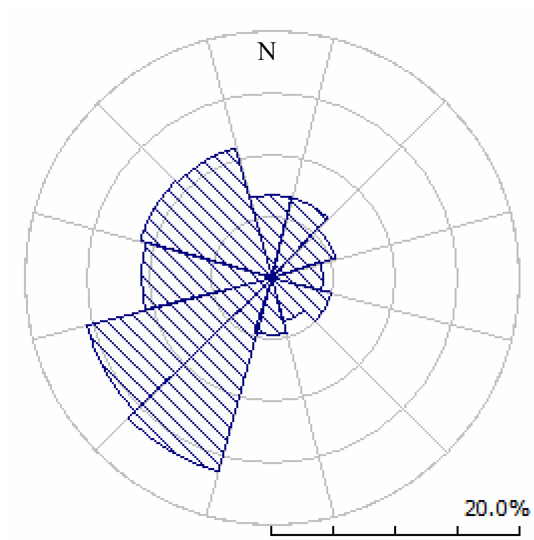

Figure 3-6. Highlands Center, Truro Percent Energy Wind Rose.

3.1.3 Eastham SODAR Data

RERL performed wind resource analysis at a site in Eastham utilizing a portable Sound Detections and Ranging (SODAR) system. SODAR systems use acoustic signals to observe wind speed and direction conditions between 30 meters and 160 meters above ground level (at 10 meter intervals). RERL used their SODAR system to collect data over a six month period in Eastham, and reported their findings in the report referenced above. Black & Veatch reviewed the report for this analysis, but did not review the collected data itself.

The RERL SODAR system was installed at the Eastham site on November 17, 2006, and removed on May 8, 2007. RERL reported problems keeping the SODAR unit operating (due to power issues) during the first few months of their campaign, and only recorded data for a few hours each day resulting in an overall data recovery of less than 40 percent. RERL indicated that by February 10, 2007 the SODAR unit was operating with limited interruptions in the data stream and the total recovery of valid data increased to 65 – 70 percent at heights up to 120 meters, but valid data was also recovered at heights up to 160 meters.

While SODAR systems can provide a great deal of information, it is evident they can be difficult to operate and maintain. The vast majority of wind resource information gathered for wind energy projects comes from anemometers on met towers over long periods of time (e.g., from Wellfleet & Truro, discussed above). Due to the short data collection intervals and high data loss amounts at the Eastham sites Black & Veatch chose not to use the SODAR data to determine the long term wind speed averages.

A critical wind resource parameter from the SODAR data that Black & Veatch does note is the vertical wind shear characteristics of the two sites. A typical assumption used in wind resource analysis is that wind speed increases with height above ground by an exponential relationship. This assumption is critical when data collected at a lower height (such as 49 meters in the case of the Town of Wellfleet's met tower) is used to predict the performance of a wind turbine whose rotor is centered at a greater height (such as 80 meters, as was done for this study). The correlations between the Eastham SODAR data and the Wellfleet and Truro met tower data are shown in Figure 3-7. A close relationship exists between the datasets. The trend line fits of the SODAR and met tower data shown in Figure 3-8 indicate that a power law approximation is a valid method for determining wind speeds at the Truro and Wellfleet sites.

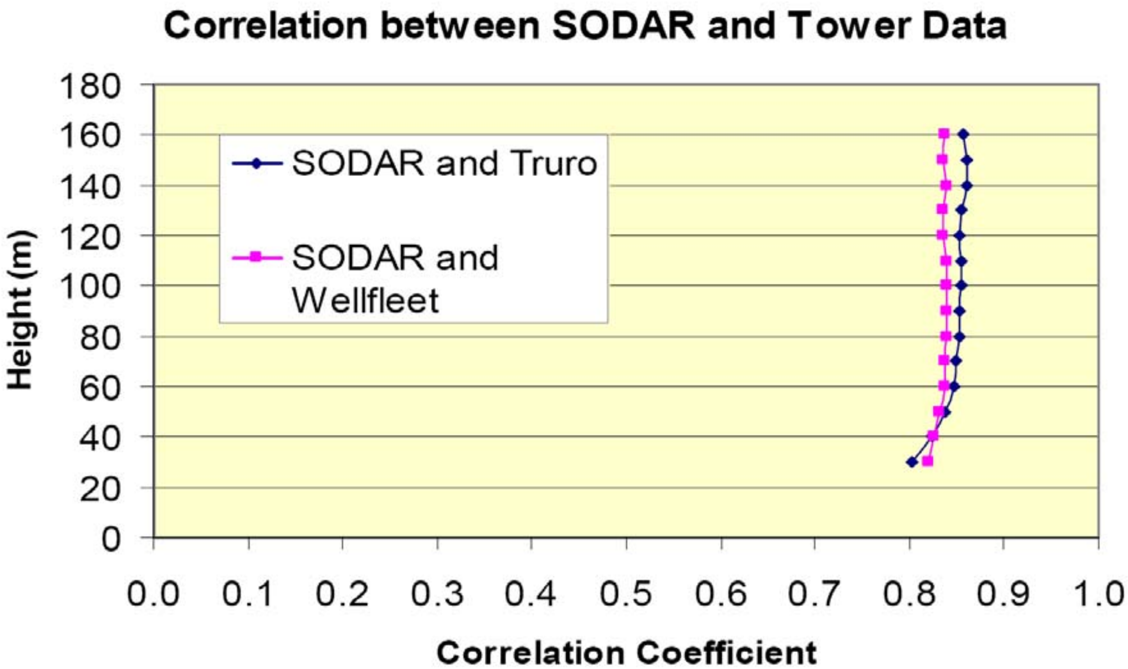

Figure 3-7. Eastham SODAR Correlations to Truro & Wellfleet Met Data.

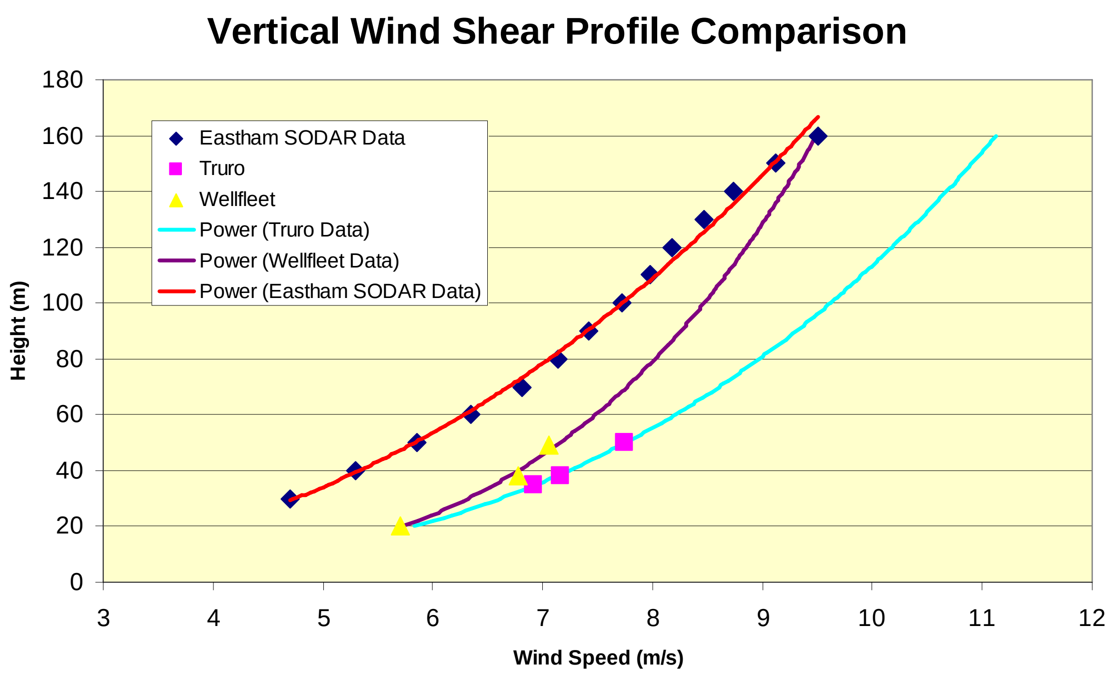

Figure 3-8. Vertical Wind Shear Comparison.

3.1.4 Provincetown Municipal Airport AWOS Station

While a year of data collection at or near a project site is usually deemed necessary for a wind energy project, a long-term data source is also needed to put the collected data into a historical perspective. Since the wind conditions at a site can change considerably between individual years, comparing the year over which data was collected to a long-term average becomes important to understand a site's average long term wind resource. Therefore Black & Veatch used the wind data collected at the Provincetown Municipal Airport as a long-term data source for preliminary wind resource estimates.

The Provincetown Municipal Airport AWOS station is located at approximately 42º04' North, 70º13' West (WGS84). This location is approximately 15 miles northwest of the Town of Wellfleet's prospective wind site at an elevation of 2.4 meters above sea level. The Provincetown Municipal Airport met tower is a National Oceanic and Atmospheric Administration (NOAA) Airway Weather Observation Station (AWOS), identified by call sign "PVC" and WBAN Identification number 64708. Figure 3-9 shows an example of this type of weather station.

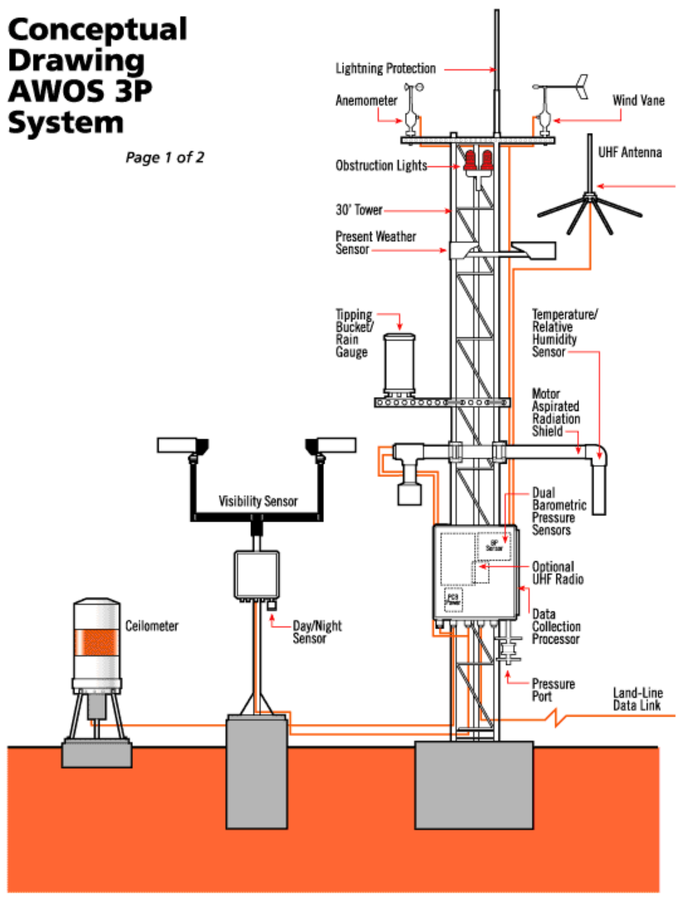

Figure 3-9. Typical AWOS Weather Station (from NOAA web site).

NOAA publishes hourly data collected at this station, and Black & Veatch reviewed the data collected from January 1996 through December 2007. Monthly averages from these years are presented in Table 3-3, and shown in Figure 3-10.

Table 3-3. Monthly Average Wind Speeds for Provincetown Municipal Airport.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1990						4.8	3.6	3.8	4.1	5.7	7.5	6.6
1991	5.9	5.1	6.3		4.6	4.4	3.4		5.3	6.0	6.0	
1992	7.0	6.7	6.3	4.8	4.9	4.9	3.7	3.7	4.2	5.0	4.9	7.0
1993	6.2	6.9	5.6	5.1	3.3	4.4	3.3	2.8	4.2	5.1	5.3	6.5
1994	6.6	6.2	5.3	4.0	4.7	4.3	3.6	3.6	4.2	4.7		6.3
1995	6.1	6.3	4.3	4.5	3.7	3.3	3.4	3.4	3.9	4.6	5.2	6.4
1996	5.8	6.4	5.5	5.4	3.9	3.2	4.1	3.0	4.3	4.6	6.1	5.7
1997	6.9	6.1	6.3	5.9	4.5	3.9	3.8	3.3	4.6	4.4	5.7	
1998	5.7	6.4	5.4	4.5	3.6	3.7	2.8		4.6	6.0	5.9	6.2
1999	6.7	6.4	7.0	5.0	3.5	3.9	4.3	4.1	4.4	5.4	6.4	6.6
2000							3.6		4.5	5.1	6.2	7.1
2001	5.9	6.7	6.3	3.9	4.3	3.5	3.7	3.7	4.1	5.6	5.6	5.8
2002	6.5	6.9	5.4	5.0	4.3	4.1	3.5	3.7	4.4	4.7		
2003	7.9	7.2	5.2	4.8	3.7	3.8	3.5	3.9	3.3	4.9	5.5	7.8
2004	8.1	6.6	5.7	4.6	4.4	4.0	3.6	4.0	4.4	5.2	6.3	6.5
2005	6.8	5.7	6.5		4.7	4.6	4.0	3.3	4.0	5.7	5.6	6.8
2006	6.0	7.1		4.8		4.2		3.9				6.3
2007	6.6	7.2	6.4	5.5	4.5	4.1	3.7	3.6	4.1	4.7	6.7	6.2
Average	6.1	6.3										

Note: All values in meters per second.

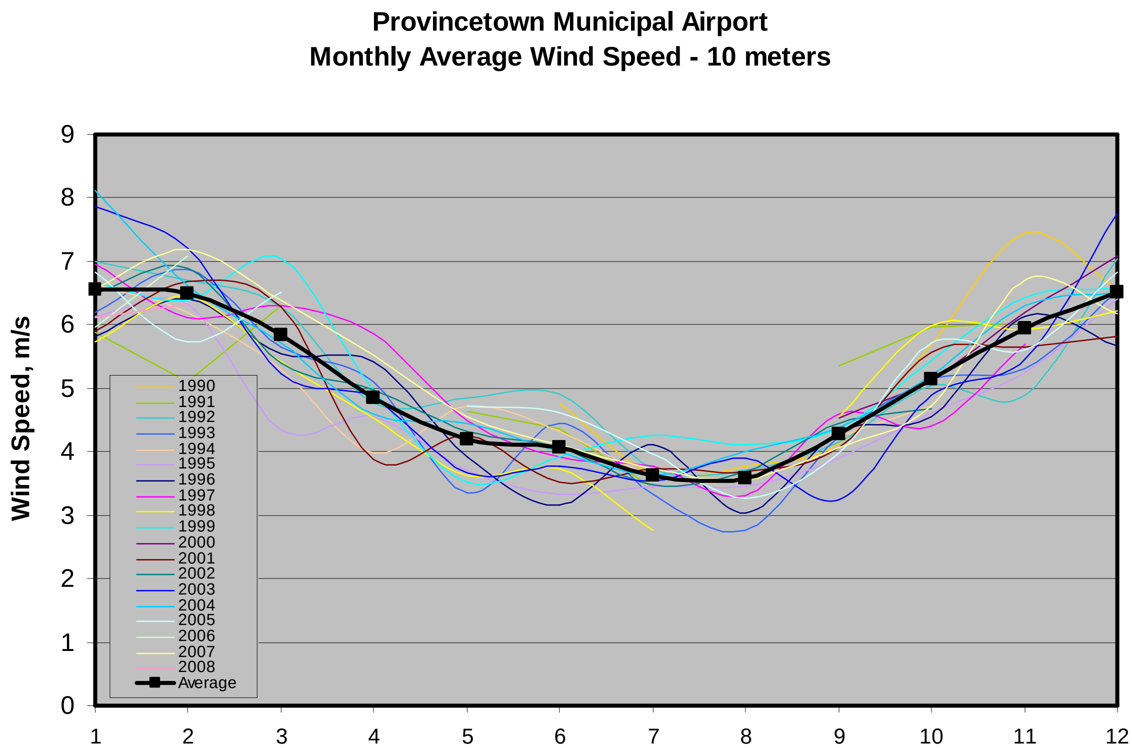

Figure 3-10. Monthly Average Wind Speeds at Provincetown Airport.

Wind data collected at airports is not intended for wind energy resource measurement since it is commonly collected with instruments fairly low to the ground. At Provincetown Municipal Airport, the data was collected at 10 meters (33 feet) above ground level, far lower than the 80 meter hub height of interest in this report. Since scaling this low-level data upward to the proposed turbine hub heights is not preferable when a better data source is available, Black & Veatch did not attempt to use this data directly for wind resource estimation. Instead, Black & Veatch used the Provincetown Municipal Airport data to review how data collected at the Provincetown tower over the time period when the Wellfleet met tower was in operation compares with the long-term average from the Provincetown tower. This comparison, and the subsequent impact to the Wellfleet data is presented in Section 3.2.

3.1.5 Massachusetts Wind Resource Map Information

Black & Veatch also referenced the New England Wind Resource Map web site (truewind.teamcamelot.com/ne/) for general information on the wind resource for the area around the project site. This map is a model of the wind resources for all of New England, and was created from atmospheric data and calibrated using various data measurement locations. Creation of this map by TrueWind Solutions was funded by MTC, the Connecticut Clean Energy Fund, and the Northeast Utilities System.

By entering the coordinates of the Wellfleet Met Tower and the prospective Wellfleet turbine sites, the web service estimated the annual average wind speed to be 6.8 m/s at 50 meters above ground level, and 7.5 m/s at 70 meters above ground level for the Wellfleet site. A wind rose for the site was also downloaded from the web site and shown below in Figure 3-11. These results should be considered to be a general estimate for the area, and not as accurate as the site collected data. The model has a specified resolution of 200 meters and a standard error estimated at 0.6 m/s.

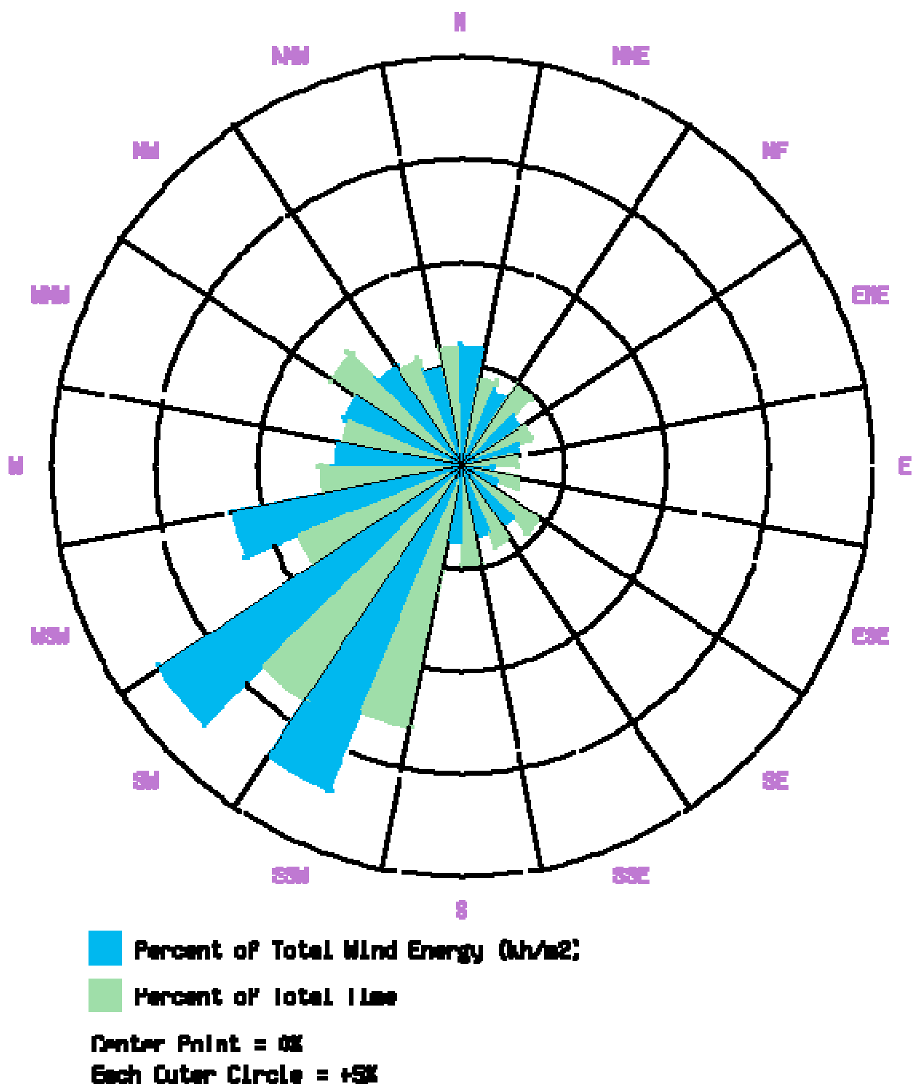

Figure 3-11. New England Wind Map Wind Rose for Wellfleet.

3.2 Site Wind Resource Estimate

As discussed in the previous section, Black & Veatch had several sources of wind resource information available for the Town of Wellfleet. To produce the most accurate estimate of the resource, Black & Veatch used some information from each source. The procedure used to create this estimate is described in this section.

As the closest site to the perspective development areas with over a year of wind data at a height near typical wind turbine hub heights, the Town of Wellfleet's met tower dataset became the primary data source. Other data sources mentioned in previous sections were used to validate wind resource characteristics such as seasonal wind speed patterns and shear. As a check on data quality, Black & Veatch performed correlations between the Wellfleet's met tower data and the other local data sources on a daily and monthly basis. Table 3-4 and Table 3-5 show the daily and monthly correlation estimates (respectively) of the Truro and Provincetown Municipal Airport datasets to the Town of Wellfleet dataset.

Table 3-4. Daily Met Data Correlations to Other Local Datasets.

	Truro 50m Wind Speed	Truro 38m Wind Speed	Truro 35m Wind Speed	Provincetown 10m Wind Speed
Wellfleet 49m Wind Speed	0.964			0.513
Wellfleet 38m Wind Speed		0.969		0.430
Wellfleet 20m Wind Speed			0.946	0.421

Table 3-5. Monthly Met Data Correlations to Other Local Datasets.

	Truro 50m Wind Speed	Truro 38m Wind Speed	Truro 35m Wind Speed	Provincetown 10m Wind Speed
Wellfleet 49m Wind Speed	0.791			0.816
Wellfleet 38m Wind Speed		0.803		0.866
Wellfleet 20m Wind Speed			0.723	0.871

The correlations of the Town of Wellfleet's met data and the Truro met data are strong enough to indicate that these towers were experiencing similar wind condition changes on a daily and monthly basis. The weaker correlation of the Wellfleet met tower data, collected every 10 minutes, to the Provincetown municipal airport data, collected daily, may be due to nearby obstructions to the weather station, which affect how wind speeds change on this time interval.

The next step in the wind resource estimate was to put the Town of Wellfleet's wind speeds into a historical perspective. Black & Veatch compared the monthly average wind speeds for the data collected at the long-term reference station (Provincetown Municipal Airport) over the period the Wellfleet data was collected (December 2006 through February 2008) with the monthly average wind speeds of every complete month on record. A set of adjustment factors was then established for each month. These are used to scale the 2006/2007/2008 averages to the long-term averages (shown in Table 4-6). These adjustment factors were then applied to the Wellfleet data to create an estimate of the long-term wind resource. Based on these adjustment factors, the long term average wind speed for Wellfleet at 49 meters is estimated to be 6.96 m/s. This average applies to the other prospective sites for development given their close proximity.

Table 3-6. Long-Term Wind Speed Adjustment Factors.

Year	Month	Adjustment Factor
2006	December	1.0418
2007	January	0.9955
2007	February	0.9032
2007	March	0.9150
2007	April	0.8756
2007	May	0.9208
2007	June	0.9901
2007	July	0.9768
2007	August	1.0068
2007	September	1.0486
2007	October	1.0916
2007	November	0.8850
2007	December	1.0554
2008	January	1.0706
2008	February	1.0280

Finally, Black & Veatch adjusted the 49 meter long-term Wellfleet wind speed data to get the estimates for the long-term averages at the wind turbine hub height of interest, 80 meters. To make this height adjustment, Black & Veatch utilized the wind shear power law approximation, which defines the relationship between wind speed and height above ground as:

$$V(Z) = V(z_r) \cdot \left(\frac{z}{z_r} \right)^{\alpha}$$

where: V(z) = wind speed at height of interest
V(zr) = wind speed at reference height
z = height of interest
zr = reference height
α = wind shear component

Black & Veatch utilized the Wellfleet data collected at 20, 38 and 49 meters to estimate the wind shear component, alpha "α", to be about 0.267, a value similar to other wind energy sites in the U.S. As a validation check, Black & Veatch reviewed the shear values from similar heights of other datasets from met towers on Cape Cod. Table 3-7 shows the resulting values for the wind shear component at other sites.

Table 3-7. Cap Cod Average Wind Shear Values.

Data Source	Heights Used	Wind Shear, α
Wellfleet Met Data (Short-Term)	49, 38 and 20 meters	0.267
Wellfleet Met Data (Long-Term)	49 and 38 meters	0.246
Truro Met Data	50 and 30 meters	0.323
Eastham Met Data	39 and 30 meters	0.400
Eastham Sodar Data	50 and 40 meters	0.450

While each of these other sites experience higher wind shear, these higher values are likely due to the relatively high surface roughness & obstacles surrounding the met locations.

The resulting long-term averages for Wellfleet at various heights above ground are given in Table 3-8, and shown in Figure 3-12. The resulting power density wind rose for the 80 meter data is shown in Figure 3-13.

Table 3-8. Estimated Wellfleet Long-Term Wind Average Wind Speeds.

Month	Average Wind Speed (m/s)		
	38 meters	49 meters	80 meters
January	7.59	8.10	9.05
February	7.05	7.51	8.34
March	7.43	7.91	8.73
April	6.61	7.01	7.64
May	5.89	6.25	6.78
June	6.47	6.88	7.58
July	5.24	5.59	6.17
August	5.42	5.81	6.49
September	6.14	6.54	7.22
October	6.60	7.09	7.90
November	6.65	7.08	7.80
December	7.25	7.77	8.68
Annual	**6.53**	**6.96**	**7.69**

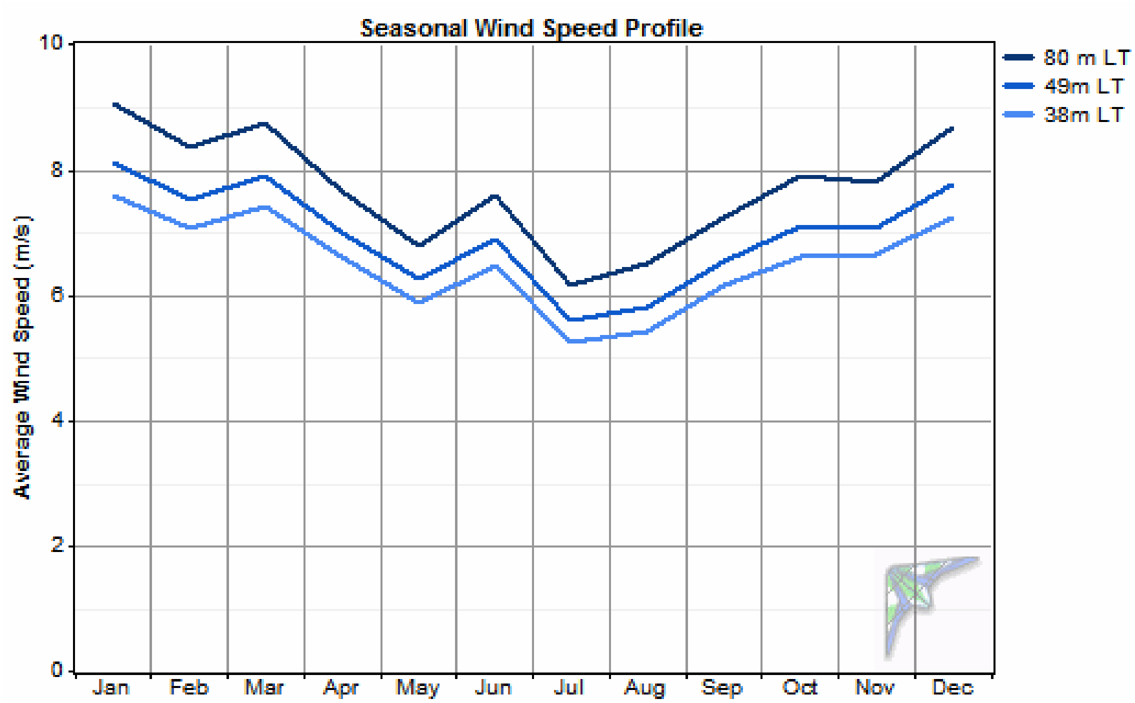

Figure 3-12. Wellfleet Long-Term Monthly Average Wind Speeds.

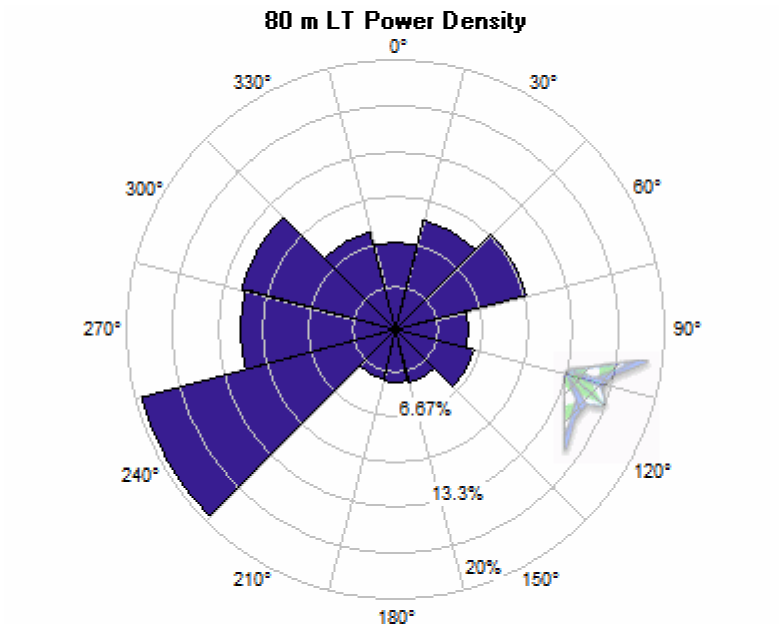

Figure 3-13. Wellfleet 80 Meter Power Density Wind Rose.

As part of the International Electrotechnical Commission (IEC) 61400 series of standards governing the design of wind turbines, a series of designation are given to the wind resource of a site. These designations are used to match the appropriate turbine designs and models for a site's wind conditions. Based on the 3rd edition of the IEC standard 61400-1, the wind resource in the Wellfleet site area appears to have a Class IIC designation. Figure 3-14 shows the mean characteristic turbulence intensity graph of the 49 meter data. This graph also includes the IEC turbulence categories for comparison. Figure 3-15 shows the return period for extreme wind speeds based upon a best-fit Gumbel distribution. Ultimately, the designation of the site as it applies to the design of a specific wind turbine will be evaluated by the wind turbine manufacturer, to ensure the proper wind turbine model is provided.

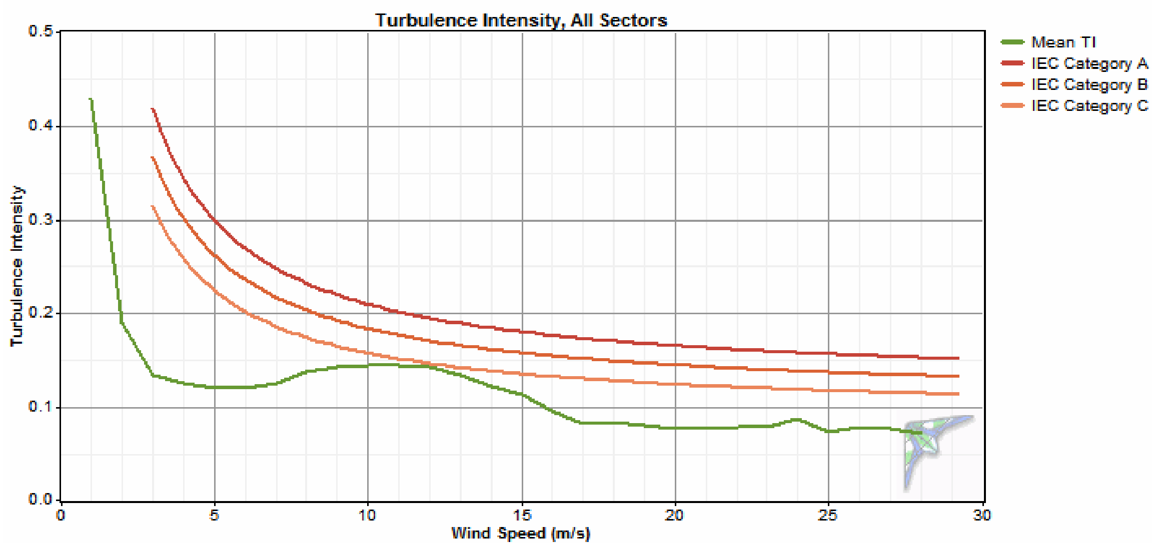

Figure 3-14. Town of Wellfleet Turbulence Intensity.

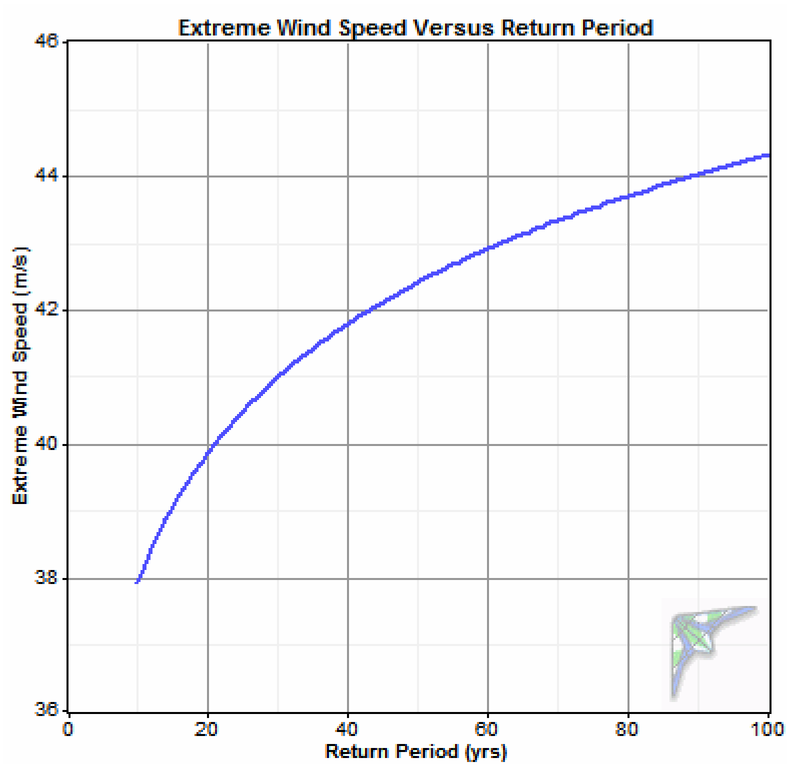

Figure 3-15. Town of Wellfleet Extreme Wind Speeds.

3.3 Resource Estimate Accuracy

Generally a full year of on-site wind data collection is considered the minimum requirement for development of a wind energy project. This site has about 15 months of on-site data. Additionally, Cape Cod is well studied from a wind resource perspective.

Wind data from nearby sites was available for correlation, as was over 10 years of historical reference. The accuracy of the wind resource estimate for Wellfleet would generally be considered to be good.

3.4 Site Viability

From a wind resource perspective this would be considered a viable site for development. Based on the long-term average wind speeds seen at the site, Black & Veatch would expect project capacity factors in the mid 30 percent range.

4.0 Site Physical Characteristics

This section evaluates the site's physical characteristics, including topography, land cover, land use, access roads, and buildings.

4.1 General Description

The project location described in this report is within the town of Wellfleet, Massachusetts. Wellfleet is located on Cape Cod near the middle of the north-south peninsula. The topography around the discussed project site is flat with elevations varying between sea-level and 100 feet. The land immediately adjacent to the proposed turbine sites has previously been zoned for residential use. The western portion of this area remains largely undeveloped while the eastern portion is a fully-developed residential area. There are several airports located on Cape Cod, the closest being Provincetown Municipal Airport, approximately 15 miles to the northwest of the general area under review. Access to the Cape is possible via Route 6, which follows the center of the Cape from south to north. The site itself can be easily accessed via Route 6 and short distances of 2 miles or less on side roads, making transport of wind turbine components to the sites relatively easy.

This feasibility study is focused on the placement of up to three large wind turbines on the proposed parcel. Prior to Black & Veatch performing this study, Jim Sexton assisted the Town of Wellfleet in identifying possible turbine locations. Jim, a former National Renewable Energy Laboratory (NREL) employee and California wind developer, provided hand sketched locations on a parcel map that was provided to Black & Veatch.

4.2 Site Usage

The site in review for this project is located near White Crest Beach on the eastern shore of Cape Cod. There exists a small housing development on the eastern portion of the parcel with houses that overlook the Atlantic Ocean. White Crest Beach at the northeastern portion of the parcel is a popular spot for recreational activities. The entire site is considered protected land within the Cape Cod National Seashore and has undergone little development other than the houses mentioned above. The western section of the parcel is an undeveloped area that appears to have been zoned as an expansion of the residential area.

4.3 Site Infrastructure

The existing infrastructure at the site appears to be very limited. There is a parking lot for White Crest Beach immediately to the east of the considered site, as well as an electrical distribution line along Ocean View Drive. Other than the residences to the east of the proposed project site, there are no adjacent buildings and no known underground infrastructure.

4.4 Potential Turbine Location Suitability

The Town of Wellfleet owns an area of undeveloped land just west of Ocean View Drive and White Crest Beach on the east side of the cape. There is sufficient land in this area to install several wind turbines while maintaining necessary setbacks from adjacent land and homes. The approximate boundaries of the Town-owned land are shown in Figure 4-1.

Figure 4-1. Town-Owned Land (Approximate).

Other than a few paved roads and what appear to be un-maintained dirt access roads, there is no development on the site. Road access for operations needs should be easy via existing roads and the turbine access roads that would be built during project construction. There are no known or apparent safety concerns with development in this area, as it does not appear to be used recreationally or commercially.

The primary areas of concern with this potential site are the potential visual and noise impacts on nearby residences. The residences east of Ocean View Drive are generally ocean-facing and appear to be used as vacation homes. While turbines at this site would not interfere directly with views of the Atlantic Ocean, there may be real or perceived issues regarding noise, shadows, and other intrusions. Noise and shadow flicker are discussed in more detail in Section 9.4.

A potential issue is the effect of erosion on the project site. It was indicated to Black & Veatch that erosion is a significant issue on this part of the cape, and that the cliff to the east is receding rapidly. Turbines sited in the potential project area should be far enough from the cliff that erosion should not directly affect them. However, there is a possibility that, within the 20 year project lifetime, erosion could affect Ocean View Drive, which is considered the most likely access route to the site.

4.5 Turbine Separation and Setback

This section discusses the spatial separation of the turbine sites from surrounding structures and known property lines.

4.5.1 Town of Wellfleet Zoning Bylaws

The town of Wellfleet currently has a zoning bylaw concerning the permitting and requirements for installing a wind turbine ("windmill"). Section number 6.5.1 of the Wellfleet zoning bylaws indicates setback requirements for a windmill to be the total height of the structure tower base-to-blade tip plus 20 feet. This setback requirement is smaller than the setback recommendation in the State's Model Wind By-Law, which Black & Veatch used as a point of reference. A copy of this document is included in Appendix G. The recommendation is for a setback distance of 1.5 times the height of the turbine tower from the base to the blade tip. The difference between the required and recommended setbacks is about 54 meters (180 feet). Meeting the Wellfleet bylaws concerning setback requirement is not expected to be an issue and can readily be built into the project design given the parcel of land being considered. However, additional windmill bylaws set forth by the Town of Wellfleet pose issues for this project. The current zoning bylaws for wind turbines in the Town of Wellfleet are such that it puts this project in violation of the turbine size requirements. Black & Veatch feels that these bylaws can perhaps be easily modified due to the Town of Wellfleet's involvement and interest in this project, but would need to take place before moving forward with the development of this project. The bylaws are discussed in detail in Section 8.2 of this report. The windmill bylaws can be found in their entirety in Appendix F.

To facilitate installation of a wind project in the Town of Wellfleet, the following changes to existing bylaws are recommended:

- The minimum setback distance from occupied buildings should be increased to 1.5 times the total turbine height, per the State recommendations.
- The minimum setback distance from property lines or public right of ways should be increased to a minimum of 100 feet, per the State recommendations.
- The maximum tower height (base to center of rotor) requirement should be changed to a maximum total height (base to tip of blade circle) requirement, and increased from 65 feet to at least 400 feet above grade.
- The restriction on maximum rotor diameter should be removed.
- The climbing access restriction should be revised to include a locked access door.
- The excessive noise requirement should be changed to an absolute maximum A-weighted sound pressure level (including ambient) or a relative A-weighted sound pressure level above ambient. The State recommendations are a maximum increase in A-weighted sound pressure level of 10 db(A) at the property line or nearest occupied structure. An absolute maximum of 55 db(A) including ambient at the nearest occupied structure may also be a reasonable restriction.

4.5.2 Turbine Siting Requirements

Black & Veatch typically uses three general guidelines for locating wind turbines on a specified parcel of land:

- Minimum spacing between the wind turbines so they do not interfere with each others operation.
- Setbacks recommended for public safety.
- Setbacks required per zoning laws.

Wind turbines generate electricity by transferring energy from the wind to the turbine's drive-train. Because they take energy from the wind, and because they are large structures, wind turbines create an area around them in which the wind flow is disturbed. Placing wind turbines too close together would result in one turbine being within the disturbed area of another, causing turbines to "steal" the wind energy from each other. To avoid this, there are two general rules about placement of wind turbines. The first is to place turbine towers at least three times the turbine rotor diameter (3D) from each other in the direction perpendicular of prevailing winds. The second is to place turbines at least 8D from each other in the direction parallel to prevailing winds. The reason for the different spacing is that the wake effects of turbines are much greater downwind than they are cross-wind. Figure 4-2 shows a diagram of this concept.

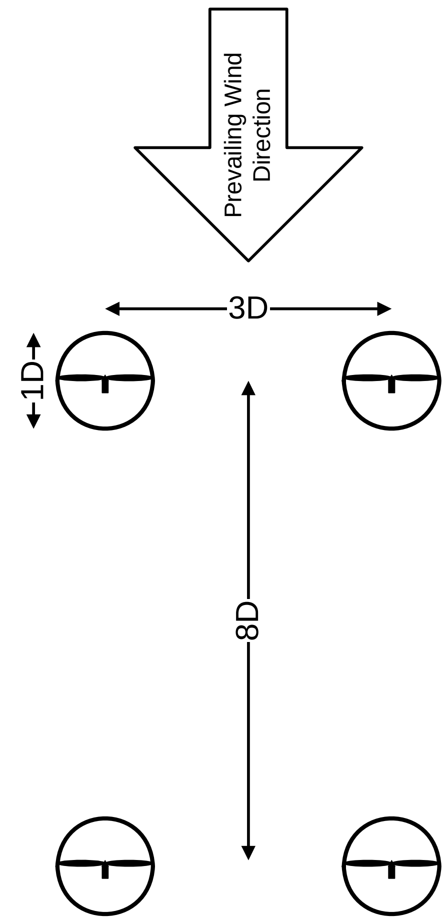

Figure 4-2. Typical Wind Turbine Spacing.

4.5.3 Typical Wind Turbine Spacing.

The prevailing wind direction for Wellfleet site reservation is expected to be generally from the southwest (240°) and, to a lesser extent, the northwest (315°). It should be noted that these guidelines are not absolute requirements. Spacing may be tighter when land use conditions require it. If closer spacing is required, an increase in the corresponding turbine's losses would also be included in the performance projection to account for the lost energy.

4.5.4 Public Safety

When Black & Veatch evaluates the general public safety issue for a wind turbine, usually the most catastrophic (and highly unlikely) scenario of complete turbine collapse is considered. Black & Veatch defines a safety zone around the turbine base equal to the maximum height of the turbine, and locates the turbine such that no public areas fall within this zone. Because the project site is undeveloped, Black & Veatch expects that the safety setbacks should be relatively easily met.

4.5.5 Preliminary Turbine Separation and Setbacks

Black & Veatch was provided with preliminary turbine locations, which were determined by Jim Sexton as a representative of the Town of Wellfleet. Mr. Sexton has a background in the wind industry and provided hand-drawn coordinates showing appropriate setbacks from property lines and nearby residences. After reviewing these sites with respect to the topics listed above, Black & Veatch has determined that these locations satisfy appropriate requirements for both of the turbine types reviewed in this report.

The available property is immediately adjacent to several homes and roads, however there is sufficient space that the distance from the nearest turbine to homes would be about 1,300 feet (396 m), well past both the suggested setback of 1.5 times the total turbine height (about 590 feet or 180 m) and the setback required in the town bylaws. The distance from the nearest turbine to Ocean View Drive and the recreation opportunities at White Crest Beach is about 1,000 feet (305 m), and the distance to the far end of the parking lot is about 800 feet (244 m).

4.6 Site Access

Access to the potential project site does not appear to be a major issue, but there are potential concerns. Access to the Cape from the mainland is possible over either the Sagamore or Bourne bridges. If components are shipped to Boston, then the Sagamore Bridge via Highway 3 appears to be the most likely route. If components are shipped from the west via the Interstate, the Bourne Bridge may be preferable. Shipping information from GE indicates that clearances of at least 15 feet are required for transport of several components. Information provided by MTC indicates that several overpasses on the main highway (Route 6) in Cape Cod have clearances lower than this. Careful routing may be able to avoid issues, by using alternate routes with grade crossings. If the project moves forward, turbine transport should be discussed with potential vendors. A detailed road survey will almost certainly be required at this point.

From the highway, access to the project area from the highway would require about 2 miles of driving on slightly smaller two lane rural roads, but these should also be sufficient for transport of equipment and personnel to the site. Figure 4-3 shows a likely route from the highway to the turbine site in blue, with the assumption that project access roads would start from the existing White Crest Beach parking lot.

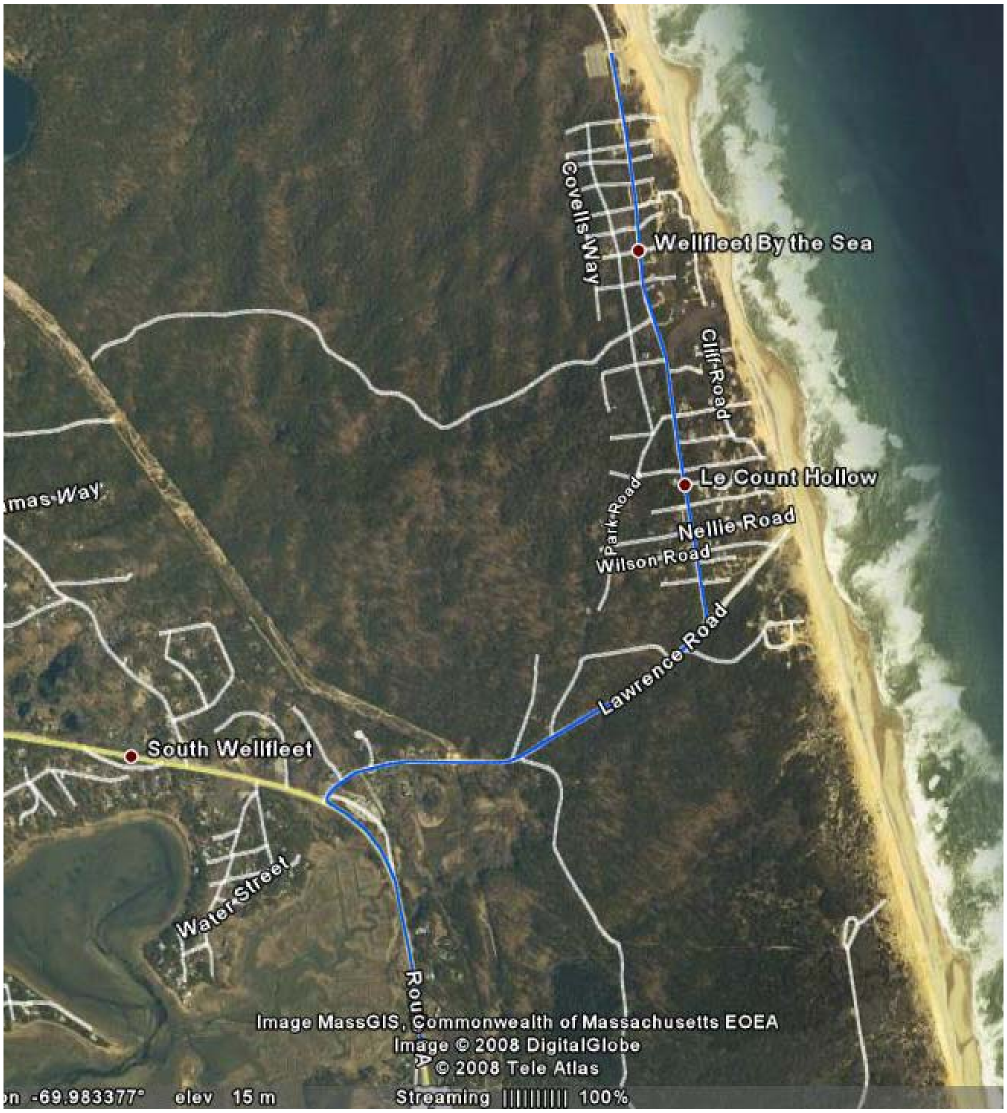

Figure 4-3. Likely Site Access Route.

While Black & Veatch feels that there are no major issues with this route, further surveying of the grade and turn radius would be performed by the wind turbine component transportation provider to more fully assess the transportation requirements.

Accessibility from water routes is likely not feasible due to the size requirements of transport equipment and the need for a large port where the wind turbine equipment can be offloaded and put onto trucks. Black & Veatch recommends road transportation to be the most viable option for the shipping of components to the project site.

5.0 Site Electrical Infrastructure

This section is an evaluation of the site electrical infrastructure, including existing transmission and/or distribution system line locations and voltages.

5.1 Potential Interconnection Points

As there is no direct load at the proposed project site, a wind project will have to connect to existing transmission or distribution lines directly. The project site is located adjacent to an existing 115 kV Transmission line owned by Commonwealth Electric Company (an NSTAR subsidiary). The close proximity of this line makes it a viable option for installing a three turbine project. Connection to distribution lines Figure 5-1 shows the Commonwealth 115 kV line and it's location along the Cape.

Figure 5-1. Existing Transmission Lines near Wellfleet.

The 115 kV line terminates at the Wellfleet 576 substation just to the northeast of downtown Wellfleet. This transmission line appears to be the main source of electricity for the Cape area and is in very close proximity to the project site. Figure 5-2 shows a more detailed overlay of the Commonwealth 115kV line with the approximate parcel and turbine locations.

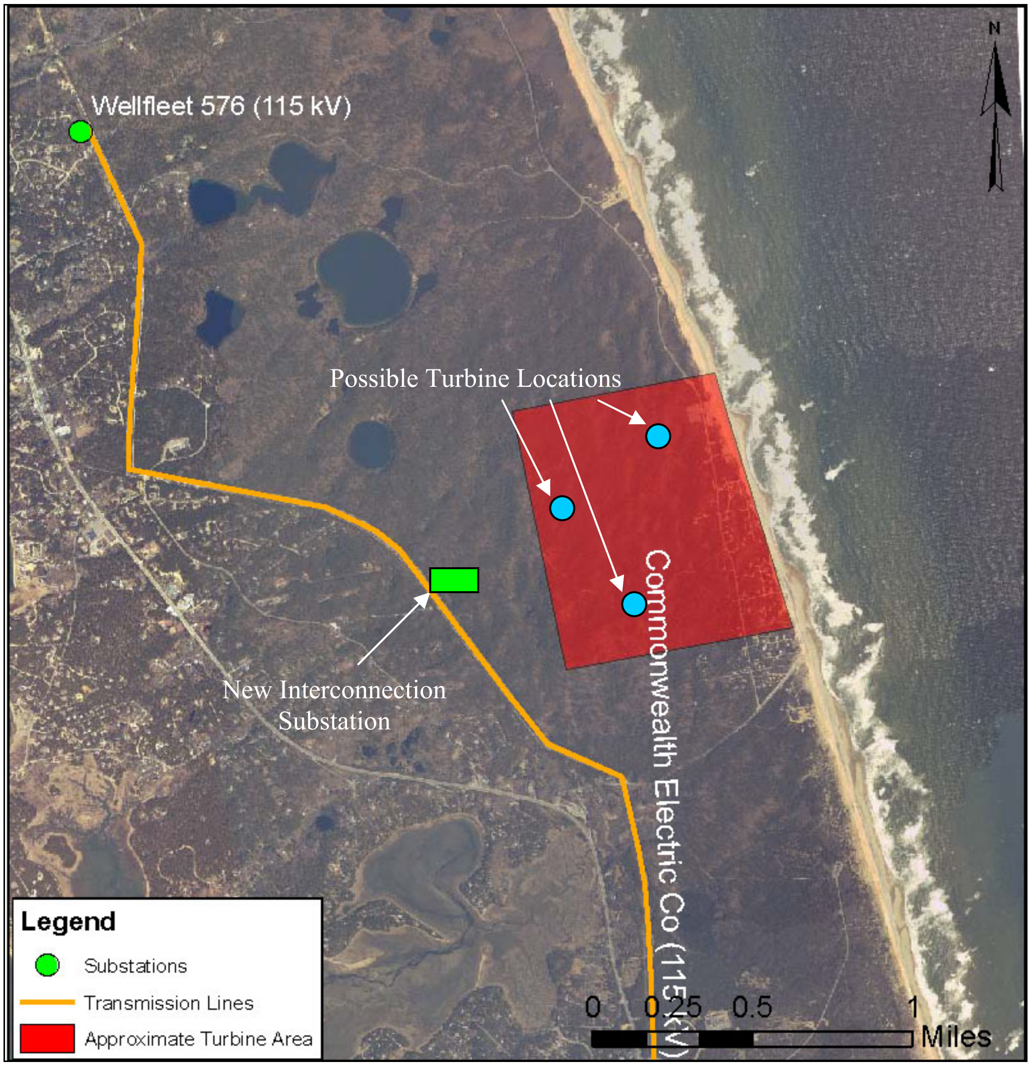

Figure 5-2. 115 kV Transmission Line Adjacent to Project Site.

5.1.1 Existing Wellfleet 576 Substation

One possible way to interconnect a small project such as this one would be to connect directly to the low-side bus at the Wellfleet 576 substation. This option would likely require little or no new substation equipment assuming that the Wellfleet substation has capacity for expansion. In order to determine the existing capacity restrictions on the substations, inquiries would need to be made with the Commonwealth Electric Company. If it is then determined that there is room to interconnect the project at the substation, a detailed system impact study would need to be performed to determine the impact to the grid and equipment in the area.

A direct route for the 35 kV underground collection system would bring the system across critical watersheds and living water habitats, which are shown in Section 7.0. Installing the collection system through this area may impact the permitting process as well as construction costs. For this reason, Black & Veatch feels that this option is not favorable and may negatively affect parts of the permitting, design, and construction processes and ultimately the overall feasibility of the project.

5.1.2 New Interconnection Substation

The second option for interconnection of the project involves constructing a new interconnection substation adjacent to the Commonwealth 115kV line about one-half mile west of the project site. This possible site is shown in Figure 5-2 above. This option would require very close coordination with the Commonwealth Electric Company due to the necessity of taking the 115 kV line out of service to energize the substation once it is built. The 35 kV underground collection system would run approximately one-half mile through land identical to the project site from the turbines to the interconnection substation. Black & Veatch believes this interconnection option will provide the least complications from a constructability standpoint and would also minimize losses at 35 kV by taking the shortest route to the interconnection point. The required permits for interconnection infrastructure would likely be similar to that of the project site; dealing primarily with the Cape Cod National Seashore.

This interconnection option would require a detailed interconnection study be performed by the Commonwealth Electric Company that would also entail performing a system impact study. It is Black & Veatch's expectation that the transmission lines in this area are not heavily loaded due to the radial nature of the grid on the Cape and the relatively small load centers located beyond Wellfleet. Therefore, Black & Veatch expects the project of this size should be able to interconnect to the Commonwealth Electric Company's system without needing major system upgrades. However, the detailed study performed by Commonwealth Electric will ultimately decide the feasibility of interconnecting the project.

5.2 Interconnection Feasibility

The cost differences between these two options are difficult to capture without a detailed engineering study, but the overall difference in cost is not expected to be large.

Black & Veatch believes that the option of building an interconnection substation to allow for interconnection to the Commonwealth 115 kV line is the better option. It is consistent with typical interconnections of this type of project, and has less potential to impact sensitive lands. While detailed studies by the transmission provider need to be performed, Black & Veatch expects the project would encounter no major road blocks in interconnecting to the grid in this fashion. These studies should be initiated shortly after a determination is made to move the project into the design phase.

6.0 Site Vicinity

This section discusses the characteristics of the site vicinity. Particularly, the uses of neighboring areas such as recreation, commerce, industry, or air traffic will be discussed along with historic or scenic sites.

6.1 Description of Site Vicinity

The Town of Wellfleet is located approximately seventy-five miles out into the Atlantic Ocean on the outer end of Cape Cod, and is bounded on the east by the Atlantic Ocean and the west by Cape Cod Bay. Over sixty-percent of the land area of Wellfleet falls within the Cape Cod National Seashore Park. The year-round population of about 3,500 can increase to an estimated 17,000 during the summer. Many of the town’s main attractions include miles of ocean and bay-side beaches as well as the wealth of outdoor activities including hang-gliding and hiking. Wellfleet is home to the Cape Cod National Seashore headquarters as well as the 1,000 acre Massachusetts Audubon Society Wildlife Sanctuary.

The project site is located approximately 2.5 miles due east of downtown Wellfleet on the Eastern Shore, and is entirely located within the boundaries of the Cape Cod National Seashore, which is shaded in purple in Figure 6-1. The land surrounding the site is mostly flat with small rolling hills at an elevation around 100 feet above sea level. The easternmost portion of the parcel drops off to sea level and sandy beaches. The cliffs are popular with hang-gliders during park hours, though hang gliding is only allowed during the fall and winter. Much of the space surrounding the site is undeveloped largely due to the existence of the National Seashore, though the eastern part of the area is residential with several houses that overlook the Atlantic Ocean.

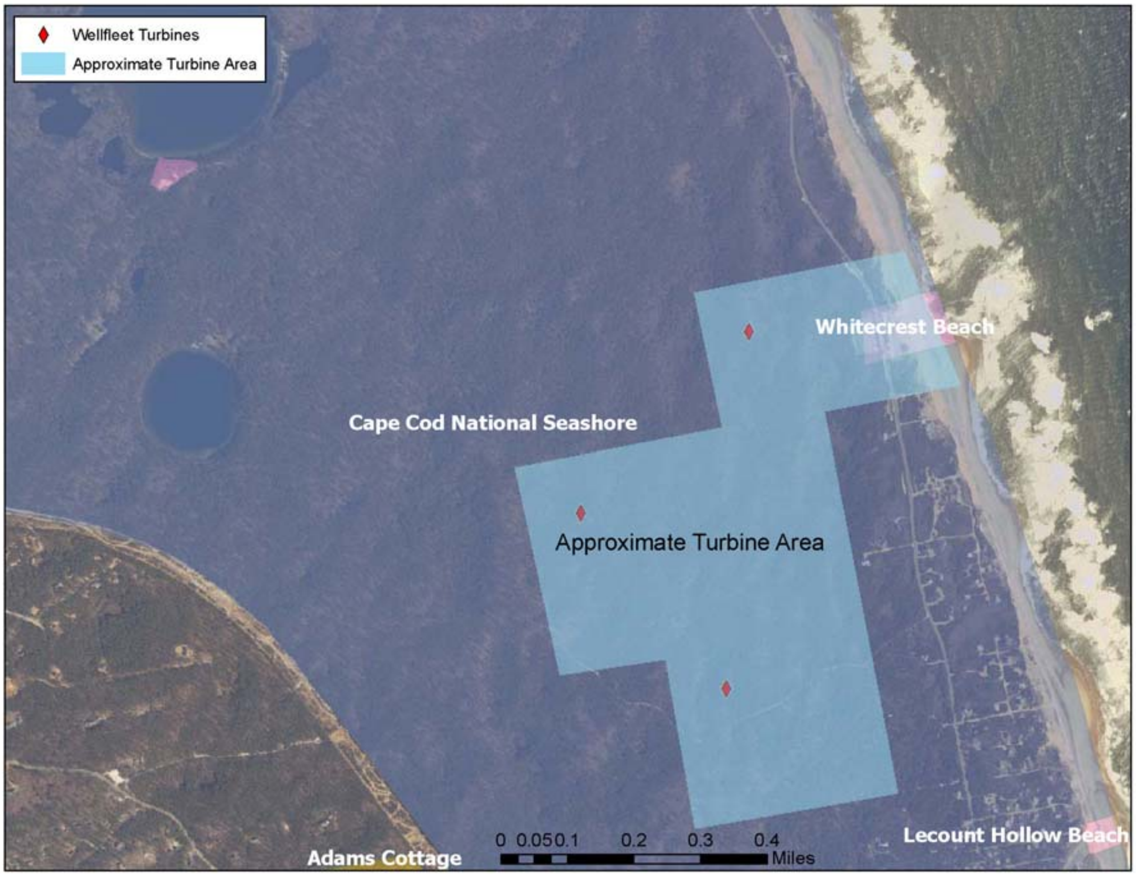

Figure 6-1. Wellfleet Project Area.

6.2 Visual and Noise Impact

Any wind turbine installed in an urban area is likely to have some adverse impacts on residential or commercial areas, though careful siting can often minimize these impacts. Some of the most common concerns are the potential noise impacts, the potential shadow flicker impacts, and the potential effects on scenic viewsheds.

Although some of the houses fall within a half-mile of the proposed turbine locations, the turbines are on the land rather than ocean side of most houses in the area. As the ocean is the primary viewshed in the area, the direct visual impact is not expected to be great. It will be possible, however for the turbines to be visible from the town of Wellfleet looking towards the Atlantic Ocean, as well as from recreational areas such as Marconi Beach and the wireless station.

Potential noise impacts include the aerodynamic noise of the turbine blades as well as noise produced by the generation equipment mounted in the turbine nacelle. Manufacturers typically provide noise data for wind turbines, which can be used along with measurements of ambient noise levels to model the likely noise impacts of a wind turbine. Typically, noise created by a turbine in operation is most noticeable directly under the turbine. The Town bylaws for wind turbines govern noise, but this is limited to not creating a nuisance. Individual tolerance for changes in ambient noise varies widely, and the term nuisance can be broadly interpreted. The State's model bylaws specify a maximum noise increase of 10 dB(A) over ambient noise levels at the nearest occupied building or property line. This is a reasonable number, and Black & Veatch recommends that an acoustic impact study be performed if project development moves forward.

Shadow flicker is a term describing the moving shadows that can be produced by rotating turbine blades. These moving shadows can produce a distracting strobe-like flickering effect. This generally occurs in the early morning and late evening, when shadows are longest. It is much more likely to be a concern for residents in the surrounding area than for those using the area recreationally.

The homes in the area are considered the primary visual and noise receptors, and those closest to the turbine areas were chosen as the impacts at these locations would be the most significant. The receptors used in this study are shown in Figure 6-2. Their locations are listed in Table 6-1.

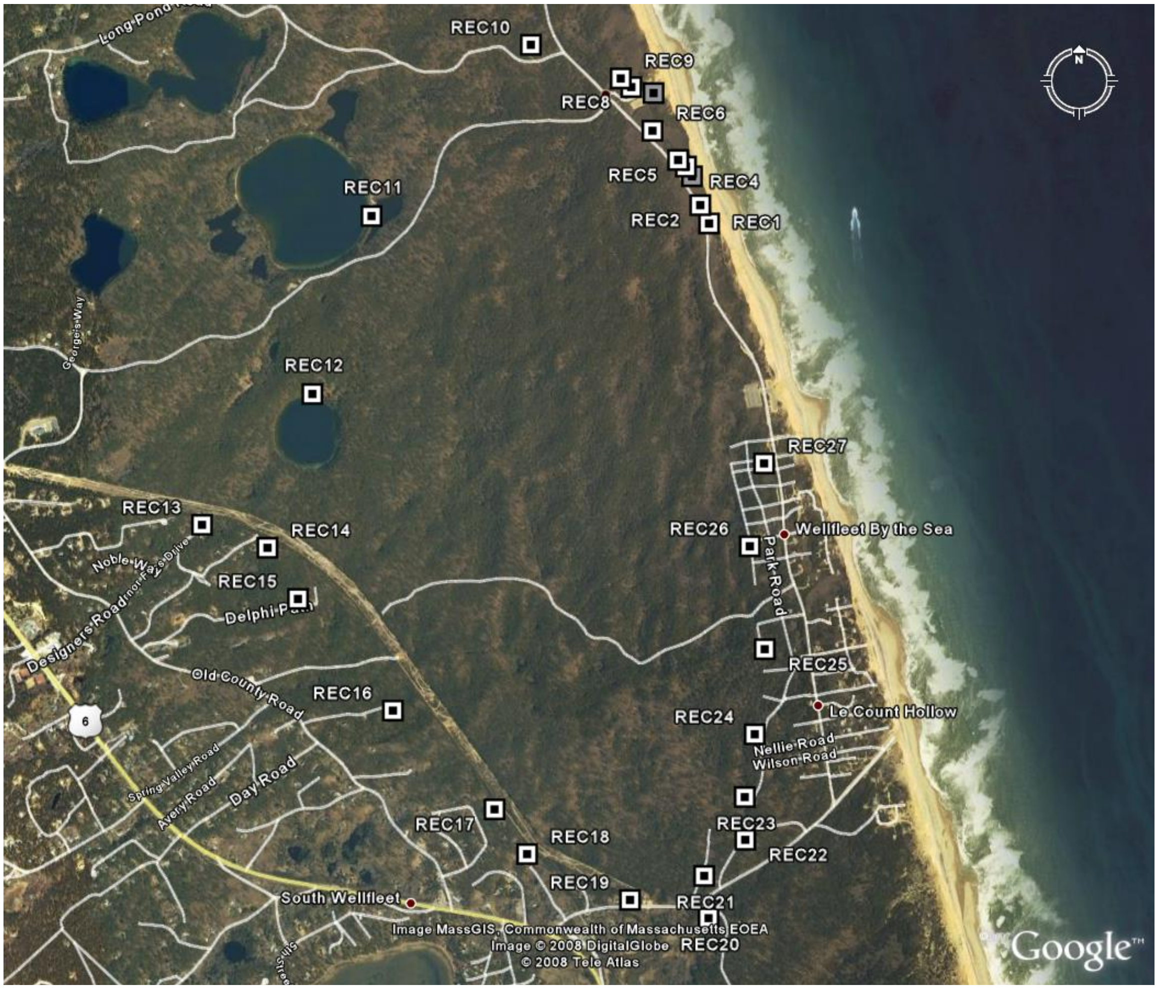

Figure 6-2. Key Visual and Noise Receptors.

Table 6-1. Key Visual and Noise Receptors.

Receptor	Latitude (Degrees North)	Longitude (Degrees West)
REC1	41.939727	69.982688
REC2	41.940307	69.983086
REC3	41.941261	69.983444
REC4	41.941552	69.983724
REC5	41.941767	69.984065
REC6	41.942726	69.985192
REC7	41.943997	69.985132
REC8	41.944170	69.986118
REC9	41.944447	69.986583
REC10	41.945554	69.990532
REC11	41.940018	69.997600
REC12	41.934155	70.000202
REC13	41.929849	70.005066
REC14	41.929096	70.002156
REC15	41.927421	70.000798
REC16	41.923758	69.996616
REC16	41.920504	69.992144
REC17	41.919022	69.990711
REC18	41.917523	69.986164
REC19	41.916900	69.982691
REC20	41.918327	69.982896
REC21	41.919504	69.981081
REC22	41.920924	69.981118
REC23	41.922992	69.980687
REC24	41.925782	69.980252
REC25	41.929150	69.980905
REC26	41.931862	69.980273
REC27	41.939727	69.982688

Note: All coordinates in WGS84

Black & Veatch performed a preliminary shadow flicker analysis for all three possible locations. A graphical representation of estimated shadow flicker impact is shown in Figure 6-3: The bands of color represent increasing levels of impact in terms of total hours per year of shadow flicker, from green to red. It should be noted that these results represent a worst-case scenario. Although they take the terrain into account, they do not account for clouds, vegetation, or other buildings.

The most affected homes are those to the east of the southernmost turbine location, which would experience flicker up to 50 minutes a day in the late afternoon during certain times of the year. The homes to the west are less affected, experiencing at most 20 minutes of flicker a few days in the year, typically in the early morning. Table 6-2 summarizes the modeled shadow flicker effects on the homes considered, as labeled in Figure 6-2, previously shown in Section 6.2.

Table 6-2. Modeled Shadow Flicker Effects for a 3-Turbine Project.			
Receptor	**Shadow Annual Hours**	**Worst Day and Time**	**Worst Day Minutes**
REC1	0		
REC2	0		
REC3	0		
REC4	0		
REC5	0		
REC6	0		
REC7	0		
REC8	0		
REC9	0		
REC10	5	11/14 7:40 AM to 8:00 AM	20
REC11	13	2/8 8:00 AM to 8:20 AM	20
REC12	3	9/8 6:20 AM to 6:40 AM	20
REC13	7	4/10 6:10 AM to 6:30 AM	20
REC14	11	4/30 5:40 AM to 6:00 AM	20
REC15	7	4/30 5:40 AM to 6:00 AM	20
REC16	0		
REC16	0		
REC17	0		
REC18	0		
REC19	0		
REC20	0		
REC21	0		
REC22	0		
REC23	50	4/24 6:00 PM to 6:50 PM	50
REC24	62	1/3 3:40 PM to 4:30 PM	50
REC25	9	3/5 5:30 PM to 6:00 PM	30
REC26	0		
REC27	0		

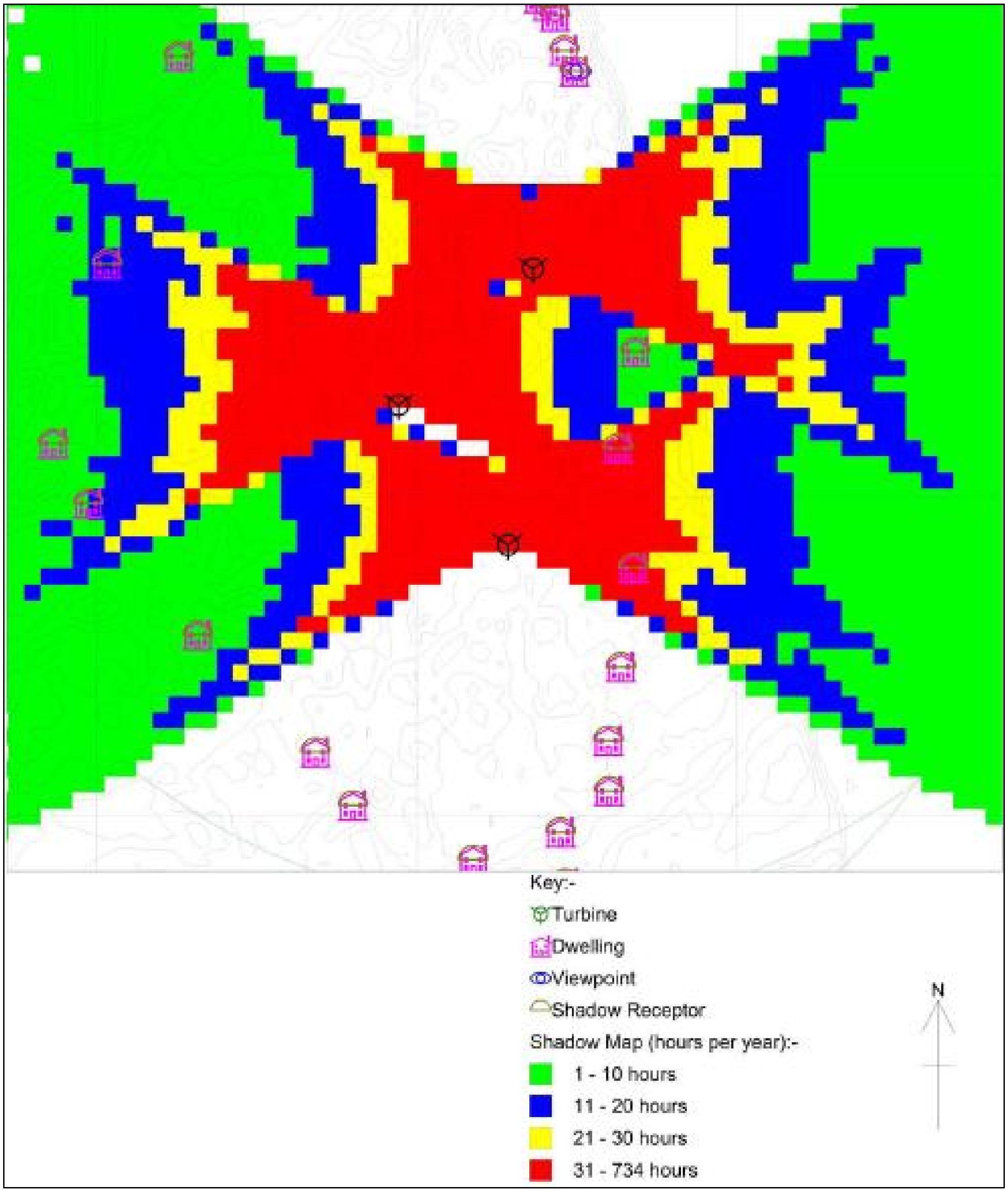

Figure 6-3. Estimated Shadow Flicker for a Three Turbine Project.

Based on the analysis, most of the neighboring residences experience no shadow flicker due to the turbines. However, there are a few residences that will experience anywhere between 3 and 62 hours of shadow flicker a year. The northernmost turbine location has the least impact on all nearby residences. If a single turbine project were to be chosen, the northern turbine would appear be the best candidate. Table 6-3 is a comparison of overall shadow flicker affects from each turbine.

Table 6-3. Estimated Shadow Flicker Impact of Turbine Locations.			
Turbine	**Receptors Affected**	**Average Worst Day Minutes**	**Maximum Daily Minutes**
North	5	12	20
Middle	6	23	30
South	7	23	50

6.3 Airspace Impact

The closest airports to the Wellfleet locations are the Chatham municipal airport to the south, the Barnstable airport to the southwest, and the Provincetown Municipal Airport to the northwest. These airports are shown in Figure 6-4.

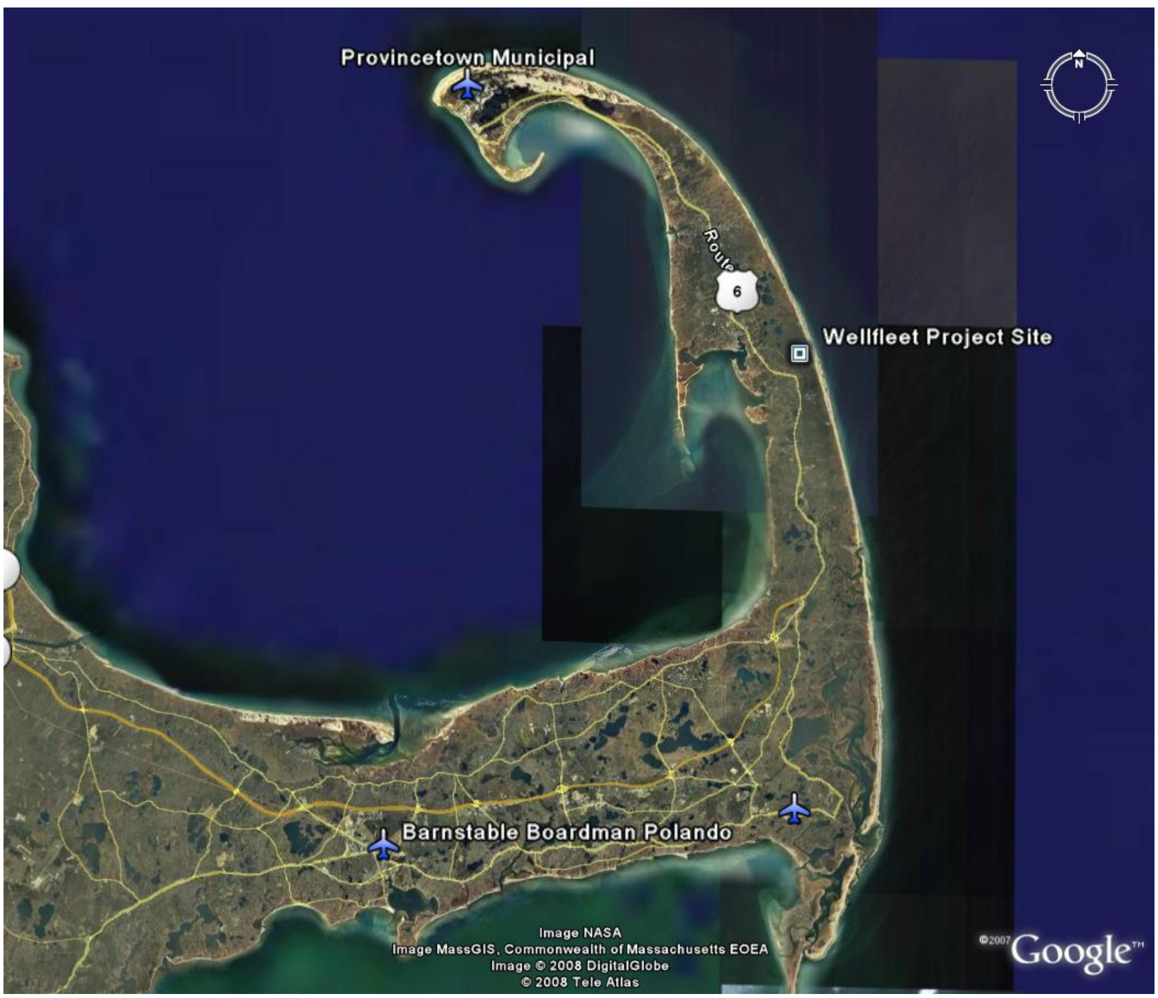

Figure 6-4. Nearby Airports.

The Chatham Municipal Airport is approximately 17 miles from the project site and the Barnstable Airport is about 23 miles away. The Provincetown airport is about 15 miles away. According to Federal Aviation Administration (FAA) Advisory Circular 70/7460-2J, a Notice of Proposed Construction must be filed with the FAA for the construction of any structure over 200 feet (61 meters) tall or within a certain distance-height zone from commercial or military airports. All commercial-scale wind turbines are more than 200 feet tall, so a notice will be required to be filed with the FAA and will require markings and lighting. Preliminary notices were filed with the FAA by MTC on behalf of the Town of Wellfleet at the initial proposed turbine sites. The FAA issued a "Determination of No Hazard" for machines up to 397 feet tall at all three sites, which is the equivalent of the total height of the tallest turbine investigated in this report (Vestas V82 on an 80 meter tower). These determinations are included in Appendix E.

6.4 Communications Impact

Figure 6-5 shows the known communication towers and antennas within four miles of the proposed turbine sites. The nearest communications equipment is over a mile away from the proposed turbine locations. This distance as well as the distance of the turbines from nearby homes makes interference with television, radio, and communications unlikely, though there is some possibility of slight telephone and radio reception issues. Wind turbines at the site should not interfere with cable or satellite communications.

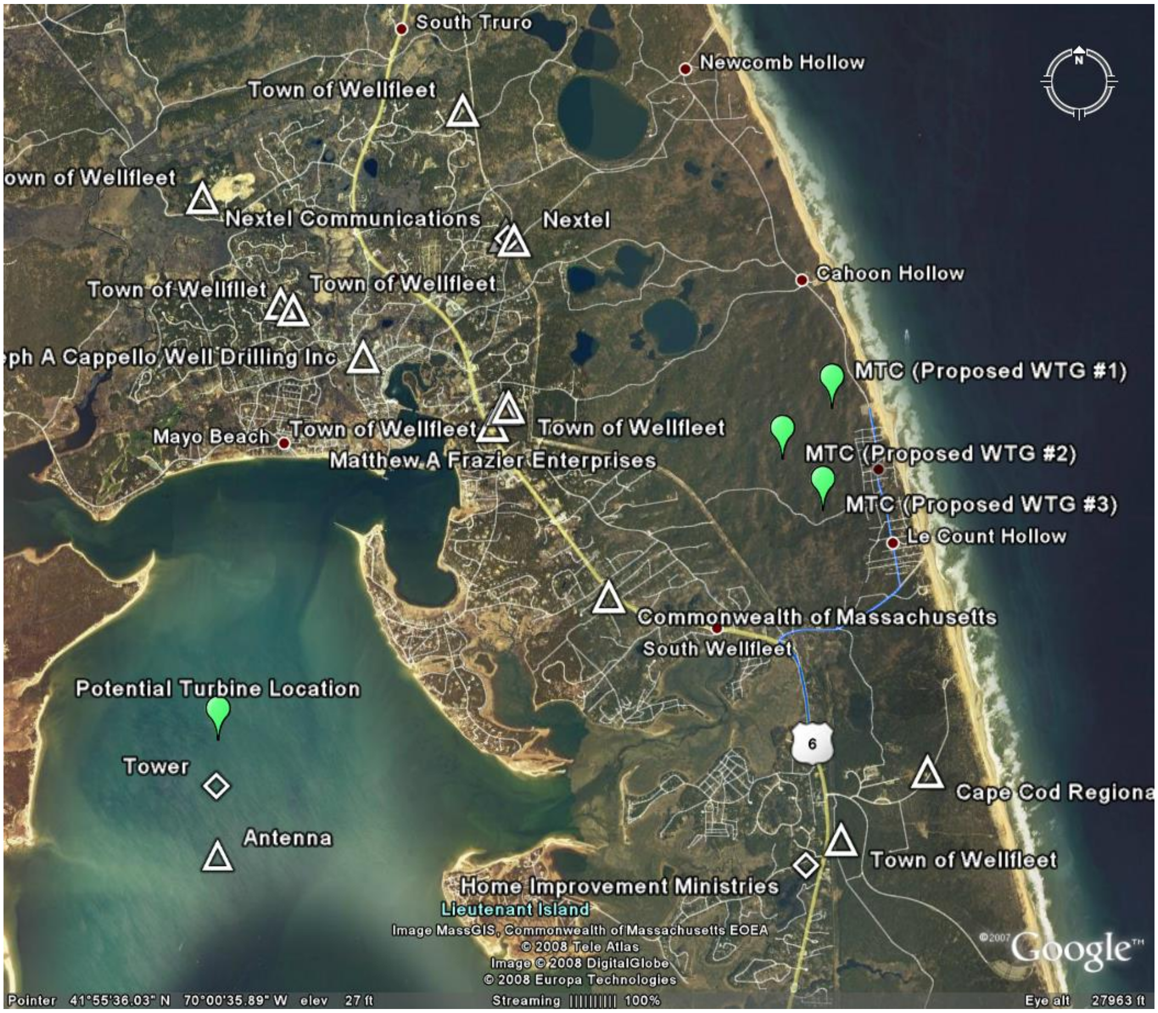

Figure 6-5. Known Towers and Antennas near Wellfleet.

Figure 6-6 shows known microwave beam paths on Cape Cod. None of these paths cross the potential project site. The nearest microwave communication site appears to be from NSTAR substation northwest of the project site back to Barnstable.

Figure 6-6. Known Microwave Paths on Cape Cod.

6.5 Community Acceptance

Black & Veatch understands that the Town of Wellfleet has an alternative energy committee that has been working on this project for some time, and the Town appears to be relatively enthusiastic about the project. Several nearby homeowners have expressed support of a wind project in Wellfleet. However, Wellfleet is a seasonal community appreciated for its scenery and recreational activities, and the presence of large structures may be viewed as intrusive. As discussed previously, the majority of the homes in the direct area of the project site are designed to optimize the view of the ocean rather than the view inland and thus the residential area east of the development will have a minimized view of the wind project.

Still, some residents have expressed concern about the noise and effects on views, which are concerns common to wind projects of this size. Black & Veatch recommends open communication of project plans with the community, and providing the community with visual simulation of the project as well as noise and flicker analysis, all of which are covered in this study. It may be appropriate to have a third party perform a formal noise impact study as development of this project continues.

7.0 Potential Environmental Concerns

Given Wellfleet's location on Cape Cod, environmental concerns regarding a community wind energy project are expected to be an important component of the project's feasibility. Black & Veatch has prepared an initial list of likely environmental issues. Black & Veatch recommends a more complete environmental review be performed prior to committing to a wind energy project.

7.1 Site Flora and Fauna

Black & Veatch reviewed information on plant and animal species that reside in or near the Wellfleet area. This section reviews the biodiversity information for the area and identifies elements that could be potentially impacted by a wind energy project and need further exploration as part of a project's full environmental review.

7.1.1 Natural Heritage and Endangered Species Program

The Massachusetts Division of Fisheries and Wildlife's Natural Heritage and Endangered Species Program (NHESP) maintains a web site (www.nhesp.org) that identifies vulnerable and protected plant and animal species, as well as sensitive core habitats broken down by town. While this information is a good resource for an initial feasibility study, Black & Veatch would not consider the information identified below to be exhaustive, and would recommend a specific environmental review be done at the project site in future phases of project development.

The following information was obtained from the NHESP website:

- **Protected and Recreational Open Space:** These are areas that have been designated at the state or community level as areas for limited or no development. The Massachusetts Geographic Information System (MassGIS), the service from where the data was obtained, indicated the accuracy of the identified open space locations was limited.
- **BioMap Core Habitats:** The BioMap program was completed in 2001 by NHESP, and identified areas considered to represent "habitats for the state's most viable rare plant and animal populations". BioMap Core Habitats and Living Water Core Habitats encompass almost 1.4 million acres, or about 28 percent of the land area of Massachusetts.
- **Living Waters Core Habitats:** Similar to the BioMap Core Habitats, the Living Waters Core Habitats are those rivers, streams, lakes, and ponds critical to the biological diversity of Massachusetts.

- **Living Waters Critical Supporting Watersheds:** These watersheds are identified as being critical for supporting Living Waters Core Habitats. They were identified in the Living Waters project completed in 2003 by NHESP.
- **Areas of Critical Environmental Concern (ACEC):** These are areas in Massachusetts that are considered special and highly significant due to their natural and cultural resources. Nominations for areas to receive ACEC designation are made by communities to the state Secretary of Environmental Affairs. Administration of the ACEC program is done by the Department of Conservation and Recreation.
- **Priority Habitat for Rare Species:** These areas are NHESP estimates of habitats for rare species. The boundaries of these habitats are considered approximate. There do not appear to be any priority habitats that directly affect a project in Wellfleet.
- **Certified Vernal Pools:** NHESP define vernal pools as "small, shallow ponds characterized by lack of fish and by periods of dryness." These pools are deemed critical to some wildlife, and are protected under a variety of state programs including the Massachusetts Wetlands Protection Act. There do not appear to be any certified vernal pools that directly affect a project in Wellfleet.

Protected and Recreational Open Space

Figure 7-1 below shows known protected spaces in the area of the project site. The main protected area that exists along the coast is the Cape Cod National Seashore. This land represents the majority of the overlap with the proposed project site. The Cape Cod National Seashore is a unit of the National Park System, and is overseen by a committee that is involved with determining the development on this land. This protected and managed land is expected to significantly affect the development a wind project in the area; however the town of Wellfleet indicated to Black & Veatch that they have been in constant communication with the National Seashore about the project and expect efficient coordination in later stages of development. The approximate project area is shown in red and also overlaps White Crest Beach in its Northeastern corner. The beach will not be impacted physically by a project in the area since this study is only considering the western portion of the area for development of a wind project.

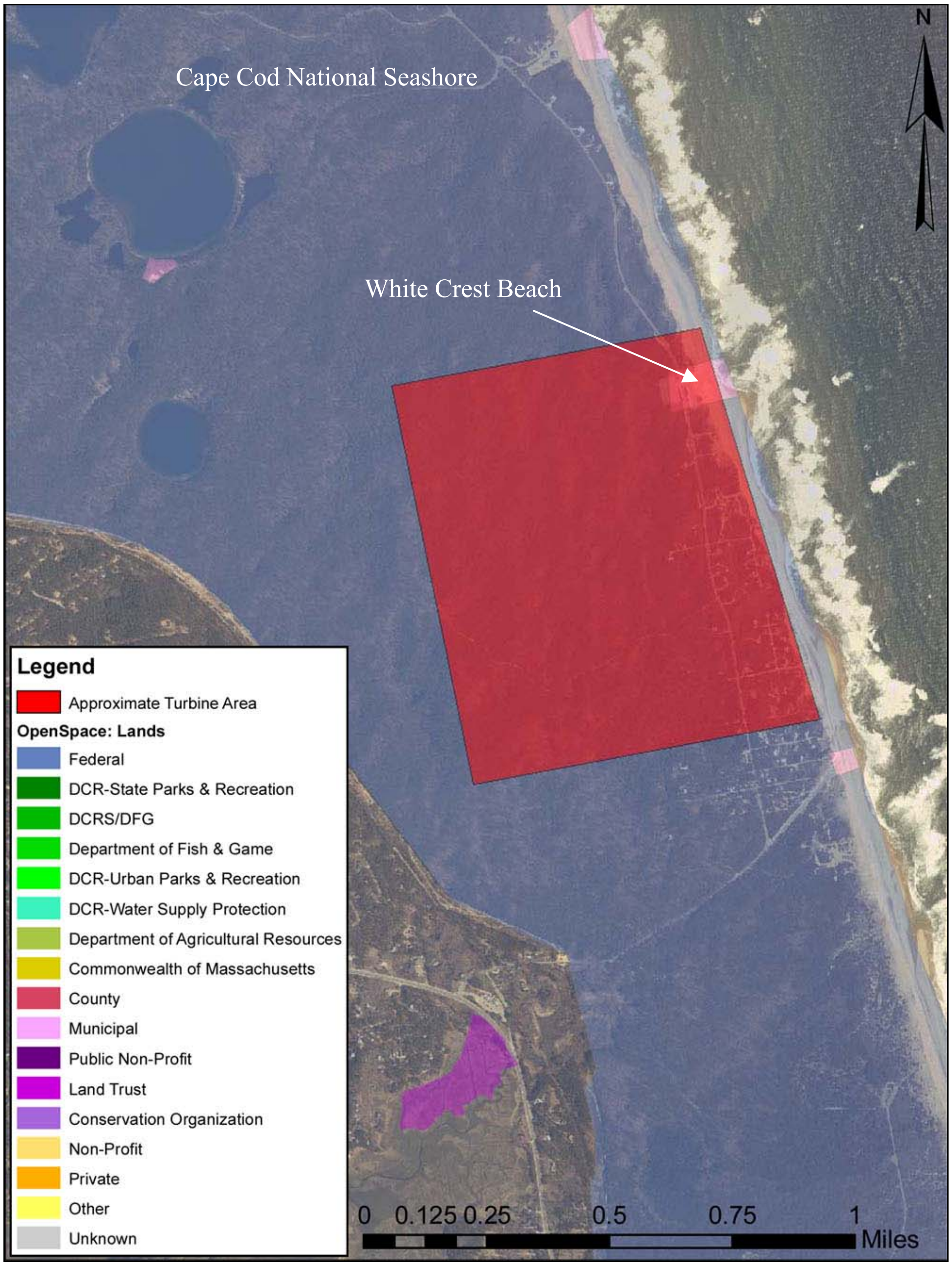

Figure 7-1. Protected and Recreational Open Space.

BioMap and Living Waters Core Habitats

The NHESP BioMap and Living Waters report *Core Habitats of Wellfleet*, dated 2004, includes a listing of those natural communities, plants, invertebrates, and vertebrates that have special designation under the Massachusetts Endangered Species Act (MESA) and an unofficial NHESP watch list. The large core habitat designated as BM 1109 that runs along outer Cape Cod supports a large species diversity. Much of the core habitat is on protected land designated by the Cape Cod National Seashore. The extent of the BioMap habitat is shown in Figure 7-2, along with the Living Waters Core Habitats in the area.

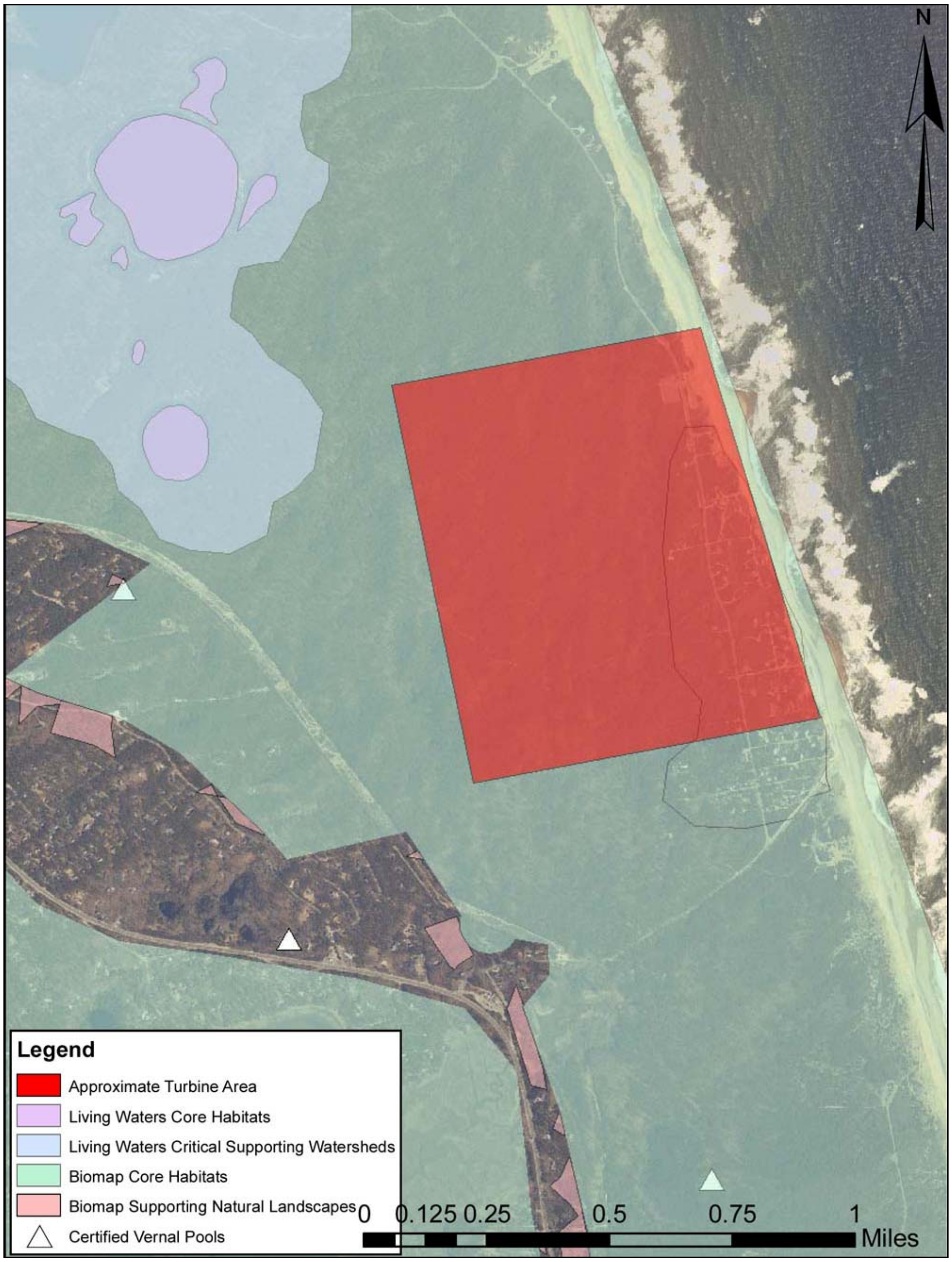

Figure 7-2. BioMap and Living Waters Core Habitats and Supporting Landscape.

The BioMap reports that a core habitat also exists throughout the project area, which by definition is the supporting habitat for at least one at-risk species. MESA has three levels of classification for rare species: Endangered, Threatened, and Special Concern. As defined in the BioMap report, the definitions of these classifications are:

- **Endangered:** Species in danger of extinction, or of no longer being found in Massachusetts.
- **Threatened:** Species deemed likely to become endangered in Massachusetts in the foreseeable future.
- **Special Concern:** Species that have suffered a decline that could threaten their existence or that are very rare in Massachusetts.

The BioMap report lists one endangered vertebrate species (MESA and Federal) and four Endangered Plant species in the Wellfleet area:

Roseate Tern: The Roseate Tern is a small to medium sized bird said to be emblematic of the Commonwealth. The bird can be found on Massachusetts beaches in the spring and though this bird experienced a population increase from 1980-2000, it has since been on the decline. The included photo is from the NHESP website.

Ovate Spike Rush: In Massachusetts, this plant is a low, tufted, annual herb with green stems that can rise up to six inches. The Spike Rushes have a single, tight cluster of tiny flowers. The picture is courtesy of an unidentified internet site found through Google images.

Walter's Sedge: A pale-green, narrow leaved, grass-like perennial often found in widespread colonies. This species prefers boggy pond shores and open peaty swamps. Specific habitats include the upper border of sandy beaches. The photo is from the USC Herbarium and was taken by Linda Lee.

Prickly Pear: This cactus grows in sprawling clumps less than three feet wide and one foot high. On the Cape, it grows in dry, sandy fields and dense grassy areas that have been mowed such as cemeteries. The last recorded observation in the Wellfleet area was in 2004. The photo included is from the Delaware Wildflowers website.

Oysterleaf: This very distinctive plant is an herbaceous, hairless perennial. The fleshy, wedge-shaped leaves are said to have an oyster-like taste. It is typically found on Arctic and Atlantic beaches where there is active sand deposition near upper beach areas. The included photo is taken from an unidentified website found through Google.

NHESP indicated that the last recorded observation of the Roseate Tern and the Spike Rush was in 1994, with observations of the other "Endangered" species occurring in the past 10 years. Additionally, there are five vertebrate, three invertebrate, and three plant species that NHESP indicates are "Threatened":

Eastern Spadefoot: This toad is long, short-legged, squat, and big-headed. This species requires dry, sand or sandy loam soils and prefers areas with leaf litter and may be found in farmland areas. The included photo is from the Amphibian Gallery on Murray State's website.

Northern Harrier: Sometimes referred to as the Marsh Hawk, this bird is slim, long-legged, and long-tailed. They establish nesting and feeding territories in wet meadows and coastal marshes. Most that do not migrate south spend the winter on coastal marshes in Cape Cod. The photo was taken from www.coffeecreekwc.org.

Piping Plover: This bird is a small, stocky shorebird that runs in patterns of brief starts and stops. They typically nest on sandy coastal beaches and dunes and sometimes may occur on vegetated dunes and in eroded areas behind dunes. The included photo is from www.birdsasart.com.

Vesper Sparrow: Breeding Vesper Sparrows are characteristic of relatively dry and sparsely vegetated areas with scattered tall structures used for song perches, though this species has been known to have broad habitat preferences. The included photo was taken by Jim Stasz.

Melsheimer's Sack Bearer: This moth has a wingspan of 35-50 mm and is generally more abundant in the South. In Massachusetts it is found solely in sandplain and especially scrub oak thickets. Adult moths fly in June and early July, with peak flight occurring in late June. The photo was taken by M.W. Nelson.

Water-Willow Stern Borer: This nocturnal moth has been observed in 59 sites throughout Cape Cod and southeast Massachusetts. The included photo is from the Moth Photographers Group web page, take by Jim Wiker.

Pine Barrens Bluet: This is a small insect about 1 inch in length that is found in coastal plain ponds on Cape Cod and various other locations in New England. The included photo is from the Massachusetts Division of Fisheries and Wildlife.

Diamondback Terrapin: This medium-sized turtle is found along the Atlantic coast from Cape Cod to Cape Hatteras (North Carolina). The included photo is from the University of Delaware Graduate College of Maritime Studies web site.

Swamp Oats: Also known as the Swamp Wedgescale, this grassy plant is a perennial herb that can be found in swamps and wet-wooded areas. Their flowering period occurs early April to late June. The included drawing is from the USDA Plants website.

Salt Reed Grass: The largest of its genus, it bears broad, rough leaves, and dense flowers of many spikes. Acres on the coast are sometimes covered by this grass, which can grow up to ten feet high and an inch in diameter at its base. The included photo is from Virginia's Department of Conservation & Recreation.

Resupinate Bladderwort: Reflecting its name, the pink flower on this plant is tipped upside-down. It inhabits muddy ground or shallow water at pond edges and flowers from July to August. The included photo was taken by Janet Novak.

Additionally, BM 1109 has several species listed as Special Concern, along with many invertebrate, plant, and natural community species of several designations. Appendix B includes the NHESP BioMap report for Wellfleet and summaries for many of the species listed above. There are other core habitats which are included in the BioMap report, and though areas adjacent to the project site should be investigated thoroughly to determine possible impacts, the lack of information indicates to Black & Veatch that there may be no significant impact from any other areas.

Areas of Critical Environmental Concern

Figure 7-3 shows the known Areas of Critical Environmental Concern. The approximate turbine area at Wellfleet does not fall within any of these areas.

Figure 7-3. Areas of Critical Environmental Concern.

Due to the existence of at-risk species and overlap of the core habitats for these species, any further project development in the area should include a wildlife survey that specifically reviews these species, as well as any others that may surface from a more in-depth study.

7.1.2 Avian and Bat Impacts

Another biological concern for this project's development may be potential or perceived risk to avian and bat species. During the permitting phase of project development, studies such as a Phase I avian analysis should be performed as part of a wildlife survey to identify any potential risks to avian and bat species due to nesting and/or migratory patterns. Modern wind turbines include slow rotating blades, and tower and hub designs that provide almost no perching or nesting points for birds. While most wind energy projects have little or no recorded bird or bat strikes, it can be a significant problem at a few sites (such as Altamont, California, or the Mountaineer Wind Energy project in West Virginia). It is therefore important to determine if species known to be susceptible to wind turbine strikes can be found at the site.

7.2 Wetlands

As shown before in Figure 7-2, the project does not appear to fall within any known protected wetlands, critical BioMap Living Waters areas, or critical supporting watersheds. The area should be mapped for wetlands early in project development to ensure that construction of a wind project at this location will not have a negative impact.

7.3 Environmental Impact

Black & Veatch feels that the likelihood of a small wind energy project having unacceptable environmental impacts is small. However, several sensitive species have been observed in the area near the site, and Black & Veatch believes that the Town will need to work closely with the Cape Cod National Seashore to facilitate progress and further development of a project.

8.0 Permitting

Black & Veatch has examined the general permitting requirements for energy projects in Massachusetts, as well as major projects on Cape Cod, and has prepared an initial list with our expectations regarding which permits would apply to a wind energy project in Wellfleet.

8.1 Site Zoning

Based on documents provided to Black & Veatch from the Town of Wellfleet, a review of aerial photography, and a site visit, the proposed project site appears to be zoned for residential use. An existing land survey map provided to Black & Veatch indicates previous plans for westward expansion of the existing residential area south of White Crest Beach, though no such development has taken place as of recent site visits.

8.2 Wind Development Bylaws

The town of Wellfleet currently has a zoning bylaw concerning the permitting and requirements for installing a wind turbine (or "windmill"). Section 6.5 of the zoning bylaws amended April 24, 2006 covers the following details concerning installing a wind turbine. A full version of the zoning bylaws is can be found in Appendix F.

- **Section 6.5.1:** "Windmills" shall be permitted by a special permit from the Board of Appeals and must comply with the following conditions:
  - **Section 6.5.1.1:** Requires that the minimum setback distance for a wind turbine from an adjacent property line should be at minimum the maximum height of the turbine (base to blade tip) plus 20 feet and setbacks are measured from the center of the tower base.
  - **Section 6.5.1.2:** The maximum tower height shall be 65 feet from the grade to the center of the rotor.
  - **Section 6.5.1.3:** Climbing access to the windmill shall be limited to a fence or locked gate around the tower base or by limiting the climbing apparatus to no lower than ten feet above the ground. The fence must be no shorter than five feet.
  - **Section 6.5.1.4:** The diameter of the rotor may not exceed thirty-five feet and may sweep no closer than fifteen feet from the ground.
  - **Section 6.5.1.5:** The "windmill" shall not generate excessive noise, cause interruption to television or radio reception.

- **Section 6.5.2:** A "windmill" will be considered abandoned if not operated for a period of two years or if it is designated as a safety hazard or public nuisance by the Building Inspector and must be dismantled by the owner
- **Section 6.5.3:** For purposes of this bylaw, the following definitions shall be applied: A "windmill" is a device which converts wind energy to mechanical or electrical energy, and a "rotor" is defined as the blades plus the hub to which the blades of a windmill tower are attached.
- **Section 6.5.4:** Before applying for a special permit under this section, the applicant shall obtain the Building Inspector's approval of the proposed windmill upon making the determination that it will not constitute a safety hazard or a public nuisance and complies with State Building Code and other applicable laws.

It is apparent that the Town of Wellfleet has made an effort to plan for the construction of wind energy projects in the area. However, due to the nature of this project and the size of the wind turbines being studied, it will be necessary for the Town of Wellfleet to revise these bylaws in order to make this project legally compliant. In particular, the wind turbines considered for this study violate the size restrictions set forth in Section 6.5.1 of the zoning bylaws, and by definition fall within the jurisdiction of these zoning bylaws. The Town should increase the maximum turbine height to at least 400 feet from grade to the blade tip and remove the rotor diameter restriction. Increases to the minimum setback distances are recommended, and noise requirements should be better defined. The bylaw recommendations from the State (Appendix G) are a good starting point for these changes.

8.3 List of Required Permits

At present, the permit requirements that seem very likely to apply to a community wind energy project in Wellfleet are found in Table 8-1. A list of abbreviation can be found at the end of the table.

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
FEDERAL						
COE	Section 10 Nationwide Permit	Construction activities in navigable waters of the US	Construction	MAYBE	3 - 4 months for nationwide; 2 - 3 months for individual	Required for construction in navigable waters of the US. Site reconnaissance needed to determine applicability.
COE	Section 404 Nationwide Permit	Discharge of dredge or fill material into US waters, including jurisdictional wetlands	Construction	MAYBE	3 - 4 months for nationwide; 2 - 3 months for individual	Required only if wetlands will be filled on site or along off-site utility right-of-way. Site reconnaissance needed to determine applicability.
EPA	SPCC Plan	On site storage of oil > 1,320 gallons	Construction	MAYBE	3 months	Threshold may be exceeded due to construction equipment at site. Exceeding threshold not expected for operational activities.
FAA	Notice of Proposed Construction or Alteration	Construction of an object which has the potential to affect navigable airspace (height in excess of 200 feet or within 20,000 feet of an airport)	Construction	YES	3 - 4 months	Chatham Municipal Airport is approximately 17 miles from the nearest candidate site. FAA will require lighting or marking of turbines or temporary construction crane. Notices for the site have already been filed and no height restrictions are expected. The tallest estimated turbine blade height is about 400 feet above sea level. May be concerns about height if close to existing flight paths. Refer also to MAC/MPA review.

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
FERC	EWG Status	Selling electric energy at wholesale to a utility or other generator	Construction	MAYBE	3 - 4 months	Electricity will likely be sold to the grid.
FERC	Qualifying Facility Certification	Qualification for PURPA benefits for small power production facility using renewable resources	Construction	MAYBE	Formal certification, 3 - 5 months. Self-certification, upon filing.	Electricity will likely be sold to the grid. This certification is for facilities producing less than 80 megawatts of power.
EPA	NPDES Stormwater Construction General Permit	Discharge of stormwater from construction sites disturbing 1 acre or more	Construction	MAYBE	9 - 12 months	Requires joint approval with MDEP. Dependent on candidate site selected. Project may disturb less than 1 acre if only one small turbine is built, or up to 14 acres if three large turbines and a substation are built.
USFWS	Migratory Bird Treaty Act Compliance	Activity with potential to harm migratory bird species	Construction	YES	1 - 2 months	Design turbines to avoid avian impacts. Several protected migratory bird species inhabit Wellfleet and the project area, including the piping plover and roseate tern. ESA compliance review may also incorporate this Migratory Bird Treaty Act review.

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
USFWS	Endangered Species Act Compliance	Confirmation of no impacts to threatened and endangered species	Construction	YES	1 - 2 months	Consultation recommended if species and/or habitat onsite or along utility interconnection right-of-way may be impacted. May be concerns about avian and other impacts from turbines since Cape Cod National Seashore and other ecologically important areas are in close proximity. Piping plover and roseate tern occur in the project area and are protected under both the ESA and the Migratory Bird Treaty Act.
NPS/Cape Cod National Seashore Advisory Commission	Courtesy Consultation	Locating project adjacent to Cape Cod National Seashore	Construction	YES	1 - 2 months	Consultation with the National Park Service and Wellfleet representative of the Cape Cod National Seashore Advisory Committee is recommended since candidate project locations are inside the Seashore boundary.
FEDERAL	NEPA	Major federal action affecting the environment	Construction	NO		May be required if COE individual permit needed.
STATE						

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
MDPU/EFSB	Site Certification	Construction of an energy generating facility	Construction	NO	10 - 12 months	Electricity will likely be sold to the grid. Project size below review threshold.
DOER	Application for Statement of Qualification pursuant to Massachusetts Renewable Portfolio Standard	Construction and operation of a new renewable energy facility proposing to sell energy to the grid	Construction	YES	2 - 3 months	Project would be considered a Small Power Production Qualifying Facility with respect to selling power to utilities that are required under Massachusetts law to purchase electricity from certain classes of renewable energy and distributed generation facilities.
EOEA	MEPA Determination: Environmental Notification Form (or expanded form)	Alteration of more than 25 acres of land	Construction	MAYBE	2 - 3 months	Must be filed if more than 25 acres of land will be directly altered or certain other EOEA criteria met. May be affected by CCNS and other triggers.
EOEA	MEPA Review: Environmental Impact Report	Alteration of more than 50 acres of land	Construction	NO	6 - 9 months	Evaluation of effects of state agency permitting action on the environment based on review of the Environmental Notification Form by the Secretary of Environmental Affairs. Environmental Impact Report required if more than 50 acres of land will be altered or other criteria met. Project will likely not meet 50 acre threshold.

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
EOEA	Protected Land Regulation Compliance	Activities on protected land	Construction	MAYBE	1 - 2 months	EOEA Article 97 Policy and Massachusetts General Law Chapter 61 govern the use of protected land. Compliance with these laws is necessary for a successful EIR or ENF process. These laws may apply if the project requires access or easements on protected parkland or agricultural land. The project will directly impact Cape Cod National Seashore lands.
MDEP	Notice of Intent	Wetland alteration	Construction	MAYBE	3 - 4 months	Site reconnaissance necessary to determine any wetland impacts from the project. GIS resources show no direct impact. Local clarification of potential wetland issues would be a logical next step.

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
MDEP	Noise Control Policy Compliance	Noise from wind turbine	Operation	MAYBE	1 - 2 months	Policy discourages a broadband noise level greater than 10 dB(A) above ambient, or pure tone noise. Noise is not expected to be an issue as long as the project is properly evaluated and any necessary mitigation requirements are implemented. Contact with Town of Wellfleet needed to determine additional requirements associated with noise. All candidate sites are close to residences.
MDEP	NPDES Individual Wastewater/Stor m Water Discharge Permit	Wastewater discharge and storm water runoff during facility operation. NOTE: This program is jointly administered by EPA and MDEP.	Operation	NO	9 - 12 months	Operation of a wind farm is not considered an industrial activity under the stormwater program.

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
MDEP	Massachusetts Clean Waters Act, Section 401 Water Quality Certification	Required for federal activities affecting state land	Construction	MAYBE	3 months	Necessary if Section 404 permit is required. Permit required if wetlands will be altered in any way. The permit application is a Notice of Intent and is also sent to the Town of Wellfleet Conservation Commission. If an area less than 5,000 square feet of wetland is altered, the Order of Conditions also serves as the project's Section 401 Water Quality Certificate. The project will most likely not affect wetlands.
MDF&G Natural Heritage and Endangered Species Program	Notice of Intent	Wetland alteration	Construction	MAYBE	3 - 4 months	Same as form submitted to MDEP. Required if project is in "estimated habitat" of rare wildlife (many rare species are present in the area).
MDF&G Natural Heritage and Endangered Species	Endangered Species Act Consultation/ Compliance	Activities that could potentially affect threatened or endangered species	Construction	YES	3 - 4 months	Conservation and Management Permit required for any take of a state endangered species. Many protected species live in the Cape Cod area.
MDOH	General Access Permit	Alteration of state roads	Construction	MAYBE	2 - 3 months	May be needed if project involves alterations to state roads to access site.

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
MDOH	Wide Load Permit	Movement of oversize project equipment	Construction	MAYBE	2 - 3 months	May be necessary for transport of oversized equipment like turbine components or certain construction equipment.
ISO New England (and transmission line owner at interconnection point)	NEPOOL Interconnection System Impact Study and Facility Study	Transmission interconnection	Construction	MAYBE	9 - 12 months	Electricity will likely be sold to the grid. Project owner determine participation in NEPOOL.
EFSB	Transmission line approval	Transmission interconnection	Construction	MAYBE	2 - 3 months	Electricity will likely be sold to the grid. Candidate sites are adjacent to a 115 kV transmission line; however, contact with Town of Wellfleet and Barnstable County is also recommended to determine right-of-way requirements.
Mass DPU	Section 72 Approval of Transmission Line	Transmission interconnection	Construction	MAYBE	2-3 months	Electricity will likely be sold to the grid. Candidate sites are adjacent to a 115 kV transmission line.
MAC	Request for Airspace Review courtesy notice	Structures over 200 feet tall	Construction	YES	3 - 4 months	Provide courtesy notification of any projects over 200 feet tall (similar to FAA review, but not a permit per se).

Table 8-1. List of Permits.						
Agency	**Permit**	**Regulated Activity**	**Required Project Phase**	**Applicable to Project**	**Minimum Review Time**	**Comments/Issues**
MPA	Request for Airspace Review	Structures over 200 feet tall near airports	Construction	YES	3 - 4 months	Chatham Municipal Airport is in fairly close proximity, approximately 17 miles from the nearest candidate site. May be concerns about the ~400 foot turbine blade height if close to existing flight paths. This review may be done concurrent with the FAA review.
CZM	Massachusetts General Law Chapter 91 (Public Waterfront Act) authorization	Structures in tidelands, ponds, certain rivers and streams	Construction	MAYBE	1 - 2 months	Chapter 91 authorization is required for structures in tidelands, Great Ponds (over 10 acres in natural state) and certain rivers and streams. Types of structures include piers, wharves, floats, retaining walls, revetments, pilings, bridges, dams, and some waterfront buildings (if on filled lands or over water). Can file Determination of Applicability if applicability of Chapter 91 in question. Site reconnaissance necessary to determine applicability.

Table 8-1. List of Permits.						
Agency	**Permit**	**Regulated Activity**	**Required Project Phase**	**Applicable to Project**	**Minimum Review Time**	**Comments/Issues**
MHC	Archaeological and Historical Review	Activities that could potentially affect archaeological or historical resources	Construction	YES	3 - 4 months	The Wellfleet area has a long history of human habitation and influence on the landscape, including Native American use, Pilgrim landings, and historic areas related to fishing and whaling, as well as historic structures like lighthouses. Many uninventoried archaeological sites are thought to exist in the area of the national seashore.
LOCAL						
Barnstable County - Cape Cod Commission	Development of Regional Impact (DRI) permit	Activity that influences the character of the Cape Cod area	Construction	MAYBE	2 - 3 months	Large wind farm may be determined a DRI because of visual impacts at the Commission's discretion. It may also be considered a Project of Community Benefit. DRI Exemption Application and Jurisdictional Determination Application are options if developer believes that wind farm is not a DRI. Opposition from local groups on scenic and aesthetic grounds is likely in this location, especially since it is adjacent to Cape Cod National Seashore. Note the vocal local opposition to the

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
						Cape Wind project proposed near Cape Cod on the supposition that a wind farm would change the character of the area. There is overall approval of wind projects statewide, but not locally. Commission also has a Regional Policy Plan for the county. This project would likely not be considered a large project since it will have only 1 to 6 turbines.
Barnstable County - Cape Cod Commission	Request for Joint MEPA/DRI Review	Development in Barnstable County	Construction	MAYBE	1 - 2 months	There is substantial overlap in jurisdictions of EOEA and the Cape Cod Commission regarding development review.
Town of Wellfleet Conservation Commission	Order of Conditions/ Wetlands Bylaw compliance review	Alteration of wetlands	Construction	MAYBE	3 - 4 months	Permit required if wetlands will be altered in any way. The permit application is a Notice of Intent and is also sent to the Massachusetts Department of Environmental Protection. If an area less than 5,000 square feet of wetland is altered, the Order of Conditions also serves as the project's Section 401 Water Quality Certificate. Site reconnaissance necessary to determine wetland impacts.

Table 8-1. List of Permits.

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Minimum Review Time	Comments/Issues
Town of Wellfleet - Building Department	Building permit	New construction activity in Wellfleet	Construction	YES	2 - 3 months	
Town of Wellfleet - Planning and Zoning Department	Zoning/Site Plan Approval - Special Permit	Construction of a wind farm outside the scope of current zoning designations	Construction	MAYBE	3 - 4 months	Reviews project for compliance with zoning code. Contact with Department needed to determine specific requirements.
Town of Wellfleet - Zoning Board of Appeals	Variances from code	Project exceeding height limit	Construction	MAYBE	3 - 4 months	Height or setback restrictions may require a variance. Contact with Board needed to determine specific requirements.
Fire Marshal	Fire Code Approval	New development	Construction	MAYBE	NA	Possible substation inclusion in project may trigger need for this approval. Contact with Fire Marshal needed to determine specific requirements.

List of Abbreviations

- COE - Army Corps of Engineers
- CZM - Massachusetts Office of Coastal Zone Management
- dB(A) - A-weighted decibel
- DOE - Department of Energy
- DOER - Massachusetts Office of Consumer Affairs and Business Regulation - Division of Energy Resources
- DPU – Department of Public Utilities
- EFSB - Massachusetts Department of Telecommunications and Energy - Energy Facility Siting Board
- EOEA - Executive Office of Environmental Affairs
- EPA - US Environmental Protection Agency
- EWG - Exempt Wholesale Generator
- FAA - Federal Aviation Administration
- FERC - Federal Energy Regulatory Authority
- ISO/NEPOOL - Independent System Operator/New England Power Pool
- MAC - Massachusetts Aeronautics Commission
- MDEP - Massachusetts Department of Environmental Protection
- MDF&G - Massachusetts Department of Fish and Game
- MDOH - Massachusetts Department of Highways
- MDPU - Massachusetts Department of Public Utilities
- MEPA - Massachusetts Environmental Policy Act
- MHC - Massachusetts Historical Commission
- MNHP - Massachusetts Natural Heritage Program
- MPA - Massachusetts Port Authority
- NEPA - National Environmental Policy Act
- NPDES - National Pollutant Discharge Elimination System
- NPS - National Park Service
- OOC - Order of Conditions
- PURPA - Public Utilities Regulatory Policy Act
- SPCC - Spill Prevention, Control and Countermeasure
- USFWS - US Fish and Wildlife Service
- WWTP - Wastewater Treatment Plant

8.4 Additional Research

In this phase of the study, Black & Veatch did not contact any local, state, or federal agencies to explore the permit requirements for this project. The above list represents a collection of permits that may be required, and identifies which permits are likely to be needed for the project. Black & Veatch recommends contacting the appropriate local, state, or federal agencies in order to determine final permitting requirements.

8.5 Permitting Timeline

To prepare for these permits, it may be advisable to have informal meetings with each agency to discuss the project and that agency's study expectations. The majority of the permits listed in this section are expected to require approximately 3 to 4 months to obtain, following completion of appropriate study work. Black & Veatch recommends that scheduling for the project allow at least 6 months for permitting to allow for delays or some level of unexpected difficulty. Black & Veatch understands the political nature of permitting may add more time to the process, but by meeting with each agency in advance it is believed some of this delay can be avoided.

8.6 Next Steps

If project development moves forward, the Town should begin some permitting and related activities in the near term. Aviation and other wildlife studies should begin, as they generally require seasonal observations. A wetlands survey should be conducted, and the wetlands mapped. A study should be conducted to determine if there are any areas of historic or archaeological interest at the site. If noise concerns are expected to be an issue for residents, an acoustic study should be performed. A more detailed study on the potential shadow flicker impacts, taking land cover and weather patterns into consideration, may be warranted. Discussion with the utility about interconnecting a project should also begin to help determine the best interconnection option, and then an interconnection request should be filed.

9.0 Conceptual Design

This section reviews the conceptual wind plant configuration as well as the proposed wind turbine types for the project.

9.1 Wind Turbine Models

Based on initial wind resource screening and analysis and project specifics, Black & Veatch chose to look at two different turbine types for the Wellfleet project. The turbines being reviewed for this report are:

- General Electric 1.5sle-1500 kW, 80 meter tower, 77 meter rotor diameter.
- Vestas V82-1650 kW, 80 meter tower, 82 meter rotor diameter

9.1.1 GE 1.5sle

General Electric (GE) purchased Enron Wind Energy in 2002, and has integrated the company into GE's Power Systems company. Since this acquisition, GE has applied their efforts to improving the design and production of their only commercial on-shore wind turbine, the GE 1.5MW, shown in Figure 9-1. This turbine is a 1,500 kW machine with a rotor diameter of 70.5, 77, or 82 meters. The turbine is commonly placed on either 65 or 80 meter towers. Because of its variable-speed ability, the GE 1.5MW has a rotational speed range between 10 and 20 RPM (or one revolution every three to six seconds).

The GE 1.5MW turbine is one of the most popular designs for U.S. wind farms. Projects with this design turbine include the Somerset, Mill Run, and Waymart projects in Pennsylvania and Fenner in New York. GE turbines are manufactured in the U.S.

The most popular of the GE 1.5MW models is the 1.5sle, which has a 77 meter rotor. This is the model that is considered in this report.

Figure 9-1. GE 1.5MW turbines at Colorado Green Project.

9.1.2 Vestas V82

The Vestas V82 turbine, shown in Figure 9-2, was originally developed by NEG Micon, a wind turbine manufacturer that merged with Vestas in 2004. This turbine design is optimized for lower wind conditions by mating a slightly larger rotor on a smaller generator than Vestas' equivalent high-wind turbine design (the V80). It is a constant-speed, variable-pitch turbine. This is Vestas' primary low-wind turbine design. Vestas has installed several projects using this turbine, and will likely continue to do so for the next few years.

Figure 9-2. Vestas V82s in New York.

Both turbines are rated for Class IIA wind conditions, and other than having the same basic operation and equipment, the main physical difference between two turbines lies in the size of the rotor diameter. Transportation and erection requirements are largely similar. For the purposes of comparison, both turbine types are incorporated into the production estimates and cost analyses in this study.

9.2 Potential Configurations

Before Black & Veatch began this feasibility study, the Town of Wellfleet and MTC did some preliminary work on available land and potential turbine locations. The Town already owned undeveloped land west of White Crest Beach and it was determined that there was sufficient space for up to three large wind turbines. Potential sites for these three turbines were chosen and notices were submitted to the Federal Aviation Administration (FAA) by MTC.

Black & Veatch reviewed the land ownership and wind resource information, and concluded that these locations are suitable for the purposes of this study. Spacing between turbines is about 600 meters (7.5 rotor diameters), and based on the west to southwest prevailing wind direction should be sufficient to avoid significant wake effects.

Though there is some margin of play in which the individual sites can be moved, the basic general layout will not be able to change much due to land ownership boundaries and the proximity of nearby homes.

Figure 9-3 shows the approximate turbine locations for a three-turbine wind project near White Crest Beach. Preliminary layouts for the collection system and a potential interconnection location are shown as well. The collection system design would not be limited regarding the last circuit run that connects the turbines to the interconnection substation (known as a "homerun").

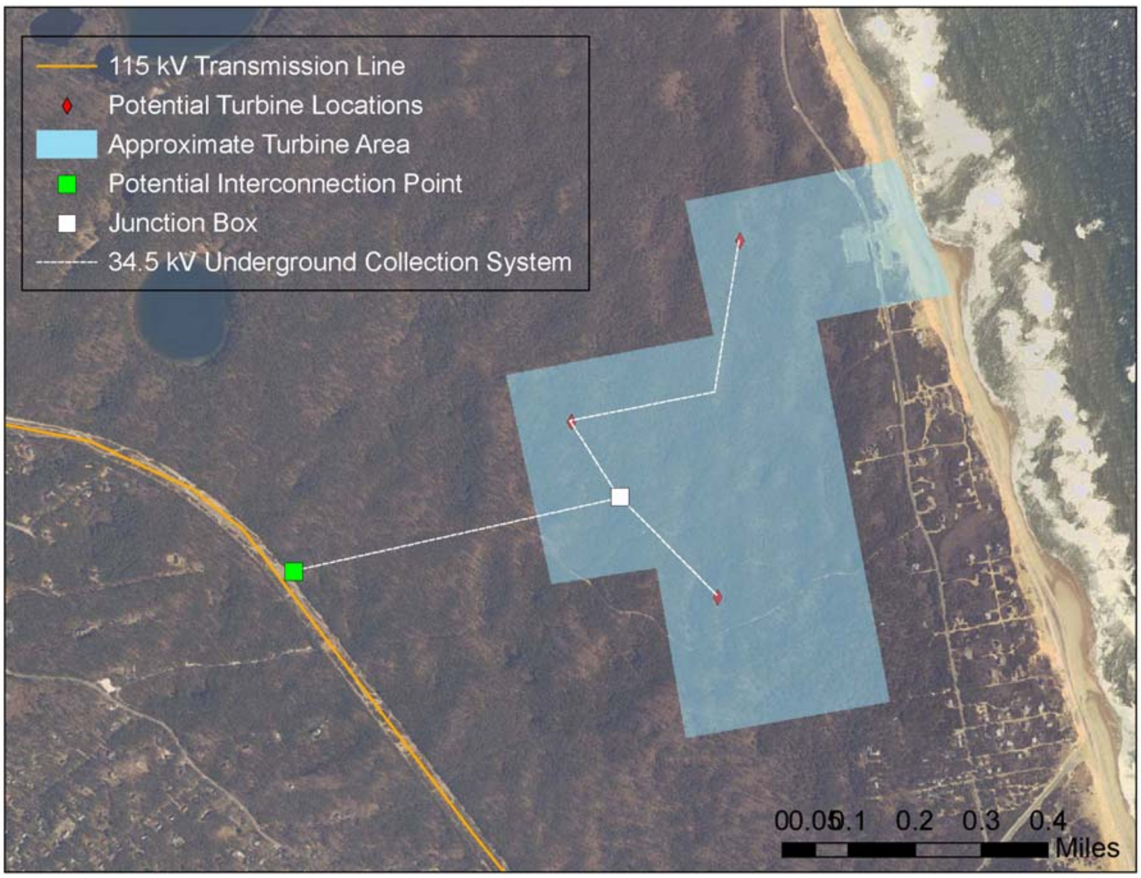

Figure 9-3. Three Turbine Project Configuration.

The text of the recently passed Massachusetts Senate Bill number 2768 puts a cap on renewable energy net metering projects at 2 MW. A single large turbine project would be in the range of 1 to 2 MW, defined as a Class III Net Metering Facility. It may be the desire of the Town of Wellfleet to build a single turbine project in order to utilize a net-metering scenario. According to preliminary shadow flicker, noise, and visual analyses, Black & Veatch believes a single turbine project would have the least negative impact at the location west of the White Crest Beach parking lot. A representation of this single turbine configuration can be seen in Figure 9-4.

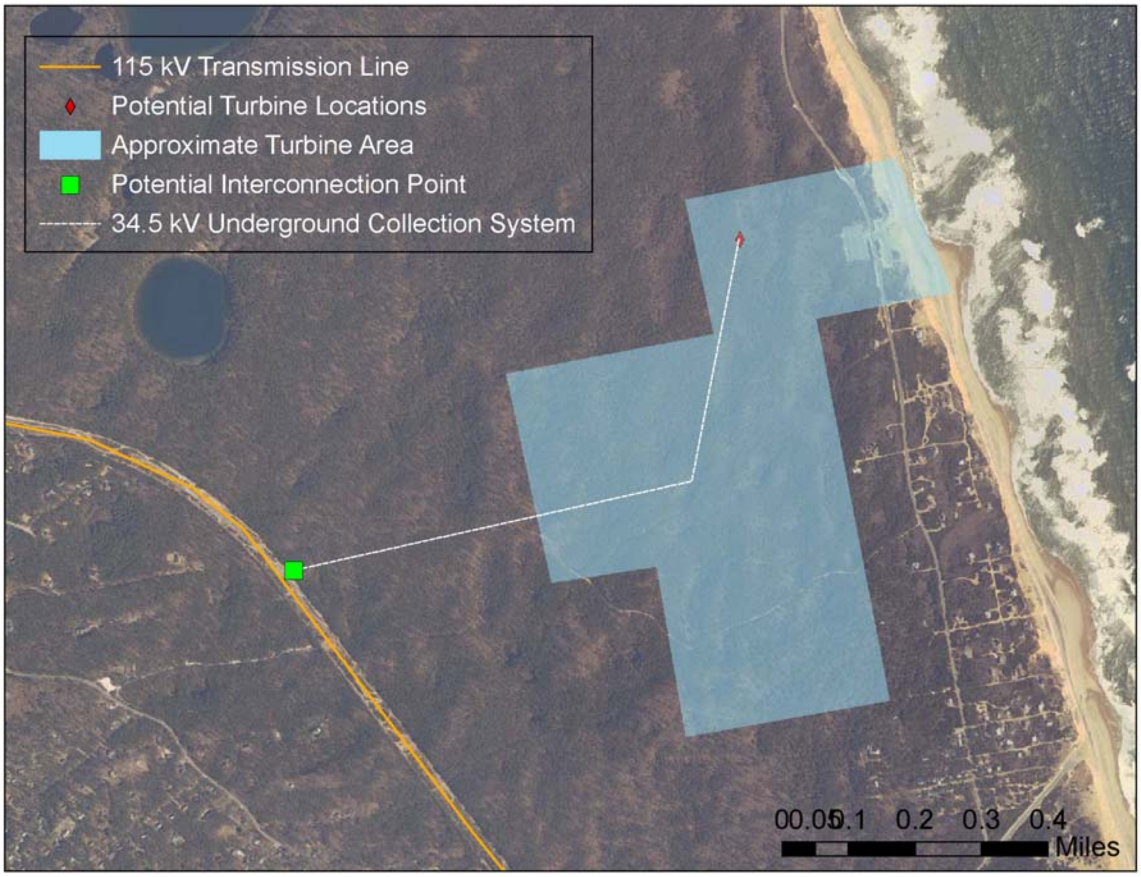

Figure 9-4. Single Turbine Project Configuration.

Utilizing the net-metering scenario with a three-turbine project such as this would require two legally separate projects and likely require two separate substations. Black & Veatch feels the cost of an additional substation would substantially offset the economic viability of this project and therefore does not recommend this option.

For both viable turbine configurations evaluated in this report, Black & Veatch feels that building an interconnection substation is the best option for interconnecting the project to the transmission grid. The close proximity of the Commonwealth 115 kV line allows for minimizing the cost of installing the 35 kV underground collection system from the turbines to the interconnection substation. Black & Veatch expects any of the three locations for both configuration options would be similar to implement.

A new interconnection substation is recommended to be located adjacent to the Commonwealth 115 kV line, giving it a rather direct and short route for interconnecting the wind turbine(s).

9.3 Distance from Key Locations

Using Google Earth, the nearest residence to any of the three possible turbine locations is estimated to be about 1300 feet. The turbines will lie approximately one-half to three-quarters of a mile from the Commonwealth 115 kV line and the nearest turbine to White Crest beach would be approximately one-quarter mile. Distances from these locations and a few others are shown in Figure 9-5. The setbacks allow for a safe distance from key locations near the wind turbines in the unlikely event that a turbine was to collapse.

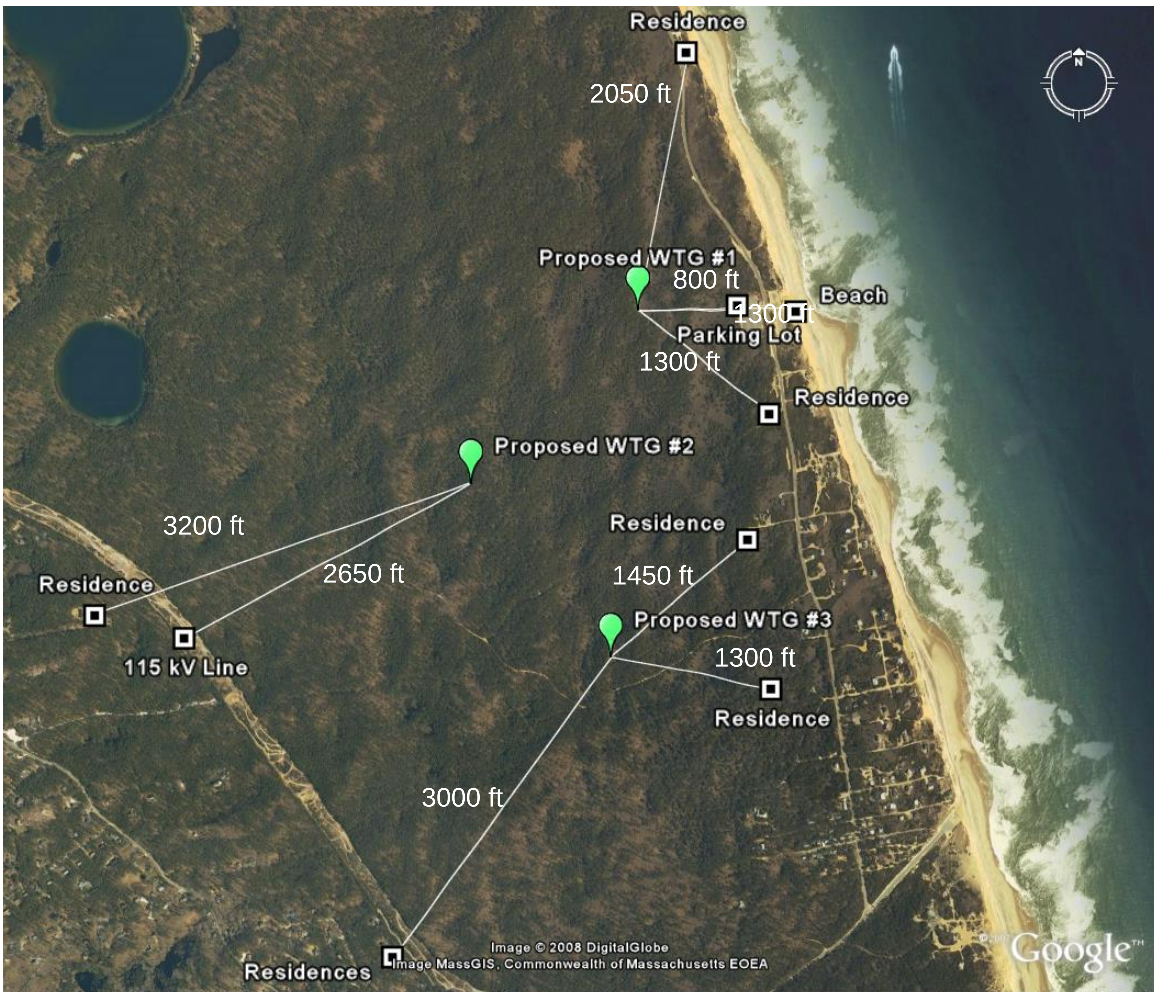

Figure 9-5. Distances from Key Locations.

9.4 Appropriateness and Community Impact

Based on the available land, current land use, proximity of roads and highways, and proximity of transmission, the area seems suitable for development of a small wind project. It exceeds all required and recommended setbacks from roads, homes, and property lines. It should not directly interfere with recreation use of the area or the primary views from homes in the area. Noise impacts are also not expected to be significant.

Black & Veatch's main concern is the potential effects of shadow flicker from the middle and southern turbine locations on homes in the area, and to a lesser extent the beach. The beach is much lower than the turbine area and the cliff may mitigate potential shadow issues. The effect on homes immediately east of the project may be unacceptable, however, and more work may need to be done to determine actual effects including what times of the year these homes are occupied (if seasonal) and the overlap between these times and shadow flicker events.

10.0 Project Development Considerations

The following section discusses the project development considerations for a wind project in the Town of Wellfleet.

10.1 Development and Ownership Options

There are typically two ownership options explored for Massachusetts communities looking to host community scale wind projects on municipal lands: municipal ownership and third party (commercial) ownership. For this project it is quite possible that the only available ownership option will be municipal, due to the requirements of the Cape Cod National Seashore. Black & Veatch understands that although the Town of Wellfleet is allowed to use land they own inside the National Seashore boundary for municipal purposes, commercial development in the Seashore is prohibited. Possibilities for shared-ownership of the project are unknown, though Black & Veatch recommends this option be looked into. Third party ownership was still modeled in the financial analysis, but is unlikely to be a viable option.

10.1.1 Municipal Ownership

Town ownership could have greater economic gains for the Town, but it would also bear the risks associated with the ownership of an income earning enterprise. Assistance from MTC is available, however, and if the Town develops the project it has the potential for higher returns than would be earned from the developer option.

10.1.2 Private Ownership

Private developers have experience with developing wind projects and could more easily develop the Brewster sites. Private owners are also eligible for federal tax incentives, such as the Production Tax Credit (PTC) and accelerated depreciation, which may make the project more viable financially. The Town’s primary benefits from private ownership are likely to be either property tax or payment in lieu of tax (PILOT), as well as lease payments for the use of municipal land.

A potential drawback with using a private developer is that it may be difficult for the Town to interest a private developer in such a small project. There is significant risk that a project could be slowed by local opposition or permitting problems, delays that could prove fatal to a private developer.

Table 10-1 summarizes the advantages and disadvantages of each ownership option.

Table 10-1. Public vs. Private Owership.

Ownership Option	Advantages	Disadvantages
Private Developer	Eligible for Production Tax Credit Takes on risk of project, experience in developing wind projects	Higher cost of debt (uncertain) May be difficult to attract developer interest for such a small project
Municipal	Lower cost of debt (uncertain) Potential for greater economic benefit	No access to the Production Tax Credit Business risk, little experience developing wind projects

10.2 Project Financing

Black & Veatch has assumed that the Town of Wellfleet would finance a wind energy project with 100 percent debt in the form of 20-year municipal bonds. This would allow a lower interest rate than financing from other sources, resulting in a lower overall cost of debt and higher return. The Town may require special legislation to be able to issue bonds for this length of time.

Private development would have a higher cost of debt, as financing would be through a private institution. For simplicity, it was assumed that a private developer would finance a project using 100 percent equity.

10.3 Development Considerations

One of the chief considerations for development of a project near White Crest Beach in Wellfleet is the presence of the Cape Cod National Seashore and its effect on permitting. It is expected that most permits will take 6 months or so to obtain, but the timeline for approval from the Seashore may be more difficult.

A wind energy project in Wellfleet will generate Renewable Energy Credits (RECs) equivalent to the number of megawatt-hours (MWh) of energy it produces. These RECs are an attempt to capture the "green" aspects of renewable energy. Massachusetts has an operating REC market where these credits can be bought and sold. Purchasing these credits may help a utility meet the requirements of the state Renewable Portfolio

Standard without purchasing a project or its energy directly. Black & Veatch has assumed that the Town would sell all RECs generated by the project.

Project management and procurement would likely be handled by a third party contractor who will actually do the project engineering and install the turbines. Alternatively, the Town could buy the turbines themselves and hire a contractor to perform the remaining engineering, construction, and installation. Often with large projects the project owner procures the turbines directly because the long lead time to obtain turbines means they are often bought before a construction contractor is selected, though there are several aggregators in Massachusetts that are able to provide a full service installation including turbine procurement for small projects such as this.

10.4 Operations and Management

A three-turbine project at Wellfleet is not likely to be large enough for a turbine manufacturer to have dedicated service personnel in the area. The nearest operating wind project is at the Massachusetts Maritime Academy in Buzzard's Bay. Since the manufacturer would likely perform routine maintenance and repair on the turbines for the first five years of operations, it is likely that personnel from other wind projects in New England would be dispatched to Wellfleet as necessary, and a project would most likely be operated and monitored from an existing project facility elsewhere as well. This may introduce delays in servicing faults that require on-site repair, though many faults could be reset remotely.

After the turbine warranty period ends, the Town would have the option of hiring a third party operations and maintenance company that would operate and maintain the turbines similarly to the manufacturer, or could have local residents trained in the operation and maintenance of the turbines.

11.0 Estimated Energy Production

This section is an estimate of annual energy production for single turbine and three turbine project scenarios using two wind turbine models, the GE 1.5sle and the Vestas V82. The production estimate is based on data collected from the Wellfleet met tower, adjusted to better represent the expected long-term wind resource at the site. The methods and assumptions for this estimate are discussed below.

11.1 Annual Energy Production

11.1.1 Wind Turbine Power Curves

A wind turbine power curve is curve representing the amount of energy a wind turbine model will generate at a given wind speed and air density. Typically, these power curves are supplied as a table of wind speeds versus air densities. At lower air densities, the power generated by a wind turbine at wind speeds below the turbine's rated speed is less than at higher densities. Based on the site elevation of 21 meters above sea level and climatic information from the RERL tower, Black & Veatch chose to use the sea level air density (1.225 kg/m3) power curves when estimating production for both the GE 1.5sle and Vestas V82 turbines. These power curves are shown in Table 11-1.

Table 11-1. Wind Turbine Power Curves.

Hub Height Wind Speed (m/s)	Power Output, kW	
	GE 1.5sle	Vestas V82
0	0	0
1	0	0
2	0	0
3	0	0
4	43	29
5	131	146
6	250	313
7	416	517
8	640	767
9	924	1,028
10	1,181	1,299
11	1,359	1,518
12	1,436	1,639
13	1,481	1,648
14	1,494	1,650
15	1,500	1,650
16	1,500	1,650
17	1,500	1,650
18	1,500	1,650
19	1,500	1,650
20	1,500	1,650
21	1,500	0
22	1,500	0
23	1,500	0
24	1,500	0
25	1,500	0

11.1.2 Estimated Losses

Black & Veatch has examined the option of a large turbine for one of the sites previously discussed to estimate the potential production losses that might impact wind turbines. Additionally, production losses are shown for a three turbine installation. Each loss factor is discussed below, and summarized in Table 11-2.

Table 11-2. Project Production Loss Factors.

Loss Type	Single Turbine		Three Turbines	
	Loss Percent	Adjustment Factor	Loss Percent	Adjustment Factor
Topographic Effect	0.00%	1.00	0.00%	1.00
Wake Effect	0.00%	1.00	1.50%	0.99
Turbine Availability	3.00%	0.97	3.00%	0.97
Turbine Power Curve	0.00%	1.00	0.00%	1.00
Grid Availability	0.50%	1.00	0.50%	1.00
Electrical Losses	1.00%	0.99	1.00%	0.99
Columnar Losses	0.00%	1.00	0.00%	1.00
Blade Contamination	1.50%	0.99	1.50%	0.99
Icing	1.50%	0.99	1.50%	0.99
Model Estimate	5.00%	0.95	5.00%	0.95
High Wind Hysteresis	0.00%	1.00	0.00%	1.00
Product of Loss Factors	**11.93%**	**0.8807**	**13.25%**	**0.8675**

- Topographic Effect: This is the loss or gain due to wind speed reductions or increases between the met tower and turbine caused by the site's topography. Because of the met tower's proximity to the potential turbine sites the topographic effect is assumed to be zero.
- Wake Effect: This is the energy loss due to the effect one turbine will have on another, or the wake caused by any structure on the wind turbines. By definition, this is zero for a single turbine project. Black & Veatch assumes that there will be minor wake losses for the three turbine project.
- Turbine Availability: Wind turbine manufacturers will specify an availability level to be covered in a warranty (this may be difficult to obtain for single turbine installations). This value assumes the turbine's availability is only at that warranty value.
- Turbine Power Curve: The wind turbine manufacturer will warranty a performance level from the turbine at a percentage of the power curve values (this may also be difficult to obtain for a single turbine installation.) Typical warranty levels are 95 to 97 percent of published power curve. However, industry practice is usually not to consider this as a potential loss, given most wind turbines operate at or slightly above their published power curves. For this study, Black & Veatch left the value as a 0 percent loss.

- Grid Availability: An estimate is made as to the amount of time the utility (or in this case, the electrical system of the plant) will be available to receive power from the project. All grid systems are off-line periodically for maintenance, and projects in more remote locations will be connected to weaker grid systems that are more prone to failure. Losses for grid availability vary between 0.1 percent for very strong grid system to as high as 5 percent for weak systems (and even larger for systems outside the US). As Black & Veatch has no specific information on grid reliability in the project area, an estimated loss of 0.5 percent was assumed.
- Electrical Losses: Losses in the lines and electrical equipment prior to the plant's revenue meters are covered by this factor. Points of significant electrical losses in a wind energy project usually include the underground and overhead distribution lines connecting the turbines to a substation, and the substation's primary transformer. Typical electrical loss values range from as low as 1 percent to 10 percent or more, depending on the layout and equipment used. Since the overall project area is small with few turbines, electrical losses were assumed to be low, at 1 percent.
- Columnar Losses: If a project of many wind turbines is arranged in rows, turbine manufacturers may require the shutdown of some turbines when the winds are coming from directions parallel to the rows. These losses will not apply to the options defined in this report.
- Blade Contamination: Wind turbine performance is sensitive to the cleanliness of the turbine's blades. In areas of high dust or insects, contamination can build on the wind turbine blades that will limit the turbine's performance (causing losses up to 5 percent or more). Often the blades are cleaned by occasional rainfall, but in some areas periodic blade washing is required. For a lack of more specific information, a general loss of 1.5 percent due to contamination was assumed in this report.
- Icing: During winter storms, snow and ice will build up on the wind turbine blades causing a similar degradation in performance to that caused by dust and insects. While this contamination will build much faster than summer contamination, it is often cleared after a few hours of direct sunlight (even at continued subzero temperatures). Given the anticipated likelihood of several significant storms per winter, a loss of 1.5 percent was assumed for the lost energy due to icing.
- Model Estimate: Black & Veatch estimated the performance of potential wind turbines using manual calculations within a basic spreadsheet. Black &

Veatch gave this value a high uncertainty due to problems associated with the wind resource campaign such as failures in the anemometers at 49 meters above ground level and the wind vanes at 49 and 38 meters above ground level.

- High Wind Hysteresis: When wind speeds exceed the operational range of a wind turbine, the turbine shuts down to protect itself. Such shut-downs normally require the turbine to remain offline for several minutes, regardless if the wind speed returns to the operational range. Sites with a significant number of these high wind events suffer lost energy due to this hysteresis effect, which is additional to the amount of time the average wind speeds remain above the cut-out wind speed. As the Project site does not have a significant number of high wind events on record, no losses due to this hysteresis effect were applied.

11.1.3 Production Estimates and Comparisons

Black & Veatch estimated production for a single turbine and a three turbine project using both the GE 1.5sle and Vestas V82 models based on the wind resource analysis performed in Section 3. For the production estimate, the data was “binned” by hub height wind speed for each turbine to determine the number of hours per year the winds would be within a 1 m/s bin (for instance, the 5 m/s bin represents all wind speed data points between 4.5 m/s and 5.5 m/s). With the hours per bin known, the total energy produced each year from winds within each bin was estimated and summed to determine the total annual gross production from the turbine. Each wind turbine installation is subject to losses discussed in above. These losses were applied to the gross energy estimate to determine the project’s net energy estimate. Finally, a net capacity factor was calculated which represents the net annual generation compared to maximum possible generation from the wind turbine (a value of 100% would mean the turbine would operate at rated power every hour of the year; a typical capacity factor for a project in the Northeast U.S. is about 30 percent).

The resulting energy and capacity factor estimates are shown in Table 11-3 for a single turbine and Table 11-4 for a three turbine project. The production estimates are plotted in Figure 11-1.

Table 11-3. Single Turbine Production Estimates.

Month	GE 1.5sle		Vestas V82	
	MWh	Net C.F.	MWh	Net C.F.
January	523	46.9%	577	47.0%
February	402	39.9%	448	40.4%
March	513	46.0%	580	47.2%
April	376	34.8%	414	34.9%
May	332	29.8%	380	31.0%
June	398	36.8%	454	38.2%
July	246	22.1%	286	23.3%
August	296	26.5%	341	27.7%
September	370	34.3%	422	35.5%
October	436	39.1%	496	40.4%
November	330	30.5%	370	31.1%
December	496	44.4%	560	45.6%
Annual (P50)	**4,718**	**35.9%**	**5,328**	**36.9%**
Annual (P90)	**3,727**	**28.4%**	**4,233**	**29.3%**
Annual (P95)	**3,446**	**26.2%**	**3,922**	**27.1%**

Notes:

C.F. refers to net capacity factor, calculated as discussed in this section.

P50, P90, and P95 refer to probability of exceedence as discussed in Section 11.1.4

Table 11-4. Three Turbine Project Production Estimates.

Month	GE 1.5sle		Vestas V82	
	MWh	Net C.F.	MWh	Net C.F.
January	1,545	46.2%	1,705	46.3%
February	1,187	39.3%	1,325	39.8%
March	1,517	45.3%	1,713	46.5%
April	1,110	34.3%	1,224	34.3%
May	982	29.3%	1,124	30.5%
June	1,176	36.3%	1,342	37.7%
July	727	21.7%	846	23.0%
August	875	26.1%	1,006	27.3%
September	1,094	33.8%	1,248	35.0%
October	1,290	38.5%	1,464	39.8%
November	974	30.1%	1,093	30.7%
December	1,466	43.8%	1,653	44.9%
Annual (P50)	**13,943**	**35.4%**	**15,743**	**36.3%**
Annual (P90)	**11,013**	**27.9%**	**12,508**	**28.8%**
Annual (P95)	**10,183**	**25.8%**	**11,591**	**26.7%**

Notes:
C.F. refers to net capacity factor, calculated as discussed in this section.
P50, P90, and P95 refer to probability of exceedence as discussed in Section 11.1.4

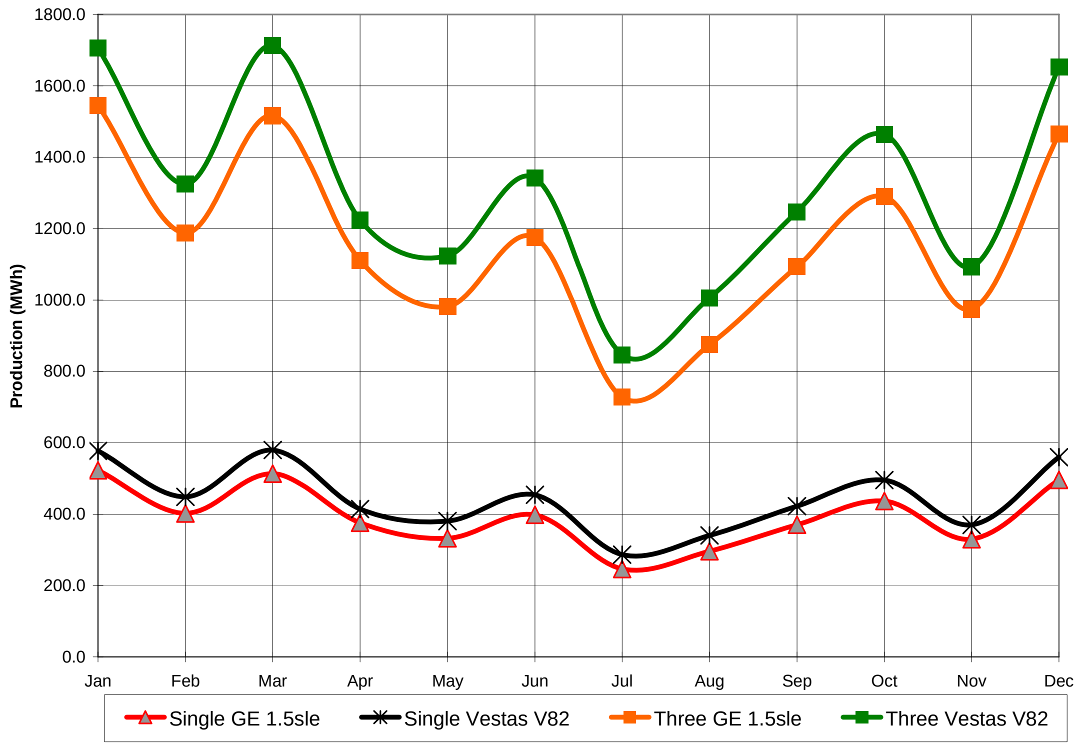

Figure 11-1. Monthly Production Estimates.

11.1.4 Uncertainty Analysis

Based on the analysis detailed above and in Section 3, Black & Veatch has estimated the long-term average wind speed for Wellfleet to be about 7.69 m/s at 80 meters. The corresponding long-term average production for the various turbine types and project options were presented as the Annual Average (P50) above. These values correspond to the 50 percent confidence value estimates, meaning that there is a 50 percent chance that the true long-term average wind speed is higher, and a 50 percent chance it is lower. To determine the sensitivity of the production to variations in wind speed, and to estimate the magnitude of variations possible, the following uncertainty analysis is performed.

- **Long-term wind speed variability:** this is a measure for how well understood the long-term wind resource is, and is determined by the length of the long-term data set analyzed.
- **Correlation standard error:** this value is a measure of how well the on-site data correlates to the long-term data source.
- **Anemometer calibration:** this is the stated calibration of the primary anemometer used to measure the on-site wind resource (or in our case, the

RERL Wellfleet met tower). For uncalibrated instruments, the standard accuracy of the anemometer published by its manufacturer is used. For instruments left installed past their calibration period, or for longer than one year for uncalibrated sensors, an increase in the calibration uncertainty may be applied for expected sensor degradation.

- **Topographic and wake modeling:** the models used to estimate the effects of topography and turbine wakes have uncertainty associated with them.
- **Wind variability:** this is a single year estimate of the long-term variability, signifying the uncertainty of estimating the "next year's" power production.

Table 11-5 shows the breakdown of uncertainty components for each turbine and project option. The combined standard error is calculated as the square root of the sum of the squares of each error component, and represents the combined standard deviation from the mean (P50) estimated generation. This value is used to calculate the P90 and P95 annual energy estimates in the previous section, based on a standard normal distribution. For each option, the true long-term annual average energy has a 90 percent chance of being greater than the P90 estimate, and a 95 percent chance of being greater than the P95 estimate. These values can be used for sensitivity evaluations in a project pro forma or payback analysis.

Table 11-5. Production Estimate Uncertainty Analysis.

Project			**Single Turbine**		**Three Turbines**	
			GE 1.5sle	**Vestas V82**	**GE 1.5sle**	**Vestas V82**
Project Rating	MW		1.50	1.65	4.50	4.95
P50 Estimated Generation	MWh/yr		4,718	5,327	13,942	15,743
P50 Wind Speed	m/s		7.69	7.69	7.69	7.69
Energy Sensitivity	MWh/yr/(m/s)		1,153	1,273	3,406	3,762
	Uncertainty					
Factor	**percent**	**m/s**	**MWh/yr**	**MWh/yr**	**MWh/yr**	**MWh/yr**
Long-Term Wind Variability*	1.5%	0.12	135	149	399	441
Correlation**		0.37	429	474	1,269	1,401
Anemometer Calibration	2.0%	0.16	180	199	531	587
Topo/Wake Model	3.0%	0.23	270	298	797	880
Wind Variability	6.0%	0.47	539	596	1,593	1,760
Combined Standard Error			**774**	**854**	**2,286**	**2,525**

Notes:
* Long-term variability based on Provincetown Airport data
** Correlation done on a monthly average basis

11.2 On-Site Energy Use

The potential project location has no actual on-site loads. However, Massachusetts Senate Bill 2768 (the Green Communities Act) outlines net metering for large renewable energy projects up to 2 MW. Under the bill, a single large turbine would be classified as a "Class III net metering facility," defined as:

> "a solar-net-metering or wind-net-metering facility with a generating capacity of more than 1 megawatt but less than or equal to 2 megawatts; provided, however, that a Class III net metering facility owned or operated by a customer which is a municipality or other governmental entity may have a generating capacity of more than 1 megawatt but less than or equal to 2 megawatts per solar-net-metering or wind-net-metering unit."

The text of the bill states that:

> "If the electricity generated by the Class III net metering facility during a billing period exceeds the customer's kilowatt-hour usage during the billing period, the customer shall be billed for 0 kilowatt-hour usage and the excess Class III net metering credits shall be credited to the customer's account. Credits may be carried forward from month to month. A Class III net metering facility may designate customers of the same distribution company to which the Class III net metering facility is interconnected and that are located in the same ISO-NE load zone to receive such credits in amounts attributed to such customers by the Class III net metering facility. Written notice of the identities of the customers so designated and the amounts of the credits to be attributed to such customers shall be in a form as the distribution company shall reasonably require. A distribution company may elect not to allocate such credits and instead may purchase net metering credits from the facility at the rates provided for herein."

Class III net metering credits are defined as:

> "a credit equal to the excess kilowatt-hours by time of use billing period, if applicable, multiplied by the sum of the distribution company's: (i) default service kilowatt-hour charge in the ISO-NE load zone where the customer is located; (ii) transmission kilowatt-hour charge; and (iii) transition kilowatt-hour charge. Notwithstanding the foregoing, in the case of a customer which is a municipality or other governmental entity, the credit shall be equal to the excess kilowatt-hours multiplied by the sum of (i), (ii) and (iii), as set forth in the preceding sentence, and the distribution kilowatt-hour charge. This does not include the demand side

management and renewable energy kilowatt-hour charges set forth in sections 19 and 20 of chapter 25."

For this study, it was assumed that the law would pass as written, and that a single turbine project less than or equal to 2 MW would be able to take advantage of this net metering system. Because the net metering credits may be applied to other accounts, it was assumed that a project would be able to garner retail value for all production.

11.3 Performance Degradation

Generally in a study such as this performance degradation over time is not considered in the production estimates. It is assumed that over the 20 year projected operating life of a wind project, operations and maintenance are sufficient to keep the turbines operating nominally at the warranted availability.

What is expected to change over time is the cost of maintaining the turbines. This is accounted for in the financial analysis by increasing the operations and maintenance costs over time.

12.0 Cost Estimate

Black & Veatch prepared preliminary cost estimates for budgetary purposes. The estimates are for either a single or three turbine project using either Vestas V82 or GE 1.5sle turbines.

The cost estimates shown in Table 12-1 are based on general pricing data from wind turbine vendors and cost breakdowns from recent small and large wind turbine projects. A detailed cost estimate has not been generated for this study, nor has Black & Veatch requested cost proposals from local construction contractors. This estimate is not an offer from Black & Veatch to install this project for this price, but rather intended to be used for study purposes only. These estimates also do not attempt to capture any internal Town costs for necessary project oversight, approvals, bylaw changes, or other internal costs.

Black & Veatch estimates that the per installed kW costs range from about $2,210 to $2,670 depending on the turbine model and project size. The cost per kW is higher for a single turbine project than for three turbines, since all of the study, engineering, mobilization, and permitting work are amortized over fewer turbines. These prices also reflect the current exchange rate between the United States Dollar and the Euro, as well as general increases in the prices of steel, copper, and other materials. The current high demand for wind turbines in the U.S. affects costs as well.

Black & Veatch assumed that the first five years of operations and maintenance would be performed by the turbine manufacturer and included in the wind turbine supply and warranty agreements. From years six to year 20, Black & Veatch assumed an all in O&M cost of $40,000 per turbine per year (2008 dollars), escalated at the inflation rate.

Table 12-1. Preliminary Project Cost Estimate.

	Single Turbine		Three Turbines	
	GE 1.5sle	V82	GE 1.5sle	V82
Turbine Rating (MW)	1.5	1.65	1.5	1.65
Project Rating (MW)	1.5	1.65	4.5	4.95
Development and Project Management				
Development Costs (pre-engineering)				
Feasibility Studies, Consulting	$150,000	$150,000	$150,000	$150,000
Interconnection Study	$100,000	$100,000	$100,000	$100,000
Project Management				
Owner's Costs, Permitting	$100,000	$100,000	$100,000	$100,000
Total Development & Project Management	**$350,000**	**$350,000**	**$350,000**	**$350,000**
Wind Turbines and Balance of Plant				
Engineering (BOP Only)				
Surveying	$7,000	$7,000	$11,000	$11,000
Geotechnical Investigation	$10,000	$10,000	$20,000	$20,000
Civil Engineering	$15,000	$15,000	$25,000	$25,000
Structural Engineering	$35,000	$35,000	$55,000	$55,000
Electrical Engineering	$30,000	$30,000	$40,000	$40,000
Engineering Management	$12,000	$12,000	$16,000	$16,000
Subtotal	**$109,000**	**$109,000**	**$167,000**	**$167,000**
Procurement: Wind Turbines				
Wind Turbine FOB Factory/Port	$2,250,000	$2,442,000	$6,750,000	$7,326,000
WTG Shipping to Wellfleet	$100,000	$100,000	$300,000	$300,000
2-Year Service/1-2 Yr Warranty	$15,000	$15,000	$45,000	$45,000
Extended Service (Years 3-5)	$120,000	$120,000	$360,000	$360,000
Communications/SCADA	$130,000	$130,000	$370,000	$370,000
Training	$10,000	$10,000	$10,000	$10,000
Subtotal	**$2,625,000**	**$2,817,000**	**$7,835,000**	**$8,411,000**
Procurement: Balance of Plant Equipment				
Switchgear/Transformer/Cables	$75,000	$75,000	$225,000	$225,000
FAA Lights	$2,500	$2,500	$7,500	$7,500
Subtotal	**$77,500**	**$77,500**	**$232,500**	**$232,500**
Construction				
Contractor Mob/Demob	$50,000	$50,000	$50,000	$50,000
Civil Construction (Roads, Crane Pads)				

Table 12-1. Preliminary Project Cost Estimate.

	Single Turbine		Three Turbines	
	GE 1.5sle	V82	GE 1.5sle	V82
Laydown/Trailer Complex Prep	$25,000	$25,000	$25,000	$25,000
Repair Roads	$20,000	$20,000	$40,000	$40,000
Stormwater/Erosion Control	$10,000	$10,000	$30,000	$30,000
General Site Maintenance/Weed Control	$0	$0	$0	$0
WTG/Crane Pad Clearing and Prep	$30,000	$30,000	$60,000	$60,000
Structural Construction				
WTG Foundation Excavation	$50,000	$50,000	$150,000	$150,000
WTG Foundation Construction	$100,000	$100,000	$300,000	$300,000
Met Tower Foundation Excavation	$0	$0	$0	$0
Met Tower Foundation Construction	$0	$0	$0	$0
Electrical Construction (Collection, SCADA)	$35,000	$35,000	$105,000	$105,000
WTG Erection	$250,000	$250,000	$500,000	$500,000
Construction Management/Indirects	$35,000	$35,000	$85,000	$85,000
Subtotal	**$605,000**	**$605,000**	**$1,345,000**	**$1,345,000**
Total Wind Turbines and Balance of Plant	**$3,416,500**	**$3,608,500**	**$9,579,500**	**$10,155,500**
Substation and Transmission				
Facility Interconnection	$135,000	$135,000	$155,000	$155,000
System Upgrades	$25,000	$25,000	$75,000	$75,000
Total Substation and Transmission	**$160,000**	**$160,000**	**$230,000**	**$230,000**
Other Costs				
Construction Contingency	$78,530	$82,370	$203,190	$214,710
Total Other Costs	**$78,530**	**$82,370**	**$203,190**	**$214,710**
Project Totals				
Development and Project Management	$350,000	$350,000	$350,000	$350,000
Balance of Plant	$791,500	$791,500	$1,744,500	$1,744,500
Substation and Transmission	$160,000	$160,000	$230,000	$230,000
Other Costs	$78,530	$82,370	$203,190	$214,7 10
SUBTOTAL	$1,380,030	$1,383,870	$2,527,690	$2,539,210
Wind Turbine Procurement	$2,625,000	$2,817,000	$7,835,000	$8,411,000
TOTAL PROJECT	**$4,005,030**	**$4,200,870**	**$10,362,690**	**$10,950,210**

Table 12-1. Preliminary Project Cost Estimate.

	Single Turbine		Three Turbines	
	GE 1.5sle	V82	GE 1.5sle	V82
Project Cost per kW				
	($/kW)	***($/kW)***	***($/kW)***	***($/kW)***
Development and Project Management	$233	$212	$78	$71
Balance of Plant	$528	$480	$388	$352
Substation and Transmission	$107	$97	$51	$46
Other Costs	$52	$50	$45	$43
SUBTOTAL	$920	$839	$562	$513
Wind Turbine Procurement	$1,750	$1,707	$1,741	$1,699
TOTAL PROJECT	**$2,670**	**$2,546**	**$2,303**	**$2,212**

13.0 Project Revenues

This section estimates project revenues for both project options with both the GE 1.5sle and Vestas V82 wind turbines.

13.1 Assumed Value of Energy

Energy from a wind project in Wellfleet would be sold in one of two ways. The first would be through a net metering arrangement, which would allow the project offset Town energy use and to obtain retail value of excess energy. The second would be through a wholesale arrangement, which would return a lower value of energy.

Black & Veatch looked at two main sources of data to determine the values of energy offset (in the first case) or sold (in the second) by a wind turbine project in Wellfleet. The first was the electrical service rates for Wellfleet, which were obtained from the NSTAR website. The energy charge for a large customer is about $110 per MWh. The Class III net metering credit also includes charges for transmission, distribution, and transition if the project is municipally owned. If the project were not municipally owned, the distribution charge would not be included. Table 13-1 summarizes the assumed energy offset value of the net metering credit.

Table 13-1. Class III Net Metering Credit for Wellfleet.

Charge	Value ($/MWh)
Default service	$110
Distribution	$11.8
Transmission	$7.5
Transition	$19.8
Total	**$149.2**

Source: NSTAR schedule of rates

Black & Veatch used this as the assumption for the value of energy use offset either directly or through a net metering arrangement. If the actual value the Town of Wellfleet pays for energy is different, it will affect the financial analysis somewhat.

To estimate the value of energy sold on the wholesale market, Black & Veatch investigated the historical pricing at the nearest Localized Marginal Price (LMP) node, in Barnstable. The annual average prices at this node are shown in Table 13-2 and in Figure 13-1. Based on the historical data, Black & Veatch assumed a wholesale price for energy of $70 per MWh, escalating with inflation.

Table 13-2. Average Annual LMP Price at Barnstable.			
Year	**Off Peak**	**On Peak**	**All Hours**
2003	$42.47	$53.29	$47.49
2004	$44.19	$57.25	$50.31
2005	$66.66	$82.29	$73.94
2006	$50.90	$66.65	$58.21
2007	$59.63	$77.88	$68.13
2008 (to date)	$71.08	$92.19	$81.16
Source: Global Energy Decisions			

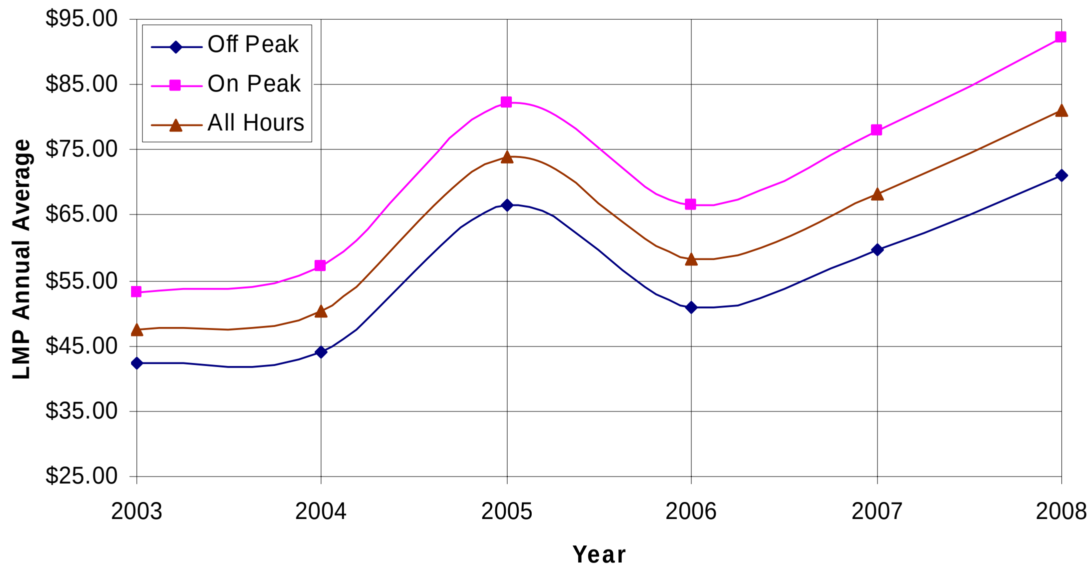

Figure 13-1. Annual Average LMP Prices at Barnstable.

13.2 Renewable Energy Credits

MTC makes a Standard Financial Offer (SFO) to purchase the RECs from a community project such as this at a price of $40 per MWh. The nominal value of the MTC REC contract is based on the nameplate capacity of the project. For a 4.5 MW project, the nominal value of the contract would be $4.2 million. The town may choose to start taking the SFO at any point during the project's lifespan. Black & Veatch assumed that the Town would sign a REC sales contract valued at $40 per MWh for the first 3 years of project operation, and then take the SFO until the nominal value of the contract is exhausted. After this, RECs are assumed to be sold on the spot market for $15 per MWh.

13.3 Potential Value of Wind-Generated Electricity

Black & Veatch has assumed two major scenarios for the sale of power. The first, which is applicable to a single turbine project, is that the electricity use could be offset by a net metering arrangement. For this scenario it was assumed that the project would be able to garner full retail value for electricity. The second is that all generated energy would be sold to the wholesale market. In both cases, RECs are sold at $40 per MWh for the first three years. After that the project would take the Standard Financial Offer until it is exhausted, after which RECs would be sold for $15 per MWh.

In the case of developer ownership, 10 years of Production Tax Credits (PTCs) at $20 per MWh are also included (escalated with inflation). All inflation escalation is assumed to be at 2 percent annually.

13.4 Project Revenues

Estimated project revenues are summarized in Appendix H.

14.0 Financial Analysis

This section is a preliminary financial analysis based on the production estimates, cost estimates, and revenue estimates detailed in the preceding sections.

14.1 Major Assumptions

Black & Veatch made several major assumptions in order to perform this financial analysis. They include debt and equity sources and amounts, debt interest rate, debt service coverage ratios, hurdle rates for return on equity, and the applicability of tax credits. The assumptions used for Town ownership of projects are shown in Table 14-1. The assumptions used for developer ownership of projects are shown in Table 14-2. It was assumed that the Town would be able to finance a project over a 20-year term.

Table 14-1. Economic Assumptions for Town Ownership.

Assumption	Value	Source
Annual Escalation Rate	2.0%	MTC estimate
Nominal Discount Rate	4.5%	MTC estimate
Debt Rate	4.5%	MTC estimate
Debt to Equity Ratio	100%	MTC estimate
Corporate Income Tax Rate	0.0%	Town not taxable entity
Tax Credits	$0	Town not taxable entity
Utility Insurance	$8.75/kW/yr	MTC estimate
REC Sales, Years 1-3	$40/MWh	MTC estimate
REC Sales, SFO	$40/MWh	MTC estimate
REC Sales, after SFO	$15/MWh	MTC estimate

Table 14-2. Economic Assumptions for Developer Ownership.

Assumption	Value	Source
Annual Escalation Rate	2.0%	MTC estimate
Nominal Discount Rate	11.0%	MTC after-tax estimate
Debt Rate	9%	MTC estimate
Debt to Equity Ratio	0%	MTC estimate
IRR Hurdle Rate	15.0%	B&V estimate
Corporate Income Tax Rate	39.6%	Federal Tax Code
Tax Credits (first 10 years)	$20/MWh	Current value of Production Tax Credit
Power Sales Rate	$70/MWh	B&V estimate, escalate at 2% annually
Lease and PILOT payments	$50,000/turbine/year	MTC estimate
REC Sales, Years 1-3	$40/MWh	MTC estimate
REC Sales, SFO	$40/MWh	MTC estimate
REC Sales, after SFO	$15/MWh	MTC estimate

14.2 Estimated Financial Results

Table 14-3 is a summary of the estimated net present value and payback in years for each development option with and without an MTC Standard Offer REC Contract. Table 14-4 is an estimate of the IRR for the developer options. For a developer owned project, the primary benefit to the Town of Wellfleet would be PILOT (Payment in Lieu of Taxes) payments. These are assumed to be $50,000 per turbine per year, escalating with inflation. The total value of these payments is summarized in Table 14-5.

Table 14-3. Estimated Net Present Value and Payback Time (Years).

Project Type	With MTC REC Offer NPV ($1000s)	With MTC REC Offer Simple Payback	With MTC REC Offer Discounted Payback	Without MTC REC Offer NPV ($1000s)	Without MTC REC Offer Simple Payback	Without MTC REC Offer Discounted Payback
Town Owned						
Single GE 1.5sle – Status Quo	$2,427	8.0	12.2	$1,674	9.1	13.9
Single GE 1.5sle – Net Metering	$7,918	4.2	6.5	$7,165	4.5	7.0
Single Vestas V82 – Status Quo	$3,084	7.4	11.3	$2,251	8.3	12.8
Single Vestas V82 – Net Metering	$9,284	3.9	6.0	$8,451	4.1	6.4
Three GE 1.5sles	$8,490	7.1	10.8	$6,658	7.8	12.0
Three Vestas V82s	$10,321	6.6	10.1	$8,387	7.2	11.1
Developer Owned						
Single GE 1.5sle	($73)	10.1	20.4	($342)	11.1	22.1
Single Vestas V82	$169	9.4	19.1	($130)	10.2	20.7
Three GE 1.5sles	$779	9.0	18.5	$93	9.7	19.8
Three Vestas V82s	$1,447	8.4	17.4	$713	9.0	18.7

Table 14-4. Estimated Developer Rate of Return.

Project Type	IRR With SFO	IRR Without SFO
Single Turbine GE 1.5sle	10.6%	9.0%
Single Turbine Vestas V82	11.9%	10.3%
Three Turbine GE 1.5sle	12.7%	11.2%
Three Turbine Vestas V82	13.9%	12.4%

Table 14-5. Estimated PILOT Payments to the Town.

Number of Turbines	20 Year PILOT Payment Nominal Value	20 Year PILOT Payment Real Value
1	$1,214,868	$1,000,000
3	$3,644,605	$3,000,000
Note: Assumed inflation of 2% annually		

14.3 Financial Viability

The estimated financial results in Section 14.2 indicate that a Town-owned wind project in Wellfleet may be financially viable. The projects with the highest return from a Town perspective appear to be the single turbine projects with net metering, assuming that all generated energy can garner retail value. It may be difficult to interest a third-party developer in a wind project, however. Based on the assumptions in Section 14.1, a developer would not be able to meet the IRR hurdle rate of 15 percent.

This analysis was prepared using a simplified cash flow spreadsheet, and does not capture all the costs associated with the ownership and operation of a wind turbine. A detailed financial analysis can be completed as part of the Business Planning phase of project development, after completion of this feasibility study.

Appendix A. Wind Resource Map of Massachusetts

A wind resource map of Massachusetts was downloaded from the New England Wind Map web site (http://truewind.teamcamelot.com/ne/).

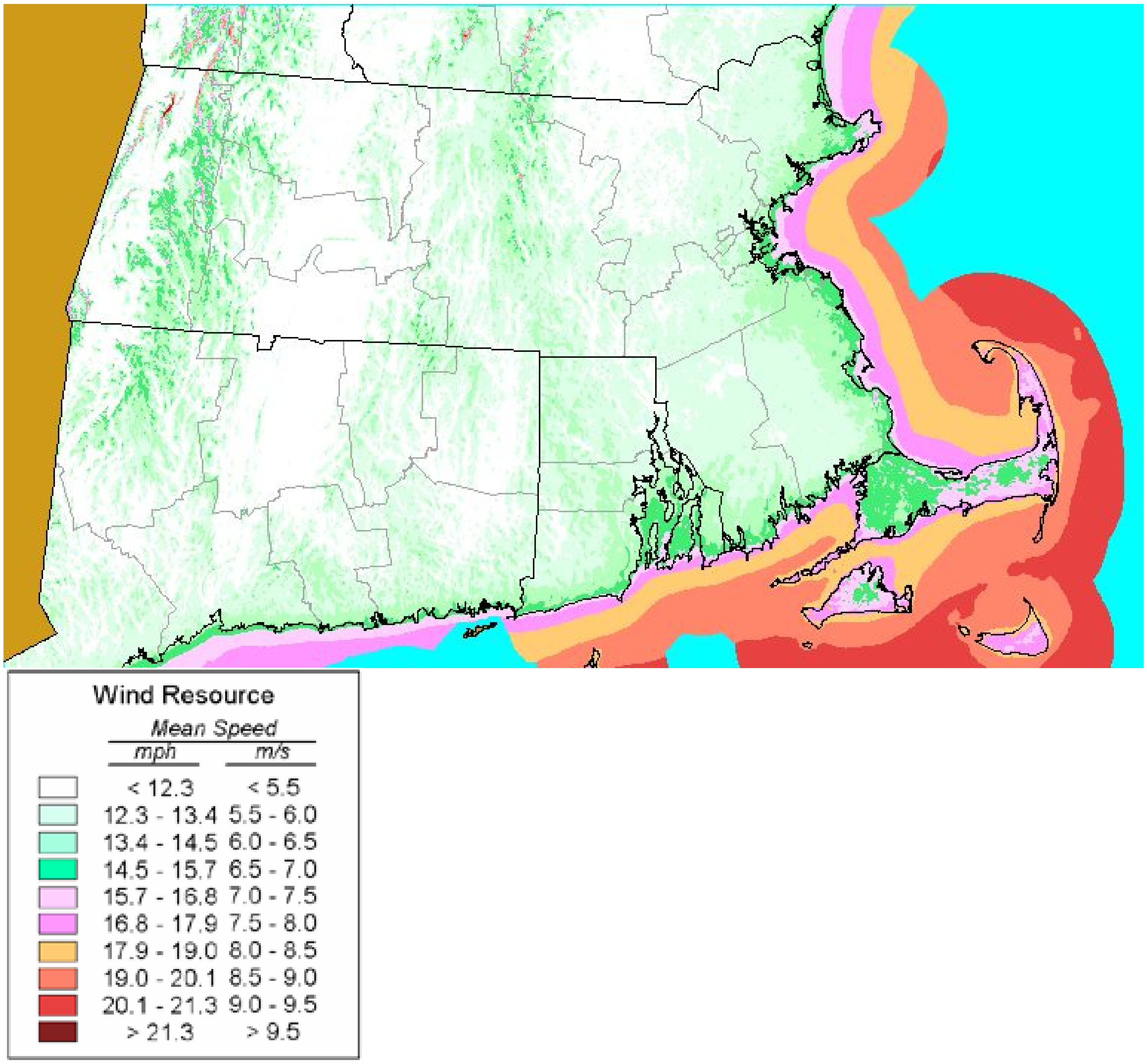

Figure A-1. Massachusetts Wind Resource Map.

Appendix B. Core Habitats of Wellfleet

BioMap and Living Waters

Guiding Land Conservation for Biodiversity in Massachusetts

Core Habitats of Wellfleet

This report and associated map provide information about important sites for biodiversity conservation in your area.

This information is intended for conservation planning, and is not intended for use in state regulations.

Produced by:

Natural Heritage & Endangered Species Program
Massachusetts Division of Fisheries and Wildlife
Executive Office of Environmental Affairs
Commonwealth of Massachusetts

Produced in 2004

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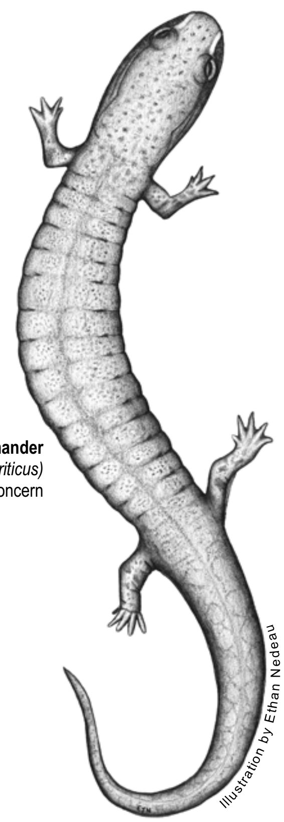
* Depending on the location of Core Habitats,
your city or town may not have all of these sections.



Spring Salamander
(Gyrinophilus porphyriticus)
Species of Special Concern

Funding for this project was made available by the Executive Office of Environmental Affairs, contributions to the Natural Heritage & Endangered Species Fund, and through the State Wildlife Grants Program of the US Fish & Wildlife Service.

Natural Heritage & Endangered Species Program

Massachusetts Division of Fisheries and Wildlife
North Drive, Westborough, MA 01581
Tel: (508) 792-7270, Ext. 200 Fax: (508) 792-7821
http://www.nhesp.org

BioMap and Living Waters:
Guiding Land Conservation for Biodiversity in Massachusetts

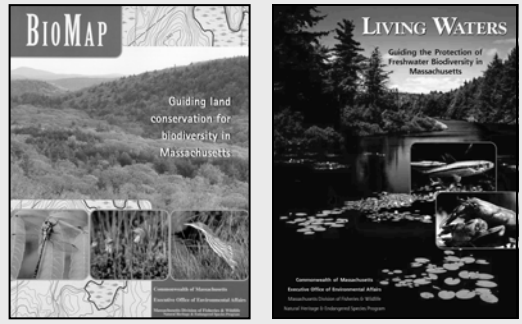
Introduction

In this report, the Natural Heritage & Endangered Species Program provides you with site-specific biodiversity information for your area. Protecting our biodiversity today will help ensure the full variety of species and natural communities that comprise our native flora and fauna will persist for generatons to come.

The information in this report is the result of two statewide biodiversity conservation planning projects, ***BioMap*** and ***Living Waters***. The goal of the BioMap project, completed in 2001, was to identify and delineate the most important areas for the long-term viability of terrestrial, wetland, and estuarine elements of biodiversity in Massachusetts. The goal of the Living Waters project, completed in 2003, was to identify and delineate the rivers, streams, lakes, and ponds that are important for freshwater biodiversity in the Commonwealth. These two conservation plans are based on documented observations of rare species, natural communities, and exemplary habitats.

What is a Core Habitat?

Both BioMap and Living Waters delineate ***Core Habitats*** that identify the most critical sites for biodiversity conservation across the state. Core Habitats represent habitat for the state's most viable rare plant and animal populations and include exemplary natural communities and aquatic habitats. Core Habitats represent a wide diversity of rare species and natural communities (see Table 1), and these areas are also thought to contain virtually all of the other described species in Massachusetts. Statewide, BioMap Core Habitats encompass 1,380,000 acres of uplands and wetlands, and Living Waters identifies 429 Core Habitats in rivers, streams, lakes, and ponds.



Get your copy of the ***BioMap*** and ***Living Waters*** reports! Contact Natural Heritage at 508-792-7270, Ext. 200 or email natural.heritage@state.ma.us. Posters and detailed technical reports are also available.

Core Habitats and Land Conservation

One of the most effective ways to protect biodiversity for future generations is to protect Core Habitats from adverse human impacts through land conservation. For Living Waters Core Habitats, protection efforts should focus on the ***riparian areas***, the areas of land adjacent to water bodies. A naturally vegetated buffer that extends 330 feet (100 meters) from the water's edge helps to maintain cooler water temperature and to maintain the nutrients, energy, and natural flow of water needed by freshwater species.

In Support of Core Habitats

To further ensure the protection of Core Habitats and Massachusetts' biodiversity in the long-term, the BioMap and Living Waters projects identify two additional areas that help support Core Habitats.

In BioMap, areas shown as ***Supporting Natural Landscape*** provide buffers around the Core Habitats, connectivity between Core Habitats, sufficient space for ecosystems to function, and contiguous undeveloped habitat for common species. Supporting Natural Landscape was

Natural Heritage & Endangered Species Program

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http://www.nhesp.org

generated using a Geographic Information Systems (GIS) model, and its exact boundaries are less important than the general areas that it identifies. Supporting Natural Landscape represents potential land protection priorities once Core Habitat protection has been addressed.

In Living Waters, ***Critical Supporting Watersheds*** highlight the immediate portion of the watershed that sustains, or possibly degrades, each freshwater Core Habitat. These areas were also identified using a GIS model. Critical Supporting Watersheds represent developed and undeveloped lands, and can be quite large. Critical Supporting Watersheds can be helpful in land-use planning, and while they are not shown on these maps, they can be viewed in the Living Waters report or downloaded from www.mass.gov/mgis.

Table 1. The number of rare species and types of natural communities explicitly included in the BioMap and Living Waters conservation plans, relative to the total number of native species statewide.

BioMap		
	Species and Verified Natural Community Types	
Biodiversity Group	**Included in BioMap**	**Total Statewide**
Vascular Plants	246	1,538
Birds	21	221 breeding species
Reptiles	11	25
Amphibians	6	21
Mammals	4	85
Moths and Butterflies	52	An estimated 2,500 to 3,000
Damselflies and Dragonflies	25	An estimated 165
Beetles	10	An estimated 2,500 to 4,000
Natural Communities	92	> 105 community types

Living Waters		
	Species	
Biodiversity Group	**Included in Living Waters**	**Total Statewide**
Aquatic Vascular Plants	23	114
Fishes	11	57
Mussels	7	12
Aquatic Invertebrates	23	An estimated > 2500

Understanding Core Habitat Species, Community, and Habitat Lists

What's in the List?

Included in this report is a list of the species, natural communities, and/or aquatic habitats for each Core Habitat in your city or town. The lists are organized by Core Habitat number.

For the larger Core Habitats that span more than one town, the species and community lists refer to the entire Core Habitat, not just the portion that falls within your city or town. For a list of all the state-listed rare species within your city or town's boundary, whether or not they are in Core Habitat, please see the town rare species lists available at www.nhesp.org.

The list of species and communities within a Core Habitat contains only the species and natural communities that were explicitly included in a given BioMap or Living Waters Core Habitat. Other rare species or examples of other natural communities may fall within the Core Habitat, but for various reasons are not included in the list. For instance, there are a few rare species that are omitted from the list or summary because of their particular sensitivity to the threat of collection. Likewise, the content of many very small Core Habitats are not described in this report or list, often because they contain a single location of a rare plant

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species. Some Core Habitats were created for suites of common species, such as forest birds, which are particularly threatened by habitat fragmentation. In these cases, the individual common species are not listed.

What does 'Status' mean?

The Division of Fisheries and Wildlife determines a status category for each rare species listed under the Massachusetts Endangered Species Act, M.G.L. c.131A, and its implementing regulations, 321 CMR 10.00. Rare species are categorized as Endangered, Threatened, or of Special Concern according to the following:

- ***Endangered*** species are in danger of extinction throughout all or a significant portion of their range or are in danger of extirpation from Massachusetts.
- ***Threatened*** species are likely to become Endangered in Massachusetts in the foreseeable future throughout all or a significant portion of their range.
- ***Special Concern*** species have suffered a decline that could threaten the species if allowed to continue unchecked or occur in such small numbers or with such restricted distribution or specialized habitat requirements that they could easily become Threatened in Massachusetts.

In addition, the Natural Heritage & Endangered Species Program maintains an unofficial ***watch list*** of plants that are tracked due to potential conservation interest or concern, but are not regulated under the Massachusetts Endangered Species Act or other laws or regulations. Likewise, described natural communities are not regulated any laws or regulations, but they can help to identify ecologically important areas that are worthy of protection. The status of natural communities reflects the documented number and acreages of each community type in the state:

- ***Critically Imperiled*** communities typically have 5 or fewer documented sites or have very few remaining acres in the state.
- ***Imperiled*** communities typically have 6-20 sites or few remaining acres in the state.
- ***Vulnerable*** communities typically have 21-100 sites or limited acreage across the state.
- ***Secure*** communities typically have over 100 sites or abundant acreage across the state; however excellent examples are identified as Core Habitat to ensure continued protection.

Legal Protection of Biodiversity

BioMap and Living Waters present a powerful vision of what Massachusetts would look like with full protection of the land that supports most of our biodiversity. To create this vision, some populations of state-listed rare species were deemed more likely to survive over the long-term than others.

Regardless of their potential viability, all sites of state-listed species have full legal protection under the Massachusetts Endangered Species Act (M.G.L. c.131A) and its implementing regulations (321 CMR 10.00). Habitat of state-listed wildlife is also protected under the Wetlands Protection Act Regulations (310 CMR 10.37 and 10.59). The ***Massachusetts Natural Heritage Atlas*** shows **Priority Habitats**, which are used for regulation under the Massachusetts Endangered Species Act and Massachusetts Environmental Policy Act (M.G.L. c.30) and **Estimated Habitats**, which are used for regulation of rare wildlife habitat under the Wetlands Protection Act. For more information on rare species regulations, see the *Massachusetts Natural Heritage Atlas*, available from the Natural Heritage & Endangered Species Program in book and CD formats.

BioMap and Living Waters are conservation planning tools and do not, in any way, supplant the Estimated and Priority Habitat Maps which have regulatory significance. Unless and until the combined BioMap and Living Waters vision is fully realized, we must continue to protect all populations of our state-listed species and their habitats through environmental regulation.

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Understanding Core Habitat Summaries

Following the BioMap and Living Waters Core Habitat species and community lists, there is a descriptive summary of each Core Habitat that occurs in your city or town. This summary highlights some of the outstanding characteristics of each Core Habitat, and will help you learn more about your city or town's biodiversity. You can find out more information about many of these species and natural communities by looking at specific ***fact sheets*** at www.nhesp.org.

Next Steps

BioMap and Living Waters were created in part to help cities and towns prioritize their land protection efforts. While there are many reasons to conserve land – drinking water protection, recreation, agriculture, aesthetics, and others – BioMap and Living Waters Core Habitats are especially helpful to municipalities seeking to protect the rare species, natural communities, and overall biodiversity within their boundaries. Please use this report and map along with the rare species and community fact sheets to appreciate and understand the biological treasures in your city or town.

Protecting Larger Core Habitats

Core Habitats vary considerably in size. For example, the average BioMap Core Habitat is 800 acres, but Core Habitats can range from less than 10 acres to greater than 100,000 acres. These larger areas reflect the amount of land needed by some animal species for breeding, feeding, nesting, overwintering, and long-term survival. Protecting areas of this size can be very challenging, and requires developing partnerships with neighboring towns.

Prioritizing the protection of certain areas within larger Core Habitats can be accomplished through further consultation with Natural Heritage Program biologists, and through additional field research to identify the most important areas of the Core Habitat.

Additional Information

If you have any questions about this report, or if you need help protecting land for biodiversity in your community, the Natural Heritage & Endangered Species Program staff looks forward to working with you.

Contact the Natural Heritage & Endangered Species Program:

by Phone 508-792-7270, Ext. 200

by Fax: 508-792-7821

by Email: natural.heritage@state.ma.us.

by Mail: North Drive
Westborough, MA 01581

The GIS datalayers of BioMap and Living Waters Core Habitats are available for download from MassGIS: www.mass.gov/mgis

Check out www.nhesp.org for information on:

- Rare species in your town
- Rare species fact sheets
- BioMap and Living Waters projects
- Natural Heritage publications, including:
    - Field guides
    - Natural Heritage Atlas, and more!

BioMap: Species and Natural Communities

Wellfleet

Core Habitat BM1109

Natural Communities

Common Name	Scientific Name	Status
Atlantic White Cedar Bog		Imperiled
Coastal Atlantic White Cedar Swamp		Imperiled
Coastal Plain Pondshore		Imperiled
Estuarine Intertidal: Saline/Brackish Flats		Vulnerable
Level Bog		Vulnerable
Maritime Dune Community		Imperiled
Sandplain Heathland		Critically Imperiled

Plants

Common Name	Scientific Name	Status
Broom Crowberry	*Corema conradii*	Special Concern
Bushy Rockrose	*Helianthemum dumosum*	Special Concern
Commons's Panic-Grass	*Dichanthelium ovale ssp. pseudopubescens*	Special Concern
Few-Fruited Sedge	*Carex oligosperma*	Endangered
Ovate Spike-Sedge	*Eleocharis ovata*	Endangered
Oysterleaf	*Mertensia maritima*	Endangered
Purple Needlegrass	*Aristida purpurascens*	Threatened
Salt Reedgrass	*Spartina cynosuroides*	Threatened
Swamp Oats	*Sphenopholis pensylvanica*	Threatened
Walter's Sedge	*Carex striata*	Endangered
Weak Rush	*Juncus debilis*	Endangered

Invertebrates

Common Name	Scientific Name	Status
Barrens Buckmoth	*Hemileuca maia*	Special Concern
Blueberry Sallow	*Apharetra dentata*	-------------------

Chain Dot Geometer	*Cingilia catenaria*	Special Concern
Chain Fern Borer Moth	*Papaipema stenocelis*	Threatened
Coastal Heathland Cutworm	*Abagrotis nefascia benjamini*	Special Concern
Coastal Swamp Metarranthis Moth	*Metarranthis pilosaria*	Special Concern
Comet Darner	*Anax longipes*	Special Concern
Drunk Apamea Moth	*Apamea inebriata*	Special Concern
Dune Noctuid Moth	*Oncocnemis riparia*	Special Concern
Gerhard's Underwing Moth	*Catocala herodias gerhardi*	Special Concern
Melsheimer's Sack Bearer	*Cicinnus melsheimeri*	Threatened
New England Bluet	*Enallagma laterale*	Special Concern
Northern Brocade Moth	*Neoligia semicana*	Special Concern
Oak Hairstreak	*Satyrium favonius*	Special Concern
Pale Green Pinion Moth	*Lithophane viridipallens*	Special Concern
Pine Barrens Bluet	*Enallagma recurvatum*	Threatened
Pine Barrens Zale	*Zale sp. 1 near lunifera*	Special Concern
Pink Sallow	*Psectraglaea carnosa*	Special Concern
Spatterdock Darner	*Aeshna mutata*	Special Concern
Water-Willow Stem Borer	*Papaipema sulphurata*	Threatened
Waxed Sallow Moth	*Chaetaglaea cerata*	Special Concern

Vertebrates

Common Name	Scientific Name	Status
Arctic Tern	*Sterna paradisaea*	Special Concern
Common Tern	*Sterna hirundo*	Special Concern
Diamondback Terrapin	*Malaclemys terrapin*	Threatened
Eastern Box Turtle	*Terrapene carolina*	Special Concern
Eastern Spadefoot	*Scaphiopus holbrookii*	Threatened
Four-toed Salamander	*Hemidactylium scutatum*	Special Concern
Least Tern	*Sterna antillarum*	Special Concern

Northern Harrier	*Circus cyaneus*	Threatened
Piping Plover	*Charadrius melodus*	Threatened
Spotted Turtle	*Clemmys guttata*	Special Concern
Vesper Sparrow	*Pooecetes gramineus*	Threatened

Core Habitat BM1189

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1109

This large Core Habitat along outer Cape Cod contains a wealth of high-quality and uncommon natural communities that together support incredible species diversity. Several highlights include the many rare species of Coastal Plain dragonflies, damselflies, and moths, as well as the diversity of rare plants. The area's beaches provide some of the most important breeding habitat for Piping Plovers along the Atlantic Coast, and the area contains other important nesting and breeding habitats for rare birds such as Least Terns. In addition, the Core Habitat supports the largest and most extensive populations of Eastern Spadefoot Toads in New England, the largest Diamondback Terrapin population in Massachusetts, and healthy populations of other rare turtles. Much of this large Core Habitat is on protected land, most of which is within the Cape Cod National Seashore, but some of which is in smaller protected areas such as the Wellfleet Bay Massachusetts Audubon Sanctuary.

Natural Communities

This Core Habitat contains over 3000 acres with the largest dune system in the state and in the northeast. It includes excellent examples of a Maritime Dune natural community, the best and largest example of classic bog vegetation on Cape Cod, Atlantic White Cedar Bogs and swamps, the state's best mainland Sandplain Heathlands, and extensive Estuarine Saline/Brackish Flats. The Core Habitat includes very diverse, interdigitated, and often uncommon natural communities.

Plants

A diversity of rare plant species, including several Endangered species, is found within this important area along outer Cape Cod. Among them are most of the state's populations of the Endangered Few-Fruited Sedge. Some of the state's best populations of Broom Crowberry, a low, bushy, heath-like plant with black fruit, are also found here.

Invertebrates

This Core Habitat includes numerous Coastal Plain ponds that are home to rare species of dragonflies and damselflies, including the spectacular red and green Comet Darner and the tiny blue Pine Barrens Bluet. Acidic shrub swamps and bogs associated with the ponds are habitat for rare species of moths such as the Pale Green Pinion moth. Open-canopy pitch pine - scrub oak barrens within this Core Habitat provide habitat for rare moths such as Melsheimer's Sack Bearer and the Barrens Buckmoth. And still other rare moths live in the coastal shrublands and dunes within this Core Habitat, including the Chain Dot Geometer, the Coastal Heathland Cutworm, and the Dune Noctuid moth.

Vertebrates

This Core Habitat contains a number of coastal beaches on both the eastern and western shores of outer Cape Cod that collectively comprise some of the most important breeding habitat for Piping Plovers along the Atlantic Coast. Significant areas of nesting habitat for Least Terns are also present. New Island in Nauset Marsh has traditionally supported one of the largest breeding colonies of Common Terns and Laughing Gulls in Massachusetts; however, birds from this colony are shifting to new locations as natural processes of coastline change weld the island to Nauset Spit and allow easier access by mammalian predators.

In this Core Habitat, the sandy upland habitats dominated by pine-oak forests and barrens support the largest and most extensive populations of Eastern Spadefoot Toads in New England. There are also significant and widespread populations of Eastern Box Turtles as well as Spotted Turtles. These woodlands and shrublands also provide some of the most important habitat in New England for landbirds characteristic of pitch pine - scrub oak barrens, including the Eastern Towhee and the Prairie Warbler. This Core Habitat also encompasses breeding habitat for Vesper Sparrows, including open, sparsely vegetated areas of pitch pine barrens in the Marconi area of Wellfleet, and the sandy habitats of the Provincelands, especially adjacent to the Provincetown airport. Northern Harriers have been observed within this Core Habitat, especially near Pilgrim Lake and Hatches Harbor.

The estuarine, salt marsh, tidal creek, beach, and sandy upland habitats in this Core Habitat support Diamondback Terrapins. Wellfleet Harbor contains perhaps the largest Diamondback Terrapin population in Massachusetts. Over 110 documented observations of nesting are known from this Core Habitat. Within the harbor, Blackfish Creek probably supports the most individuals. Wellfleet Harbor is also the northernmost site at which the species occurs in the U.S. Here the Core Habitat is surrounded and interspersed with development, increasing the likelihood of disturbance, collisions with vehicles, and degradation of foraging and nesting habitat. Entrapment by marine debris is a potential source of mortality for this species.

Much of this Core Habitat is protected as part of the Cape Cod National Seashore, but further protection of other suitable habitat is needed.

Living Waters: Species and Habitats

Wellfleet

Core Habitat LW051

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Core Habitat LW052

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Core Habitat LW333

Exemplary Habitats

Common Name	Scientific Name	Status
Fish Habitat		-------------------
Lake/Pond Habitat		-------------------

Core Habitat LW342

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Core Habitat LW343

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Core Habitat LW051

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Williams Pond is one of the few such ponds that has little surrounding development and is removed from cranberry agriculture. Located within the Cape Cod National Seashore, Williams Pond is nutrient-rich, and supports spawning habitats for sea-running fishes.

Core Habitat LW052

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Dyer Pond is one of the few such ponds that has little surrounding development and is removed from cranberry agriculture. Located within the Cape Cod National Seashore, Dyer Pond is low in nutrients, reflecting the low amount of development in the area.

Core Habitat LW333

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Herring Pond is one of the few such ponds that has little surrounding development and is removed from cranberry agriculture. Located within the Cape Cod National Seashore, Herring Pond is sandy-bottomed, nutrient-rich, and surrounded by emergent vegetation. The pond contains spawning habitat for Alewife, an anadromous fish that migrates from coastal waters into fresh waters to spawn. This and other migrating fish species are important components of Massachusetts' aquatic biodiversity.

Core Habitat LW342

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Great Pond in Wellfleet is one of the few such ponds that has little surrounding development and is removed from cranberry agriculture. Located within the Cape Cod National Seashore, Great Pond is large, deep, and low in nutrients reflecting the low amount of surrounding development. The adjacent ponds, including Turtle, Northeast, and Southeast Ponds, provide habitats for rare damselflies.

Core Habitat LW343

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Duck Pond is one of the few such ponds that has little surrounding development and is removed from cranberry agriculture. Located within the Cape Cod National Seashore, Duck Pond is deep and has a low to moderate nutrient level, reflecting the low amount of surrounding development.

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Natural Heritage &
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To learn more about the Natural Heritage & Endangered Species Program and the Commonwealth's rare species, visit our web site at: www.nhesp.org.

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ROSEATE TERN (*Sterna dougallii*)

State Status: **Endangered**
Federal Status: **Endangered**

B. Byrne, MDFW

The elegant Roseate Tern, with its long, white tail-streamers and rapid flight, alights on Massachusetts beaches in the spring. It tunnels under vegetation to nest within colonies of its more rough-and-tumble relative, the Common Tern, from which it derives protection from intruders. The Roseate Tern is a plunge-diver that feeds mainly on the sand lance, and availability of this fish may influence the timing of breeding. Depredations of plume hunters in the 19th century and displacement from breeding sites by gulls and increased predation in the 20th century contributed to a decline in numbers and loss of major breeding sites in the northeast. In a sense, the Roseate Tern is emblematic of the Commonwealth, because for the past century, about half the northeastern population has nested in Buzzards Bay and outer Cape Cod. The Roseate is now considered an Endangered Species. The population, which increased from the 1980s through 2000, is now in decline. Several projects are in progress to restore the Roseate to historical breeding locations in Massachusetts.

Description. The Roseate Tern measures 33-41 cm in length and weighs 95-130 g. Breeding adults have pale gray upperparts, white underparts (flushed with pale pink early in the breeding season), a black cap, orange legs and feet, and a black bill (which becomes more red at the base as the season progresses). The tail is mostly white, and is deeply forked with two very long outer streamers, which extend well past the tips of the folded wings. In non-breeding adults, the forehead becomes white and the crown becomes white marked with black, merging with a black patch that extends from the eyes back to the nape. The down of hatchlings is distinctive: it is grizzled buff/black or gray/black, and is spiky-looking because the down filaments are gathered at the tips. Juveniles are buff or gray above, barred with black chevrons, and have a mottled forehead and crown, black eye-to-nape patch, and black bill and legs. The Roseate's vocal array includes a high-pitched *chi-vik* advertising call, and musical *kliu* and raspy *aaach* alarm calls, the latter sometimes likened to the sound of tearing cloth.

Similar Species in Massachusetts. The Common Tern (*Sterna hirundo*) is similar in size, but has a black-tipped orange bill, darker gray upperparts, pale gray underparts, a shorter tail that does not extend beyond the folded wingtips, and an "irritable" voice. The Arctic Tern (*Sterna paradisaea*) is also similar in size, but has a shorter, blood-red bill, very short red legs, gray underparts with contrasting white cheeks, a shorter tail (which still extends past the folded wingtips), and a very different, high-pitched voice. The Least Tern (*Sterna antillarum*) is markedly smaller, with a yellow-orange bill, a white forehead, and a short tail.

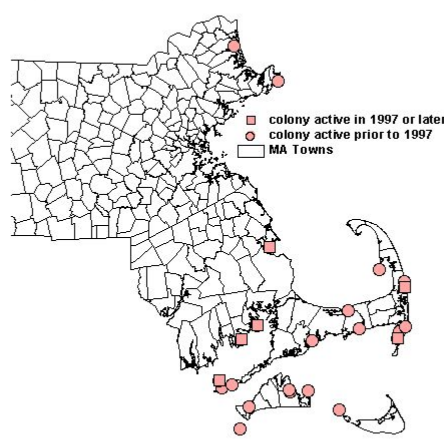

Figure 1. Distribution of present and historic Roseate Tern nesting colonies in Massachusetts.

Distribution and Migration. The Roseate Tern has a scattered breeding distribution primarily in the tropical and sub-tropical Atlantic, Indian, and Pacific Oceans. In North America, it breeds in two discrete populations: from Nova Scotia south to New York and in the Caribbean. The northeast population, at about 40-45° N, is among the most northernmost nesting groups of this mostly tropical species. Roseates arrive in Massachusetts from late-April to mid-May to nest at just a handful of coastal locations (Fig. 1). The largest colonies occur in Buzzards Bay (see Status, below). Massachusetts birds depart from breeding colonies in late-July and August and concentrate in "staging areas" around Cape Cod and the Islands, before departure for wintering grounds in September. Roseates appear to feed offshore and return to the staging areas to rest and roost. Most have departed staging areas and have begun migrating southward by mid- to late-September. The Roseate's wintering range remains poorly known, but increasing evidence indicates that Northeastern birds winter along the north and east coasts of South America southward along the coast of Brazil to approximately 18° S.

Breeding and Foraging Habitat. In Massachusetts, the Roseate Tern generally nests on sandy, gravelly, or rocky islands and, less commonly, in small numbers at the ends of long barrier beaches. Compared to the Common Tern, it selects nest sites with denser vegetation, such as seaside goldenrod and beach pea, which is also used for cover by chicks. Large boulders are used for cover at other locations in the northeast. It feeds in highly specialized situations over shallow sandbars, shoals, inlets or schools of predatory fish, which drive smaller prey to the surface. The Roseate is known to forage up to 30 km from the breeding colony.

Food Habits. The Roseate Tern feeds almost exclusively on small fish; occasionally it includes crustaceans in its diet. It is fairly specialized, consuming primarily sand lance (about 70% of diet in Massachusetts). Other prey species of importance in Massachusetts are herrings, bluefish, mackerel, silversides, and anchovies. In the northeast, it often forages with Common Terns. The Roseate captures food mainly by plunge-diving (diving from heights of 1-12 m and often submerging to ≥ 50 cm), but also by surface-dipping and contact-dipping. Some individuals specialize in stealing fish from Common Terns.

Breeding.

Phenology. Roseates usually begin to arrive in Massachusetts in late-April or the first week of May. Egg dates are 12 May to 18 August, and laying usually begins about 8 d later than that of Common Terns in the host colony. Incubation lasts about 3 wk, and the nestling period about 4 wk.

Colony. The Roseate Tern is gregarious. In the northeast it nests in colonies of a few to about 1,700 pairs, and the largest colony in Massachusetts numbers about 1,100 pairs (see Status, below). In this portion of its range, the Roseate invariably nests with the Common Tern, forming clusters or sub-colonies within larger Common Tern colonies. Pairs defend their nest site. (See also Predation below).

Pair-bond. Courtship involves both aerial and ground displays, including spectacular High Flights (in which ≥ 2 birds spiral up to 30-300 m above ground and then descend in a zig-zag glide), and Low Flights (in which a fish-carrying male is chased by up to 12 other birds). Males feed females before and during the egg-laying period. The Roseate Tern is socially monogamous, but extra-pair copulations occur. Both parents spend roughly equal amounts of time incubating, and incubation shifts last about 26 min. Males and females also contribute approximately equally to brooding and feeding chicks. The average length of pair bonds in Connecticut was 2.5 yr. The sex ratio in Massachusetts (and probably other northeast colonies) is skewed towards females (1.27 females:1 male). This results in multi-female associations (≥ 2 females), and often ≥ 3-egg clutches, at nests.

Nests. Nests (usually beneath vegetation or debris, or in special nest boxes) are depressions or "scrapes" in the substrate, to which nesting material may or may not be added throughout incubation. In the northeast, nests are usually 50-250 cm apart, depending on the distribution of vegetation and rocks.

Eggs. Eggs are various shades of brown with dark spots and streaks. The second egg may be paler than the first. Eggs measure approximately 43 x 30 mm, and are subelliptical in shape. The eggs are difficult to distinguish from those of the Common Tern, but Roseate eggs are generally longer, more conical, less rounded, darker, and more uniformly and finely spotted. Clutch size is usually 1-2 eggs; older females generally lay 2 eggs (laid about 3 d apart), and younger females, 1. Nests with ≥ 3 eggs are often attended by more than one female. Incubation, which begins after laying of the first egg, may be sporadic until the second egg is laid. The period between laying and hatching is about 23 d for both eggs.

Young. Chicks are semi-precocial. They are downy at hatching. Eyes open after a couple hours, and chicks are able to waddle and take food within hours after hatching. In 2-chick broods, there is often a substantial size difference between the young that persists throughout the growth period; this is because the first chick (*A*-chick) is usually 3 d older. Chicks are brooded/attended most of the day and night for the first few days of life. Parental attendance ceases after about a week, except for cold, rainy days. Parents carry prey to chicks in their bills one fish at a time. Feeding rates at sites in Massachusetts and Connecticut are about 1 fish/h. At sheltered nests, undisturbed chicks may remain at the nest site until they are nearly fledged. Where there is more disturbance, chicks may move more than 60 m away to new hiding spots. In 2-chick broods, the younger chick (*B*-chick) is less likely to survive than the *A*-chick. Most losses of *B*-chicks appear to be due to starvation. The peak of fledging is at 27-30 d. Four to 10 d after fledging, young birds accompany parents to fishing grounds. They begin to catch fish after 3 wk, but remain dependent on parents for food at least 6 wk, or until migration in September. This notably long period of dependence reflects the highly specialized fishing techniques that the young must master. At Bird I., MA, family units depart the nesting colony 5-15 d post-fledging to congregate at staging locations. When two chicks are raised, the male leaves first with the older chick and the female leaves up to 7 d later with the younger chick. Nothing is known of family cohesion during migration.

Predation.

Predators. In North America, predators of Roseate Tern eggs, young, and adults include birds and mammals, snakes, ants, and land crabs. In the northeast, the Great Horned Owl is the primary predator on adults, and predation on adults by the Peregrine Falcon has also been documented. Other significant avian predators (on eggs or chicks) include: Black-crowned Night-Heron, Herring and Great Black-backed Gulls, American Crow, and Red-winged Blackbird.

Responses to predators and intruders. The Roseate Tern prefers to nest on islands lacking mammalian predators. Eggs and chicks are cryptically colored and well-concealed under vegetation, debris, or rocks. Roseates are less aggressive birds than Common Terns, and rely on Commons for defense in the nesting colony. Attack rate peaks at hatching. Roseates dive at, and sometimes strike, various avian predators. Roseates circle above humans and dive at them, but do not make physical contact or defecate on them. Roseates in the Caribbean have been shown to respond more vigorously to familiar *versus* unfamiliar humans. As is the case for Common Terns, Roseates desert colonies at night when subject to nocturnal predation. This prolongs incubation periods for eggs, and exposes eggs and chicks to the elements and predation. Roseate nests and chicks, however, are better concealed, and thus less vulnerable, than those of Common Terns. Roseate adults, in contrast, are often disproportionately preyed upon in comparison to Common Terns from the same colony. Perhaps for this reason Roseates are quicker to abandon a site when predators are active.

Life History Parameters. In Massachusetts, most Roseate Terns breed annually starting at 3 yr, some at ≥ 4 yr. Only one brood per season is raised, but birds renest after losing eggs or chicks. Estimating productivity is challenging due to inaccessible nest sites and chicks' hiding behavior, but productivity usually exceeds 1 chick fledged per pair (range: 0-1.6 chicks fledged per pair); older birds are more productive than younger ones. Survival from fledging to first breeding was estimated at about 20% for Connecticut birds. Annual survival of adults in the northeast was estimated to be about 80%. The oldest Roseate Tern documented was 25.6 yr old; it was originally banded as a chick in Massachusetts.

Status. The northeastern population of the Roseate Tern is listed as Endangered federally and in Massachusetts principally because of its range contraction and secondarily because of its declining numbers. Prior to 1870, its status was somewhat obscure, but the Roseate was considered to be an abundant breeder within Common Tern colonies on Nantucket and Muskeget Is., MA. Prior to the 20th century, egging was a problem in northeast colonies, but it was persecution of terns for the plume industry that greatly reduced numbers in the northeast to perhaps 2,000 pairs, mostly at Muskeget and Penikese Is., MA, by the 1880s. Following protection, numbers rose to the 8,500 pair level in 1930. From the 1930s through the 1970s, Roseates were displaced from nesting colonies by Herring and Great Black-backed Gulls, and had declined to 2,500 pairs by 1979. Following two decades of fairly steady increase, the Northeast U.S. population peaked at 4,310 pairs in 2000. Since then, however, the population has declined rapidly to 3,320 pairs (Roseate Tern Recovery Team, unpubl. 2006 data). The cause of this has not been identified, but data suggest that it may be related to mortality on the wintering grounds. Approximately 85% of the population is dangerously concentrated at just 3 colonies: Great Gull Island, NY (1,227 pairs); Bird I., Marion, MA (1,111); and Ram I., Mattapoisett, MA (463). The only other nesting colonies in Massachusetts in 2006 were at Penikese I. (48 pairs) and Monomoy National Wildlife Refuge (NWR) (S. Monomoy and Minimoy Is)., Chatham (26 pairs).

Desertion of ≥ 30 major breeding sites over the past 80 years in most cases has been related to occupation of sites by gulls, and secondarily, to predation in the colonies (which may have intensified as terns were displaced by gulls to sites closer to the mainland). While populations in the state receive protection during the breeding season, the species is unprotected by South American governmental entities and while in international waters. Prior to the 1980s, persecution by humans (trapping for food) on the wintering grounds may have affected Roseates nesting in the northeast. Major wintering areas for this population have not been identified; this, along with investigation of current threats on the wintering grounds, is badly needed.

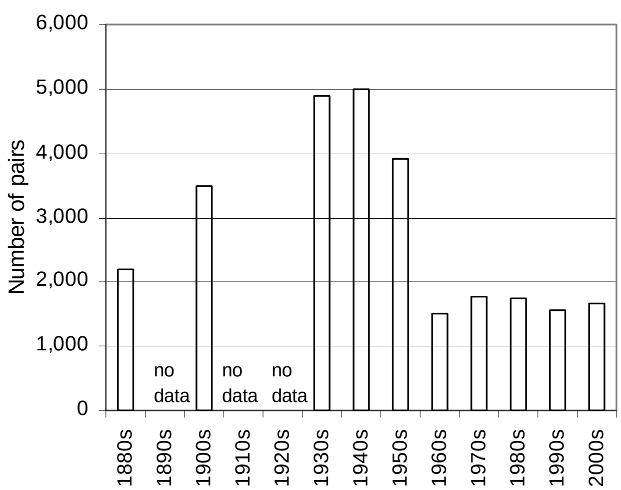

Figure 2. Roseate Tern population trends in Massachusetts, 1880s to 2006 (modified from Blodget and Melvin 1996).

Conservation and Management. Colonies are protected by posting of signs, by presence of wardens, and/or by exclusion of visitors. Wooden nest boxes and boards, partially buried tires, and other structures enhance the number of potential nest sites. Vegetation control is sometimes necessary when plant growth is dense enough to actually impede adults' ability to access nesting sites. The gradual loss of breeding sites in the Northeast, coupled with the Roseate's reluctance to colonize new sites, is a serious obstacle to recovery of the northeast population. The current overwhelming concentration of Roseates in Massachusetts in just two colonies in Buzzards Bay (Bird and Ram Is.), despite suitable conditions elsewhere, does not bode well for the population should one of these sites become unsuitable. Because of the regional importance of Massachusetts for Roseate recovery, several restoration projects have been initiated in the state. Restoring Common Terns to nesting sites is a necessary first step in restoring Roseates because of the Roseate's close association with the Common Tern at breeding colonies. Roseates were successfully restored to Ram I. after a gull control program in 1990-1991. A similar program at Monomoy NWR, begun in 1996, encouraged the expansion of a huge colony of Common Terns (9,747 pairs in 2005), but only a handful of Roseates nest there. Two other tern restoration projects -- at Penikese I., in Buzzards Bay, and at Muskeget I., in Nantucket Sound -- are currently underway, both involving aggressive discouragement of gulls from small portions of the islands; Roseates returned to Penikese in 2003, but numbers have fluctuated widely since then. Tern restoration is a long-term commitment that requires annual monitoring and management to track progress, identify threats, manage vegetation, prevent gulls from encroaching on colonies, and remove predators.

References.

Blodget, B. G. and S. M. Melvin. 1996. Massachusetts tern and piping plover handbook: a manual for stewards. Mass. Div. of Fisheries and Wildlife. Natural Heritage and Endangered Species Program. Westborough, MA.

Gochfeld, M., J. Burger, and I. C. T. Nisbet. 1998. Roseate Tern (*Sterna dougallii*). *In* The Birds of North America, No. 370 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

U. S. Fish and Wildlife Service. 1998. Roseate Tern recovery plan: northeastern population. First update. U. S. Fish and Wildlife Service. Hadley, MA.

Veit, R. R. and W. R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society. Lincoln, MA.

C. S. Mostello, 2007

Partially funded by the New Bedford Harbor Trustee Council

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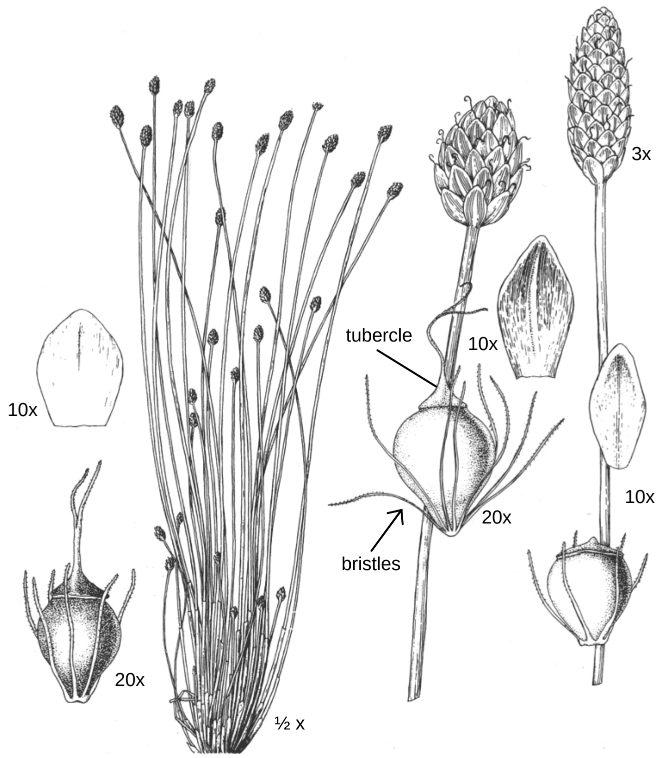
Ovate Spike-rush or Spike-sedge

Eleocharis ovata (Roth) Roemer & Schultes

(*Eleocharis obtusa* var. *ovata* (Roth) Drapalik & Mohlenbrock)

State Status: **Endangered**
Federal Status: None



Holmgren, Noel H. The Illustrated Companion to Gleason and Cronquist's Manual. NY Botanical Garden. 1998.

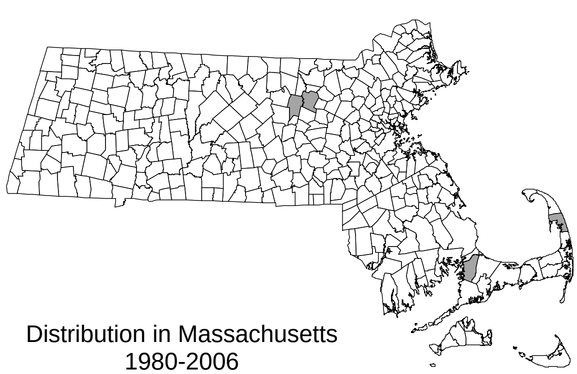
Description: In Massachusetts, the ovate spike-rush (*Eleocharis ovata*) is a low (2-6 inches or about 5 to 15 cm), tufted, annual herb with straight, ascending, deep-green stems. Although the ovate spike-rush and the other spike-rushes superficially resemble the group of plants called "rushes," they do not belong to the Rush Family, and are actually members of the Sedge Family (Cyperaceae). The spike-rushes have a single, tight cluster of inconspicuous flowers (a "spike") at the apex of each stem. The stems of spike-rushes appear leafless, and in fact these plants do not have leaf blades (the expanded part of the leaf), only leaf sheaths (the part which surrounds the stem).

Aids to Identification: To positively identify the ovate spike rush and other spike-rushes (genus *Eleocharis*), a technical manual should be consulted. It is usually necessary to look at the tiny fruits of the plant under magnification to distinguish the species of spike-rush. Members of this genus possess a type of fruit called an "achene," which is hard and nut-like and does not split open to release its single seed. Achenes in the spike-rushes are topped by a protuberance (called a "tubercle"), which varies in shape, size, and texture among species.

It should be noted that *Elecharis ovata* (syn. *E. obtusaa* var. *ovata*) is a member of a taxonomically controversial complex within the genus *Eleocharis*.

Some authors (i.e. Gleason and Cronquist, 1991) have not recognized *Eleocharis ovata* as a separate entity from the more common *Eleocharis obtusa*. There is yet additional controversy as to whether another taxon, *E. diandra*, is a separate entity from *E. ovata*. Currently, based on the recent Flora of North America treatment, the Massachusetts Natural Heritage & Endangered Species Program recognizes *E. ovata* as a distinct species from both *E. obtusa* and *E. diandra*.

The achene of the ovate spike-rush matures in mid to late summer, and is olive to light brown to dark brown in color. It is two-sided (like a tiny lentil), smooth and glossy. The tubercle hugs the top of the achene closely (there is no constriction separating it from the achene).



Distribution in Massachusetts
1980-2006
Based on Records in Natural Heritage Database

Similar Species: There are many common spike-rushes that could be confused with the ovate spike-rush, and a technical manual should be consulted when trying to distinguish members of this genus. Of particular concern is separating this spike-rush from its close relative, the soft-stemmed spike rush (*Eleocharis obtusa*), which can be difficult. In the soft-stemmed spike-rush, the tubercle is relatively short and squat with a wide base covering almost the entire top of the achene. The base of the tubercle in the ovate spike rush is usually narrower, not quite covering the entire summit of the achene. Technically, a tubercle 0.5-0.8 mm wide is found in the soft-stemmed spike-rush, while a tubercle 0.3-0.5 mm wide is found in the rare ovate spike-rush.

Eleocharis diandra is a rare spike-rush known only from a few local areas in the Northeastern U.S. and Ontario Canada. It is distinguished from *E. ovata* by its lack of "perianth bristles," a whorl of bristles emanating from the base of the achene in most species of *Eleocharis*. In contrast, *E. ovata* usually has six or seven perianth bristles which overtop the achene and tubercle.

Range: The ovate spike-rush occurs from Newfoundland, south to Connecticut, west to New York and Indiana, north to Minnesota.

Habitat: The ovate spike-rush can be found growing on sandy freshwater margins, including lake, pond and river shores. It has been documented to occur with the following species in Massachusetts: soft-stemmed spike-rush (*Eleocharis obtusa*), threeway sedge (*Dulichium arundinaceum*), buttonbush (*Cephalanthus occidentalis*), soft rush (*Juncus effusus*), wool-grass (*Scirpus cyperinus*), and common bur-reed (*Sparganium americanum*).

Population Status in Massachusetts: The ovate spike-rush is listed under the Massachusetts Endangered Species Act as "Endangered". All listed species are protected from killing, collecting, possessing, or sale and from activities that would destroy habitat and thus directly or indirectly cause mortality or disrupt critical behaviors. The ovate spike rush was historically known from six different counties in the Commonwealth, but is presently reported only from Barnstable, Worcester, and Franklin Counties.

Management Recommendations: As for many rare species, exact needs for management of ovate spike-rush are not known. The following comments are based primarily on observations of populations in Massachusetts. Since the ovate spike-rush inhabits relatively open, sandy, freshwater margins, it is important to maintain these conditions where populations exist. Threats to the species include nutrient enrichment of freshwater bodies, which is likely to encourage growth of weed species, and permanent flooding.

Mature Fruit Present

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Updated: October 2006

Natural Heritage & Endangered Species Program

Commonwealth of Massachusetts
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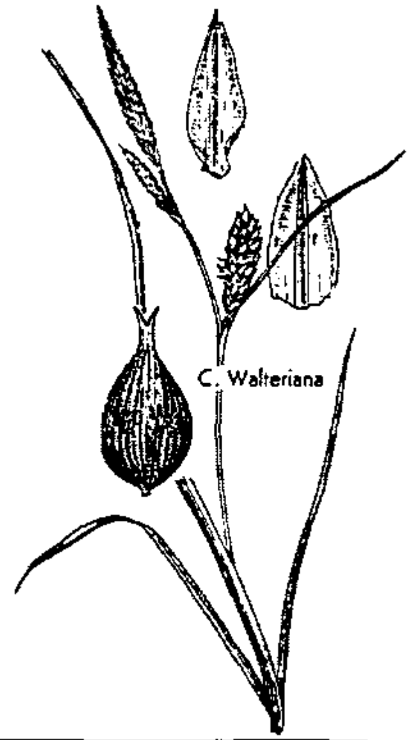
MASSACHUSETTS ENDANGERED PLANTS

WALTER'S SEDGE
(*Carex striata* var. *brevis* L. Bailey)

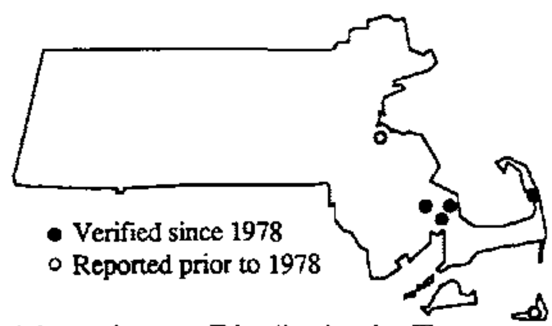
Description

Walter's sedge, a variety of the species *Carex striata*, is a pale-green, narrow-leaved, grass-like perennial that often forms extensive colonies. The sharply angled stems, or culms, rise from long, slender rhizomes and reach from 4 to 12 dm (1 to 4 ft.) in height. Principal leaf blades are stiff and 2-5 mm (0.08 - 0.2 in.) wide. Like most members of the Sedge family (Cyperaceae), Walter's sedge lacks showy floral parts Each culm bears two or more spikes (elongate, unbranched inflorescences of stalkless flowers): The one to three staminate, or male, spikes are located at the top, and the one or two pistillate, or female, spikes are lower on the culm. Pistillate spikes are stalkless, or nearly stalkless, cylindric and 2-4 cm (0.8 - 1.6 in.) long. The uppermost staminate spike is 3-5 cm (1.2 - 2 in.) long. Hairless, leathery-textured, 4.5-6.6 mm (0.18 - 0.26 in.) long perigynia (sac-like structures that enclose the pistil) taper to a shallowly two-toothed beak. The pistillate scales, which subtend each of the female flowers, are red-purple on their sides. The lowest bract (modified leaf associated with a



Gleason, H.A. The New Britton and Brown Illustrated Flora of the US & Adjacent Canada. NY Botanical Garden, 1952.

Documented Range of Walter's Sedge



Massachusetts Distribution by Town

flower or inflorescence) reaches above the end of the culm. The achene (a type of dry, one-seeded fruit) is three-angled and widest at the middle. Mature fruits form in August.

Range

The documented range of Walter's sedge is the coastal plain from southeastern Massachusetts to northern Florida.

Similar Species

Slender woolly-fruited sedge (*Carex lasiocarpa*) could easily be mistaken for Walter's sedge. However, slender woolly-fruited sedge has pubescent (hairy) perigynia; those of Walter's sedge are hairless.

Habitat in Massachusetts

In our area, Walter's sedge prefers boggy pondshores and open peaty swamps. Specific habitats include the upper border of a sandy beach, a pondshore with peaty-muddy substrate, a shrub bog with a wet pool, a former shrub bog that has been partially cleared, and a peat bog in a cranberry reservoir. Among the plant species associated with Walter's sedge are leather-leaf (*Chamaedaphne calyculata*), cranberry (*Vaccinium macrocarpon*), dwarf huckleberry (*Gaylussacia dumosa*), the sedge small-headed beak-rush (*Rhynchospora capitellata*), and various rushes (*Juncus* spp.). Rare Massachusetts plants that have been found with Walter's sedge include the following coastal plain pond species: inundated horned-sedge (*Rhynchospora inundata*), Plymouth gentian (*Sabatia Kennedeyana*), and terete arrowhead (*Sagittaria teres*).

Population Status

Walter's sedge is presently listed as "Endangered" in Massachusetts, where there are five current stations (discovered or relocated since 1978) in four towns and four historical stations (unverified since 1978). (Two towns contain both historical and current sites and are represented by a single black dot on the town distribution map.) All current stations are in Plymouth or Barnstable counties. Threats to the species include land development and crushing by both foot traffic and boats. Walter's Sedge is also considered rare in New York and Rhode Island.

KS-1993

Massachusetts Natural Heritage Program

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MASSACHUSETTS RARE AND ENDANGERED PLANTS

PRICKLY PEAR

(Opuntia humifusa (Raf.) Raf.)

DESCRIPTION

Prickly Pear cactus grows in sprawling clumps 2 to 3' (.6-.9m) across and generally less than a foot high. It has flat, fleshy green pads covered with clusters of short reddish-brown barbed bristles. Flowers are bright yellow, 2 to 3 inches wide (5-8cm), and bloom from the tops of the pads, opening only for several days in July. The large red fruits are pear-shaped, 1 to 2 inches (3-5cm.) long, juicy, sweet, and edible.

Britton, N.L. and H.A. Brown. An Illustrated Flora of the Northern United States and Canada. Dover Publications, Inc. 1970 reprint of 1913 ed.

HABITAT IN MASSACHUSETTS

On Nantucket O. humifusa grows on low stabilized dunes and ridges often with Red Cedar (Juniperus virginiana), Virginia Rose (Rosa virginiana), Poison Ivy (Toxicodendron radicans), Red Fescue (Festuca rubra) and Seaside Goldenrod (Solidago sempervirens). On the outer Cape, it grows in dry, sandy fields, dense grassy areas which have been mowed, cemeteries, and roadside embankments often with Little Bluestem (Andropogon scoparius), Poverty Grass (Danthonia spicata), Field Bentgrass (Agrostis stolonifera), Cat's Ear (Hypochoeris radicata) and Ribleaf Plantain (Plantago lanceolata).

RANGE

Opuntia humifusa ranges from Massachusetts to Minnesota, south to South Carolina and west to Alabama and Oklahoma. It is the only cactus which is widespread in the East.

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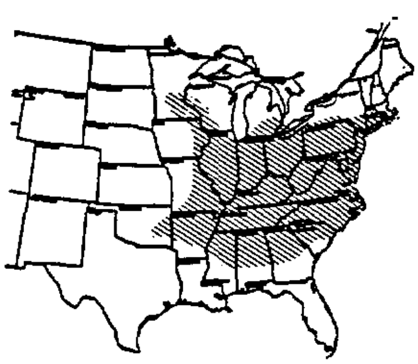
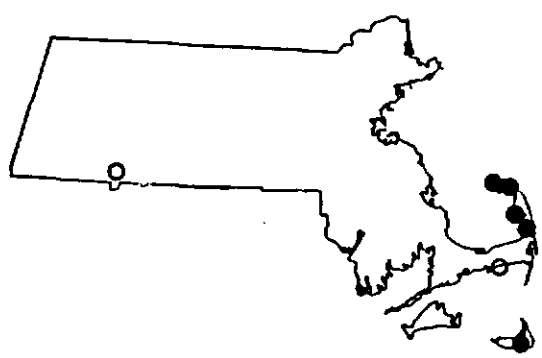


Distribution of Opuntia humifusa



● Verified since 1978
○ Reported prior to 1978

Distribution in Massachusetts by Town

POPULATION STATUS

Prickly Pear is a species of "Special Concern" in Massachusetts. Since 1978, fourteen occurrences have been reported and prior to that four occurrences had been recorded. This species rarity is attributable to the scarcity of suitable habitats, its occurrence at the northern edge of its range, and possibly limited dispersal of seeds.

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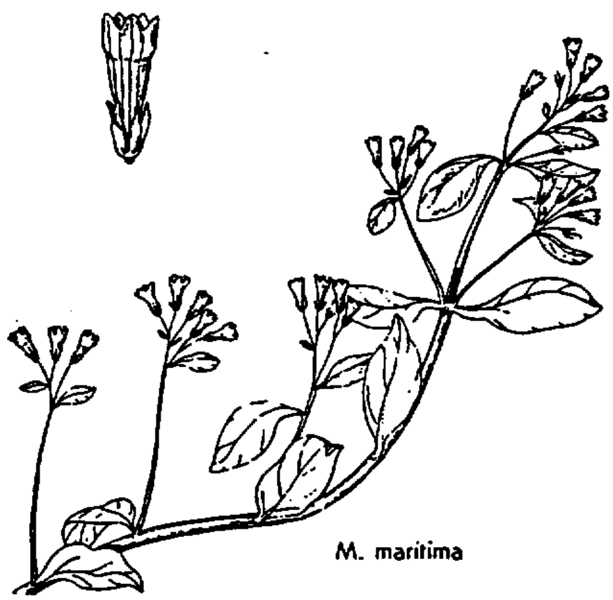
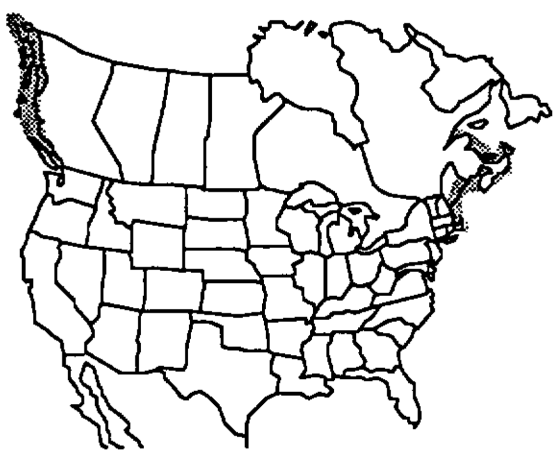
MASSACHUSETTS RARE AND ENDANGERED PLANTS

OYSTERLEAF
(*Mertensia maritima* (L.) S.F. Gray)

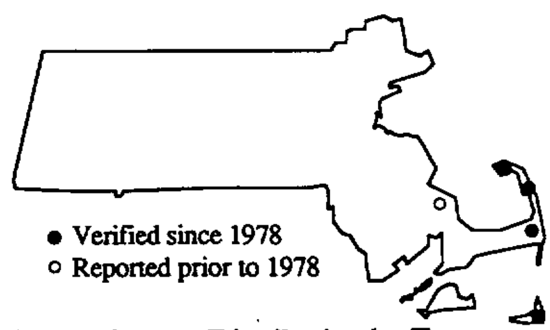
Description
Oysterleaf is an herbaceous, prostrate, hairless perennial in the Borage or Forget-Me-Not family (Boraginaceae). The overall aspect of the plant is glaucous or whitish. Its trailing stems reach up to 1 m (3.3 ft.) in length. The plant's common name comes from its alternate, 2-6 cm (0.8 - 2.4 in.) long leaves: These fleshy, ovate or broadly wedge-shaped leaves are reputed to have an oyster-like taste. The 6-9 mm (0.24 - 0.35 in.) long, bell-shaped flowers are pink when young and mature to a pale blue. Oysterleaf has a five-lobed calyx (outermost floral whorl) and five stamens. Such pentamerous flowers are characteristic of the Borage family.



Gleason, H.A. The New Britton and Brown Illustrated Flora of the US & Adjacent Canada. NY Botanical Garden, 1952.



Documented Range of Oysterleaf



Massachusetts Distribution by Town

Oysterleaf flowers in August, and the smooth, shiny, sharply angled nutlets mature from about the middle of July to early September.

Range

Oysterleaf is found on Arctic and Atlantic beaches. Its North American range has been documented as extending along sea beaches from Newfoundland to Massachusetts and from Alaska to British Columbia.

Similar Species

None of the plants that grow in oysterleaf's habitat could be confused with it. Oysterleaf is a very distinctive plant, especially when in flower.

Habitat in Massachusetts

Oysterleaf is found on the foredunes of beaches, where there is active sand deposition. In Massachusetts, habitats include a maritime sand spit, an area of sparsely vegetated sand on an upper beach, and the upper edge of a sand berm on a barrier-beach sandspit. Plant species associated with oysterleaf include sea poppy (*Glaucium flavum*), seabeach knotweed (*Polygonum glaucum*), seaside spurge (*Euphorbia polygonifolia*), and various species of orach (*Atriplex* spp.) and beach grass (*Ammophila* spp.).

Population Status

Oysterleaf is presently listed as "Endangered" in Massachusetts. There are seven current stations (discovered or relocated since 1978) in four towns and seven historical stations (unverified since 1978) in two towns. (One town has both historical and current stations and is represented by one solid dot on the town distribution map.) Reasons for the plant's rarity in the Commonwealth include destruction of habitat by off-road vehicles (ORVs) and the fact that Massachusetts is at the southern edge of the plant's range. In addition to ORVs, foot traffic and storms threaten oysterleaf populations. Oysterleaf is also considered rare in Maine.

Massachusetts Natural Heritage Program

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MASSACHUSETTS RARE AND ENDANGERED WILDLIFE

EASTERN SPADEFOOT
(*Scaphiopus h. holbrooki*)

DeGraaf, R.M. and D.P. Rudis. Amphibians and Reptiles of New England. University of Mass., Amherst. 1983.

DESCRIPTION

The Eastern Spadefoot Toad, only 1.75-2.25" (4.4-5.7cm) long, is a short-legged, squat, big-headed toad. The unmistakable cat-like, vertically elliptical pupils are distinctive. The skin is fairly smooth and scattered with small warts. Colors are somber, grayish or blackish-brown with olive. Two yellowish lines originate from each eye and run down the back to form a lyre-shaped pattern. Another light line runs along each side of the body. The toad's name comes from the horny, sharp-edged, sickle-shaped spade on the inner surface of the hind foot. It belongs to a primitive amphibian family that is neither a true frog nor a true toad.

SIMILAR SPECIES

The Eastern Spadefoot is the only toad in its family occurring east of the Mississippi River. It is distinguished from the true toads by its smoother skin, vertically elliptical pupils and single, sharp-edged spade on each hind foot.

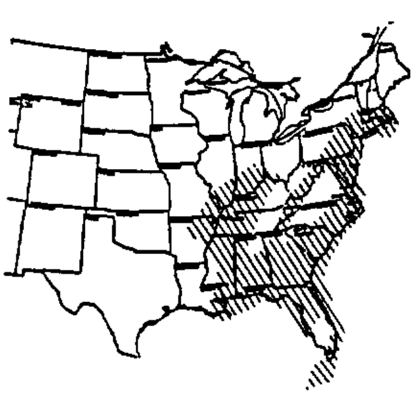
HABITAT IN MASSACHUSETTS

This burrowing species requires dry, sand or sandy loam soils characteristic of Pitch Pine barrens, coastal oak woodlands or sparse shrub growth, interspersed with temporary ponds. It prefers areas with leaf litter, and may be found in farmland areas. Colonies may occur within the floodplains of major rivers.

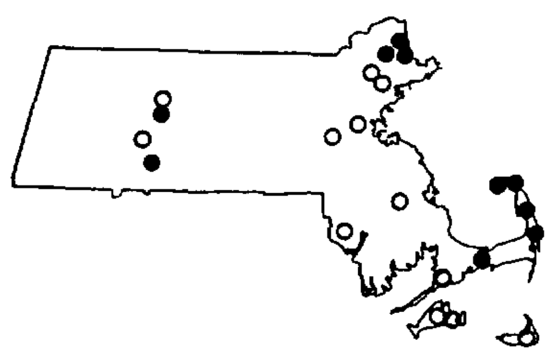
BEHAVIOR

The Eastern Spadefoot is the most fossorial species of frog or toad in Massachusetts. It burrows up to eight feet below the ground's surface

(continued overleaf)



Range of *Scaphiopus h. holbrooki*



● Verified since 1978
○ Reported prior to 1978

Breeding Distribution in Massachusetts by Town

1986

to hibernate during the cold months and to avoid desiccation during the rest of the year. It backs down into its burrow, digging with the hind feet and covering itself over with the fore feet. In the warmer months, from April to September, the Spadefoot comes up to breed after prolonged warm and heavy rains. Spadefoots are secretive and nocturnal; activity peaks just after sundown and before sunrise. In the summer months, individuals remain in their burrows an average of 9.5 days between feedings. They emerge uttering explosive, low-pitched grunts, short in duration and repeated at brief intervals. Home range movements are estimated to be an average of 108 sq. ft./10 sq. m., 90% of which falls within an area of 67 sq. ft./6.2 sq. m. Spadefoots have been recaptured in the same ranges after 5 years. Individuals may live for several decades. Adults apparently produce noxious or distasteful skin secretions, because native predators usually ignore them.

BREEDING SCHEDULE
Colonial breeding is initiated by heavy rainfall in April or May and lasts until August or September. This one or two night phenomenon has been likened to an orgy of raucous squawks and frantic courtship. Since Spadefoots do not breed successfully in permanent waters with fishes, they breed in temporary ponds. The adhesive eggs, laid in masses or strings of 1000-2500, are draped over submerged twigs or grass, where they hatch in 5 to 15 days. Metamorphosis of larvae to adults is said to coincide with pond conditions; longer pond life results in longer larval life. In Essex County, a natural population metamorphosed in less than 4 weeks. Sexual maturity is reached during the second year after metamorphosis, males at 15 months and females at 19 months.

FEEDING HABITS
Larvae feed on plankton for the first few days, later becoming vigorously carnivorous and sometimes cannibalistic. Adults eat flies, spiders, crickets, caterpillars, true bugs, other ground-dwelling arthropods, earthworms, snails, moths, and small vertebrates, such as salamanders.

RANGE
The Eastern Spadefoot Toad is found from Massachusetts to New York, south to eastern Florida and some of the Keys, west through Pennsylvania, through the southern Great Lakes region, to Arkansas and south to Louisiana. The species is absent from the higher elevations of the Appalachians and the Everglades. In Massachusetts, the Spadefoot is known only in scattered coastal locations from Plum Island, south to Cape Cod and Martha's Vineyard and several locations in the southern Connecticut Valley.

STATUS
The Eastern Spadefoot is listed as "Threatened" in Massachusetts. Only 12 current sites have been verified since 1978. Museum specimens and literature attest to the former widespread, if not abundant, status of the species. Several factors contribute to the rarity of the species. Plum Island is the northern limit of species' range. Destruction of suitable habitat continues to limit its numbers; Spadefoot populations have been extirpated by development from Middlesex County, inland Essex County and parts of Martha's Vineyard. The species is vulnerable to pesticides, as it was extirpated in Nantucket after WWII by the use of DDT. Many individuals are killed crossing roads, especially during the breeding season.

Adapted from: Lazelle, J.D., Jr., 1987. Eastern Spadefoot. In T. W. French and J. E. Cardoza (eds). Endangered, Threatened, and Special Concern Vertebrates of Massachusetts. Massachusetts Division of Fisheries and Wildlife (in press).

Natural Heritage & Endangered Species Program

Commonwealth of Massachusetts
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MASSACHUSETTS THREATENED WILDLIFE

Northern Harrier
(*Circus cyaneus*)

DESCRIPTION: The Northern Harrier or Marsh Hawk is a slim, long-legged, long-tailed hawk, about 40 to 60 cm (16 to 24 in.) in length, with an owl-like face and long, rounded, narrow wings extending up to 1.2 meters (46 in.) from wing tip to wing tip. Males are pale bluish gray on the head and upper surface, white on the undersurface, and have black wing tips; the tail has a broad subterminal bar with 5 to 7 narrower dark brown bars. Females are dusky brown on the head and upper surface, and light brown with darker vertical streaks on the lower surface; the tail is dark in the center, becoming paler near the outer edges, and has 5 to 7 broad brown bars. Both sexes possess a conspicuous white rump patch, white upper tail coverts, light orange-yellow legs, and black bills. Northern Harriers have large ear openings, but they are usually hidden underneath their feathers.

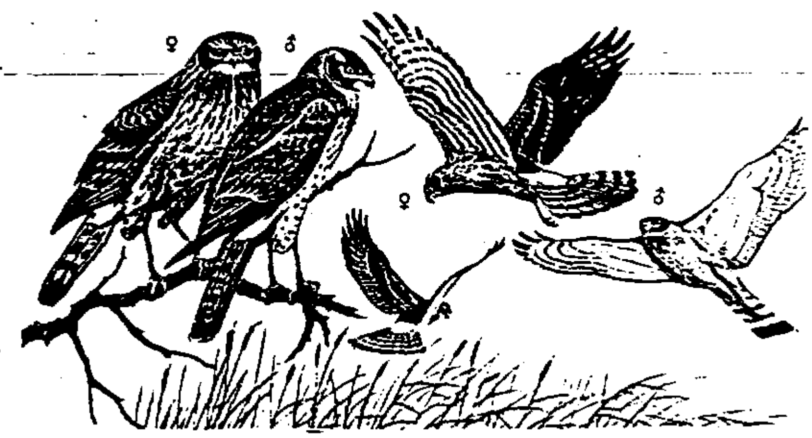
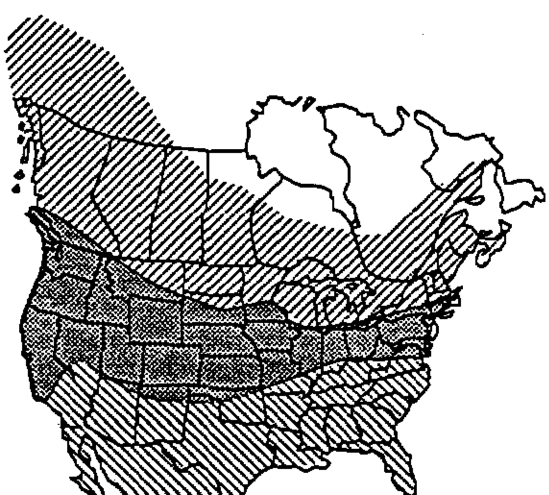


Illustration by Arthur Singer, from Robbins, C.S., Bruun,Bertel, Zim,Herbert. Birds of North America. Golden Press, NY 1966

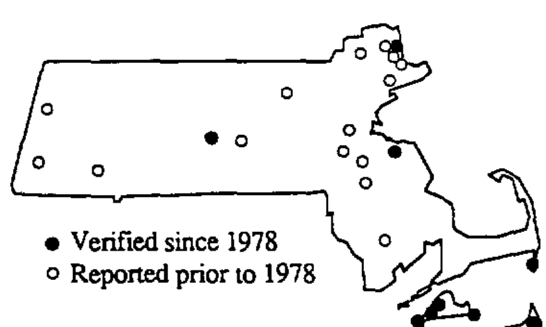
SIMILAR SPECIES IN MASSACHUSETTS: The male Northern Harrier's gray coloration makes it distinct from other local birds. However, the female Northern Harrier vaguely resembles the Short-eared Owl (*Asio flammeus*): both occupy the same habitat type, have a brownish upper surface and white breast with vertical brown streaks, long rounded wings and black wingtips. However, the Short-eared Owl is smaller, with short feathered legs, a white facial disk, and lacks the bright white rump patch possessed by Northern Harriers.

RANGE: The Northern Harrier breeds from Massachusetts north to Newfoundland and Alaska, south to southeastern Virginia, and west to northern Texas and central California. Wintering range extends from New England west to southern British Columbia and south into Central America and the West Indies.



Range of Northern Harrier

Summer (breeding) range
Year - round range
Winter range



Massachusetts Distribution by Town
1990

HABITAT IN MASSACHUSETTS: Northern Harriers establish nesting and feeding territories in wet meadows, grasslands, abandoned fields, and coastal and inland marshes, mostly along the coast. Northern Harriers in Massachusetts are uncommon summer residents or migrants, although they once were much more abundant in the state. Most Harriers in the state which do not migrate south spend the winter in coastal marshes on Cape Cod and the offshore islands. Some Northern Harriers that breed in areas north of Massachusetts may also spend the winter on the offshore islands and along the coast. Northern Harriers are known to share habitat and territory with Short-eared Owls.

LIFE CYCLE / BEHAVIOR: The breeding season of Northern Harriers extends from March to July in Massachusetts and is initiated by a spectacular courtship ritual called skydancing, which is usually performed only by males and is used to attract mates. A skydancing Northern Harrier performs an aerial acrobatic display of dives, somersaults, loops, and tumbles, often accompanied by shrill screaming calls.

Once the male has found a mate, the female Northern Harrier builds a nest made of grasses, weeds, water plants, and other vegetative material supplied to her by her mate. The nest is usually located in a slight hollowed-out area on the ground, among bushes, grasses, and other low vegetation, and consists of a thick pad of grasses surrounded by dry stalks of plants, weeds, and small twigs. Sometimes the nest is built over shallow water on a raised mound of sticks, hollowed in the center and lined with dry grass, stubble and weed stalks.

After courtship and mating have occurred, the female lays from 2 to 9 bluish-white eggs (3 to 6 on average), about 1 egg every other day. Both parents help incubate the eggs until they hatch 30 to 32 days later. The male Harrier provides all the food to his mate and young until they fledge 30 to 35 days after hatching. Although Northern Harriers are known to readily abandon nests when disturbed before the eggs hatch, they vigorously defend their nests once their young have hatched. After the young have fledged, they may hunt together with their parents through the remainder of the summer, until they disperse on their own or are driven off. The Northern Harriers which do not spend the winter in Massachusetts begin to migrate south in late August or early September.

Northern Harriers prey on a variety of small creatures, including rodents, rabbits, and other small mammals, small birds, insects, amphibians, reptiles, and carrion. In Massachusetts, voles constitute a very important component of the Harrier's diet; there is a direct correlation between the breeding success of Northern Harriers and the number of voles found in their territory. When hunting, the Northern Harrier flies low over the ground, slowly and systematically, usually in early morning and late afternoon or early evening. When it detects prey, it hovers a moment before swooping straight down to the ground. The Harrier uses its talons to capture prey and then kills its catch via repeated stabs with its sharp beak.

POPULATION STATUS IN MASSACHUSETTS: The Northern Harrier is listed as a Threatened Species in Massachusetts, with 26 current (post-1978) breeding sites and 16 historical breeding sites. The Northern Harrier was once a common breeder throughout Massachusetts from the mid-1800's to the early 1900's. Today, almost all of the breeding Harriers in the state are confined to the offshore islands, Cape Cod, and Plum Island.

The most significant factor in the Northern Harrier's decline has been destruction of suitable habitat by reforestation of agricultural land and destruction of coastal and freshwater wetlands. In coastal areas, human disturbance may cause some Harriers to abandon their nests. Natural factors such as prey abundance, prolonged periods of rain (which may destroy nests and eggs), and predation on eggs and nestlings all affect the breeding success of Northern Harriers. In order to prevent further decline in the Northern Harrier's population, it is crucial to protect suitable habitats from development and destruction.

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Piping Plover
(*Charadrius melodus*)

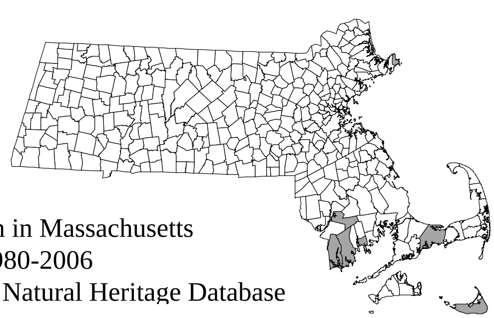
State Status: **Threatened**

Illustration by J. Zickefoose, 1986

DESCRIPTION: The Piping Plover is a small, stocky shorebird with pale brownish gray or sandy-colored plumage on its backside, with a white breast, forehead, cheeks, and throat, a black streak on the forecrown extending from eye to eye, and a black breastband which may not always form a complete circle. Its coloration gives it excellent camouflage in sandy areas. The average Piping Plover is 15 to 17 cm (6 to 7 in.) long, with a wingspan of 35 to 40 cm (14 to 16 in.). The tail is white at the base and tip, but dark in the middle. It has yellow-orange legs and its short bill is yellow-orange with a black tip in the summer, but turns completely black during the winter. In general, females have darker bills and lighter plumage than males. The Piping Plover runs in a pattern of brief starts and stops; in flight, it displays a pair of prominent white wing stripes. Its call is a series of piping whistles.

SIMILAR SPECIES IN MASSACHUSETTS: The Piping Plover is similar to the Semipalmated Plover (*Charadrius semipalmatus*) in size, shape, and coloration. However, the Semipalmated Plover is a darker brown in color, and has much more black on its head than the Piping Plover. The Semipalmated Plover does not breed in Massachusetts but is present on sandy beaches and intertidal flats from late July to early September during its southward migration.

RANGE: During spring and summer, the Atlantic Coast population of Piping Plovers nests from the Newfoundland south to North Carolina. In winter they migrate farther south, from North Carolina to Florida, the Gulf of Mexico, and the Caribbean. Other populations of Piping Plovers nest along rivers on the Northern Great Plains and along the shores of the Great Lakes, migrating to the Gulf of Mexico in the winter.



Distribution in Massachusetts
1980-2006
Based on records in Natural Heritage Database

HABITAT: Piping Plovers in Massachusetts nest on sandy coastal beaches and dunes. which are relatively flat and free of vegetation. Piping Plovers often build their nests in a narrow area of land between the high tide line and the foot of the coastal dunes; they also nest in Least Tern colonies. Nesting may also occur on vegetated dunes and in eroded areas behind dunes.

LIFE CYCLE / BEHAVIOR: As soon as Piping Plovers return to their breeding grounds in Massachusetts in late March or April, the males begin to set up territories and attract mates. Territorial rivalry between males is very strong; adjacent male Piping Plovers mark off their territories by running side by side down to the waterline. Each bird takes turns, one running forward a few feet, then waiting for the other to do likewise. Nests are usually at least 200 feet apart; the nesting pair will confront any intruding Piping Plover which approaches the nest. Male Piping Plovers also defend feeding territories encompassing beach front adjacent to the nesting territory.

Courtship consists of a ritualized display by the male, who flies in ovals or figure-eights around a female, then displays on the ground by bowing his head, dropping his wings, and walking in circles around the female. The male also scrapes shallow depressions in the sand at potential nest sites. The female then chooses one of these nesting sites, usually in a flat, sandy area. The nest itself is a shallow depression which is often lined with shell fragments and small pebbles, which may aid in camouflaging the eggs. Female Piping Plovers typically lay four eggs per clutch, one egg every other day over a week's time. The eggs are sandy gray in color with dark brown or black spots, and all hatch within 4 to 8 hours of each other. Both parents take part in incubating the eggs until they hatch 26-28 days later.

The young chicks leave the nest within hours after hatching and may wander hundreds of meters before they become capable of flight. When threatened by predators or human intruders, the young run or lie motionless on the sand while their parents often pretend to have broken wings in an effort to attract the intruder's attention away from the chicks. Young Piping Plovers are brooded by their parents for 3 to 4 weeks and finally fledge 4 to 5 weeks after hatching, at which time they leave the nesting area.

Piping Plovers feed on marine worms, mollusks, insects, and crustaceans. They forage along the waterline, on mudflats at low tide, and in wrack (seaweed, marsh vegetations and other organic debris deposited by the tides) along the beach. Foraging behavior consists of running a short distance, then staring at the ground with the head tilted to one side, often standing on one foot while vibrating the other foot on the ground, and finally pecking at the food item it has detected in the sand.

Piping Plovers begin to migrate southward between late July and early September, although occasional stragglers remain behind until late October. Adult birds often return to the same nesting area every spring, although they usually change mates from year to year. Young birds may nest anywhere from a few hundred feet to many miles from where they were hatched.

POPULATION STATUS IN MASSACHUSETTS: The Atlantic Coast population of Piping Plovers is listed as Threatened at both the state and federal levels. In 2005, 475 breeding pairs nested at about 100 sites. Massachusetts has the largest breeding population of Piping Plovers along the Atlantic Coast.

Originated: 1990
Updated: 2006

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Melsheimer’s Sack Bearer

Cicinnus melsheimeri

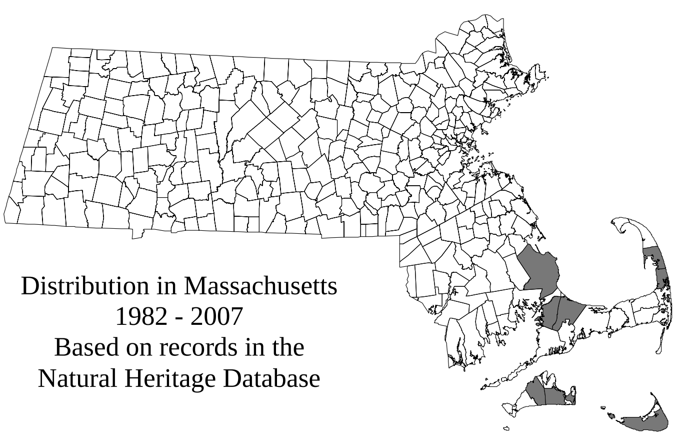
State Status: **Threatened**
Federal Status: None

Description: Melsheimer’s Sack Bearer is a mimallonid moth with a wingspan of 35-50 mm. The wings are pale pink, overlaid with black speckling, with gray postmedial lines and small, gray reniform spots; on the forewings the postmedial lines curve inward near the costal margins. The forewings are hooked at the tips.

Habitat: Melsheimer’s Sack Bearer is more ecologically generalized to the South, but in Massachusetts it is restricted to sandplain pitch pine/scrub oak barrens, especially scrub oak thickets within frost pockets.

Life History: Adult moths fly in June and early July, with the peak flight normally in late June. Larvae feed on scrub oak (*Quercus ilicifolia*) from summer through fall, constructing a portable, protective shelter (“sack”) out of leaves and silk. Larvae overwinter and pupate in the spring.

Range: Melsheimer’s Sack Bearer is found from Massachusetts south to Florida, west to Wisconsin and Texas. It is rare and local in the northern part of its range, more common from the New Jersey pine barrens southward. In Massachusetts it is restricted to Cape Cod and the offshore islands, west to Plymouth.



Distribution in Massachusetts
1982 - 2007
Based on records in the
Natural Heritage Database

Photo by M.W. Nelson

Adult Flight Period in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Threats

- Habitat loss
- Fire suppression
- Invasion by exotic plants
- Introduced generalist parasitoids
- Insecticide spraying
- Off-road vehicles
- Light pollution

Updated June 2007
M.W. Nelson

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Water-willow Stem Borer

Papaipema sulphurata

State Status: **Threatened**
Federal Status: None

Description: The Water-willow Stem Borer is a noctuid moth with forewings that are ochre to straw yellow with purplish-brown shading in the basal and terminal areas; the reniform and orbicular spots are straw yellow, outlined in purplish-brown. The hind wings are pinkish-tan. Wingspan is 32-38 mm.

Habitat: The Water-willow Stem Borer inhabits shallow portions of coastal plain wetlands (swamps, edges of streams and ponds, abandoned cranberry bogs, etc.) where water-willow (*Decodon verticillatus*) grows.

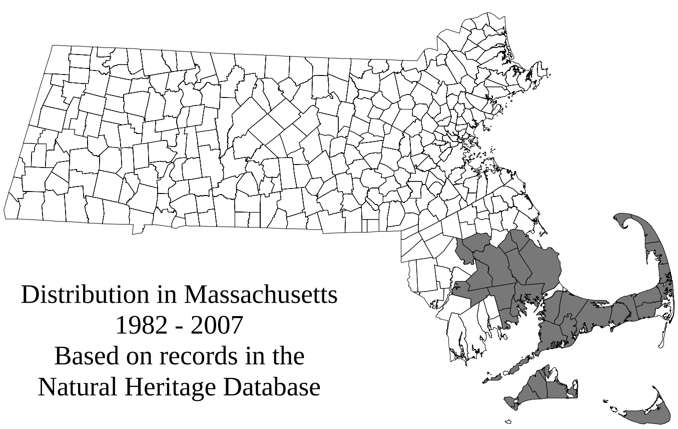
Life History: Adult moths fly in late September and early October. Eggs overwinter, hatching in the spring. Larvae bore into and feed internally on stems of water-willow (*Decodon verticillatus*). Larvae pupate in August.

Range: The Water-willow Stem Borer is endemic to southeastern Massachusetts, occurring in Plymouth and Bristol Counties as well as on Cape Cod and the offshore islands.

Photo by M.W. Nelson

Adult Flight Period in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec



Distribution in Massachusetts
1982 - 2007
Based on records in the
Natural Heritage Database

Threats

- Habitat loss
- Hydrologic alteration
- Invasion by exotic plants
- Insecticide spraying
- Light pollution

Updated June 2007
M.W. Nelson

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Pine Barrens Bluet Damselfly

Enallagma recurvatum

State Status: **Threatened**
Federal Status: None

DESCRIPTION OF ADULT: The Pine Barrens Bluet is a small, semi-aquatic insect of the order Odonata, suborder Zygoptera (the damselflies), and family Coenagrionidae (pond damsels). Like most damselflies, Pine Barrens Bluets have large eyes on the sides of the head, short antennae, and four heavily veined wings that are held folded together over the back. The male's thorax (winged and legged section behind the head) is mostly blue with black stripes on the "shoulders" and top. The Pine Barrens Bluet has a long, slender abdomen, which is composed of ten segments. The abdominal segments are blue with an increasing amount of black distally through segment 7. Segments 8 and 9 are entirely blue, except segment 8 has a small horizontal black dash on each side of the segment. This mark can sometimes be absent. The top of segment 10 is black. Females have thicker abdomens than the males, and are generally brown where the males are blue, though older females may become quite bluish.

Pine Barrens Bluets average just over one inch (26mm to 29mm) in length.

SIMILAR SPECIES: The bluets (genus *Enallagma*) comprise a large group of damselflies, with no less than 20 species in Massachusetts. Identification of the various species can be very difficult and often requires close examination of the terminal appendages on the males (Nikula *et al.* 2003) or the mesostigmal plates (located behind the head) on the females (Westfall and May 1996). The Pine Barrens Bluet is most similar in appearance to the New England Bluet (*E. laterale*), a species of Special Concern in Massachusetts. Both are found at several of their known locations. The two species are most safely distinguished by the shape of the terminal appendages on the male and the mesostigmal plates of the females. The black dash on the sides of segment 8 is generally larger in the New England Bluet, however this feature is highly variable and should not be used for definitive identification.

HABITAT: Pine Barrens Bluets are regional endemics and appear to be restricted to coastal plain ponds. Their range coincides closely with the distribution of those ponds. Some of the common attributes shared by ponds inhabited by the Pine Barrens Bluet include: sandy shallow shores; large amounts of vegetation close to the shore, especially Military Rush (*Juncus militarus*); and yearly natural fluctuations in water levels. The nymphs are aquatic and live among aquatic vegetation and debris. The adults inhabit nearby uplands and emergent vegetation along the shore.

LIFE-HISTORY/BEHAVIOR: The flight season of the Pine Barrens Bluet is generally restricted to the month of June, with emergence generally occurring during the last week of May. Adults are rarely seen after June. Although little has been published specifically on the life history of the Pine Barrens Bluet, it is likely similar to other, better-studied species in the genus. All odonates have three life stages: egg, aquatic nymph, and flying adult. The nymphs are slender with three leaf-like appendages extending from the end of the body which serve as breathing gills. They have a large, hinged lower jaw which they are able to extend forward with lightning speed. This feature is used to catch prey, the nymph typically lying in wait until potential prey passes within striking range. They feed on a wide variety of aquatic life, including insects and worms. They spend most of their time clinging to submerged vegetation or other objects, moving infrequently. They transport themselves primarily by walking, but are also capable of swimming with a sinuous, snake-like motion.

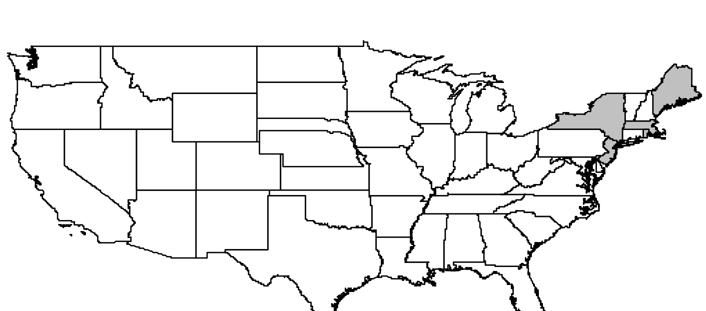
PINE BARRENS BLUET FLIGHT PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

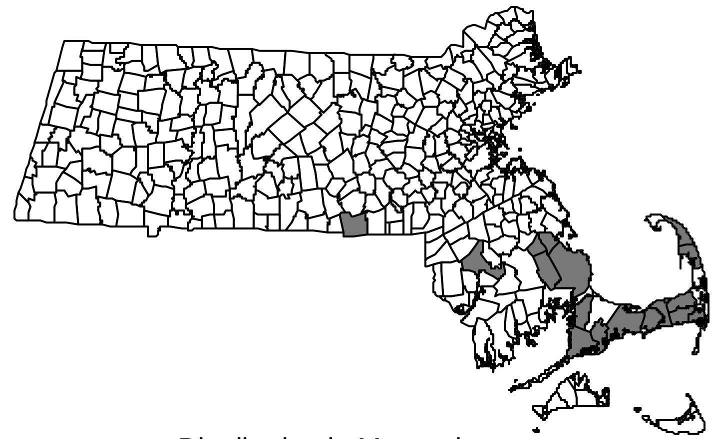
Pine Barrens Bluets have a one-year life cycle. The eggs are laid during the early summer and probably hatch in the fall. The nymphs develop over the winter and spring, undergoing several molts. In early to mid-summer the nymphs crawl up on emergent vegetation and begin their transformation into adults. This process, known as emergence, typically takes a couple of hours, after which the newly developed adults (tenerals) fly weakly off to upland areas where they spend a week or two feeding and maturing. The young adults are very susceptible to predators, particularly birds, ants, and spiders; mortality is high during this stage of the life cycle. The adults feed on a wide variety of smaller insects which they typically catch in flight.

When mature, the males return to the wetlands where they spend most of their time searching for females. When they locate a female, the male attempts to grasp her behind the head with the terminal appendages at the end of his abdomen. If the female is receptive, she allows the male to grasp her, then curls the end of her abdomen up to the base of the male's abdomen where his secondary sexual organs ("hamules") are located. This coupling results in the heart-shaped tandem formation characteristic of all odonates. This coupling lasts for a few minutes to an hour or more. The pair generally remains stationary during this mating but, amazingly, can fly, albeit weakly, while coupled.

Once mating is complete, the female begins laying eggs (ovipositing) in emergent grasses and rushes, using the ovipositor located on the underside of her abdomen to slice into the vegetation where the eggs are deposited. Although the female occasionally oviposits alone, in most cases the male remains attached to the back of the females head. This form of mate-guarding is thought to prevent other males from mating with the female before she completes egg-laying. The adult's activities are almost exclusively limited to feeding and reproduction, and their life is short, probably averaging only three to four weeks for damselflies like the Pine Barrens Bluet.



Range of Species in US



Distribution in Massachusetts
1977 - 2002
Based on records in Natural Heritage Database

RANGE: The Pine Barrens Bluet has a very small range restricted to scattered locations in the northeastern United States. It has been found only in Maine, Massachusetts, Rhode Island, New York and New Jersey.

POPULATION STATUS IN MASSACHUSETTS: The Pine Barrens Bluet is listed as a Threatened Species in Massachusetts. The species is known mainly from southeastern portions of Massachusetts, primarily Barnstable and Plymouth counties. Unlike the closely related New England Bluet, the Pine Barrens Bluet has occasionally been found in large numbers at some locations, though its overall range is more limited.

MANAGEMENT RECOMMENDATIONS: The major threat to the Pine Barrens Bluet is degradation and destruction of the wetlands which are its breeding and nymphal habitat. Threats include construction and development, artificial drawdown of pond water-level by groundwater pumping, and run-off from roadways and sewage. In addition, high-impact recreational use such as off road vehicles driving through pond shores, which may destroy breeding and nymphal habitat, and motor boats, whose wakes swamp delicate emerging adults, are threats. Since Pine Barrens Bluets, like many species of damselflies, spend a period of several days or more away from the pond maturing, it is important to maintain natural upland habitats adjoining the breeding sites for roosting and hunting. Without protected uplands the delicate newly emerged adults are more susceptible to predation and mortality from inclement weather.

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Diamondback Terrapin

Malaclemys terrapin

State Status: **Threatened**
Federal Status: None

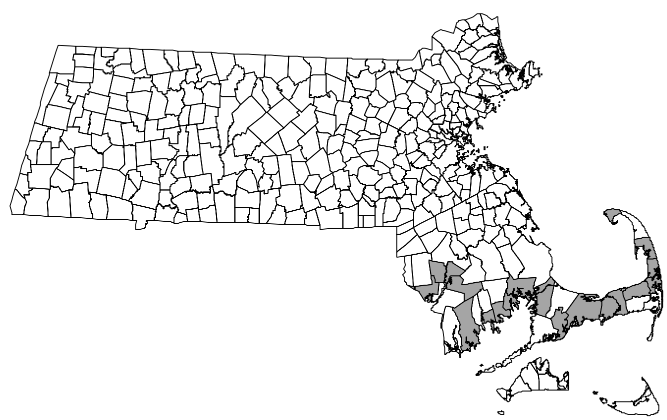
Photo by Bill Byrne

DESCRIPTION: The Diamondback Terrapin is a medium-sized salt marsh turtle. It has a wedge shaped carapace (top shell) variably colored in ash grays, light browns, greens and blacks. It has concentric ring patterns on the carapace and a pronounced ridged or bumpy mid-line keel. Both sexes have grayish to black skin, spotted with dark green flecks and light colored upper and lower jaw. This turtle has very large, paddle like hind feet that are strongly webbed. Sexual size dimorphism is prominent in this species. Adult females are considerably larger than males ranging from 15-23 cm (6-9 in.) in length, while males are 10-15 cm (4-6 in.). Hatchlings look like adults and are about 2.6 cm (1 in.) long.

SIMILAR SPECIES: There are no other brackish water species in Massachusetts. This is the most distinctive turtle in both appearance and its habitat use. It is not likely to be confused with any other turtle species resident within the Commonwealth. Occasionally casual observers may report Diamondback Terrapins as "sea turtle" sightings.

HABITAT IN MASSACHUSETTS: Diamondback Terrapins inhabit marshes which border quiet salt or brackish tidal waters. They can also be found in mud flats, shallow bays, coves, and tidal estuaries. Adjacent sandy dry upland areas are required for nesting.

RANGE: The Diamondback Terrapin (*Malaclemys terrapin terrapin*) is found along the Atlantic coast from Massachusetts south to Florida and along the Gulf coast from the Carolinas to Texas.



Distribution in Massachusetts
1980 - 2006
Based on records in Natural Heritage Database

LIFE CYCLE & BEHAVIOR: Diamondback Terrapins overwinter in the bottom of estuaries, creeks and salt marsh channels. In late spring, males and females gather to create mating aggregations in small, quiet coves along the coast. Salt marshes are critical wintering, foraging, and nursery areas. Egg-carrying females will make the journey upland and sometimes inland as much as a 0.4 km (1/4 mile) to lay eggs. Except when basking, males spend their time in water; females venture onto land normally twice a year for nesting, once in early June and once in July. Females travel from water's edge to nesting habitat usually at high tide to reach sites above the high water line. Hatchlings and juveniles are thought to hide out among the grasses in brackish water marshes.

Diamondback Terrapins feed on crabs, mollusks, crustaceans, insects, fish, and carrion. They forage in the water.

The Diamondback Terrapin is polygamous (each individual may breed with several others) and mates in the water. Females are capable of retaining viable spermatozoa for up to 4 years without subsequent matings. Females become sexually mature at 8 to 10 years of age (males mature earlier) and are known to live to 40, but this is likely to be an underestimation of longevity. A single female may lay 1-3 nests per year. The female digs a nest about 10-20 cm (4-8 in.) deep and then deposits a clutch of approximately 12 eggs. Most females exhibit nest site fidelity, where they return to the same nesting location year after year.

On Cape Cod, Diamondback Terrapins have been observed nesting during both day and night and on both vegetated and unvegetated uplands; in contrast, southern populations have reported nesting only during the day and only on vegetated dunes. Eggs laid in unvegetated areas, although more susceptible to wind erosion, receive more heat thereby decreasing incubation time. Diamondback Terrapins have temperature dependant sex determination; eggs will develop into males if temperatures are below 28º C (82º F) and at temperatures above 30ºC (86ºF) females will develop. At temperatures ranging from 28-30 ºC (82-86ºF), there will be a mixture of males and females.

Incubation of eggs in Massachusetts lasts between 59 and 116 days depending on temperature. It may take from 2 to 11 days after the eggs hatch for the young turtles to emerge and start the hazardous trip from the nest to the water. Part of this time may be spent rotating towards the sun in what is thought to be an orientation behavior. When the climate is unseasonably cold, some hatchlings may overwinter in their nests waiting until the following May to erupt from the sand.

ACTIVE PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

THREATS: Diamondback Terrapin population declines have been documented in many areas with a number of factors contributing to these declines. This species was nearly wiped out by gourmet consumption around the turn of the 20^{th} century. Today, the harvest of Diamondback Terrapins is illegal in Massachusetts. However, other human activities continue to threaten this species.

Reduction of salt marsh habitat and alteration of water composition due to ditching, dredging and channelization, loss of sandy nesting habitats, and destruction of dune areas continue to contribute to the decline of the Diamondback Terrapin in Massachusetts. "Armoring" and sea-walling coasts thwart Diamondback Terrapin access to upland nesting areas.

One of the Diamondback Terrapins healthiest populations in Massachusetts is located on Cape Cod. Today this area is also heavily used for recreational activities. Human activity may disrupt nesting turtles and hatchlings. Off road vehicles increase the chances of disturbing, injuring or killing nesting females, crushing nests, and killing migrating hatchlings. When interrupted, females will abort nesting attempts which may have taken hours.

Additional causes of mortality are pollution and roads, as well as predation of eggs and hatchlings by predators whose unnaturally high populations are encouraged by high human densities. As air breathers, Diamondback Terrapins get trapped and drown in improperly discarded "ghost" netting, as well as by-catch in estuarine crab traps. Nesting females often must cross roads to get to appropriate nesting habitat.

MANAGEMENT RECOMMENDATIONS: Diamondback Terrapin habitat needs to be targeted for protection and management. NHESP records can be used to assess and prioritize areas based on the extent, quality, and juxtaposition of habitats and their predicted ability to support self-sustaining populations of Diamondback Terrapins. Given limited conservation funds, alternatives to outright purchase of conservation land for nesting habitat is an important component to the conservation strategy. These can include Conservation Restrictions (CRs) and Agricultural Preservation Restrictions (APRs). Another method of protecting large blocks of land is allowing the building of small or clustered roadside developments in conjunction with protecting large areas of unimpacted land.

Habitat management and restoration guidelines should be developed and implemented in order to create and/or maintain consistent access to nesting habitat at key sites. This is most practical on state-owned conservation lands (i.e. DFW, DCR). However, educational materials should be made available to guide private land-owners on the best management practices for Diamondback Terrapin habitat.

Alternative wildlife corridor structures should be considered at strategic sites on existing roads. In particular, appropriate wildlife corridor structures should be considered for bridge and culvert upgrade and road-widening projects within Diamondback Terrapin habitat. Efforts should be made to inform Mass Highways of key locations where these measures would be most effective for turtle conservation.

Educational materials need to be developed and distributed to the general public in reference to the detrimental affects of keeping native Diamondback Terrapins as pets, which is illegal in Massachusetts. Of equal concern is the release of pet store turtles (which could spread disease), leaving cats and dogs outdoors unattended (particularly during the nesting season), mowing of fields and shrubby areas, feeding suburban wildlife (which increases the numbers of natural predators to turtles), and driving ATVs in nesting areas from June-October. People can be encouraged, when safe to do so, to help Diamondback Terrapins cross roads (always in the direction the animal was heading); however turtles should never be transported to “better” locations. They will naturally want to return to their original habitat and likely need to traverse roads to do so.

Increased law enforcement is needed to protect our wild turtles, particularly during the nesting season when poaching is most frequent and ATV use is common and most damaging.

Diamondback Terrapins are an extremely elusive, non-migratory species. They can be easily extirpated by the unintended consequences of human activities before they are even identified as being present. Coastal residents are often surprised to learn their abutting estuary hosts a Diamondback Terrapin population.

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Updated: 2007

Massachusetts Natural Heritage Program

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MASSACHUSETTS RARE AND ENDANGERED WILDLIFE

Arctic Tern
Sterna paradisaea

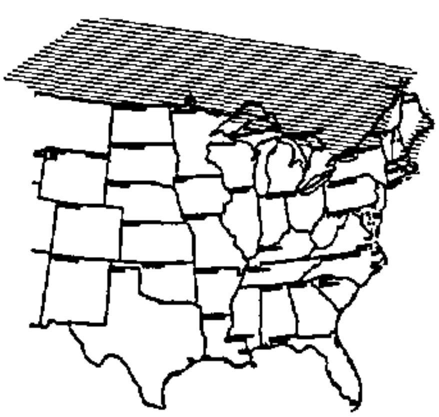
DESCRIPTION The adult Arctic Tern is a small, coastal bird 14-17 inches (35-43 cm) in length and 3-4 oz. (107g) in weight. It has a white body with a gray back between the wings (mantle), a black capped head, a blood-red bill, and a deeply forked tail. It has a wingspread of 29-33 inches (65-90 cm). Its most distinguishing features are its short red legs and its long tail which extends to the end of its folded wings. Its small feet and short legs make it appear to be crouching on the ground when it is actually standing. Juveniles have a short black bill, white forehead, short legs and a sooty colored area from its eye to the nape of its neck. The Arctic Tern has a high pitched squeaky call of "kee-kee," "kip, kip, kip-TEE-ar," and a short "kee-kahr."

The Audubon Society Field Guide to North American Birds, Bull and Farrand, Jr. 1977

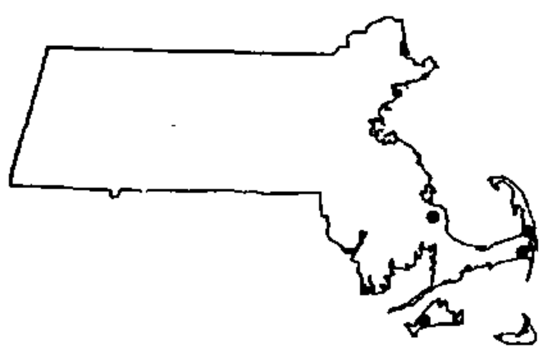
SIMILAR SPECIES The Arctic Tern is distinguished from the very similar Common Tern (Sterna hirundo) by its shorter legs and bill, longer tail and grayer underparts. The tail of the Arctic Tern reaches to the tip of its folded wings whereas the Common Tern's does not. In addition, the Arctic Tern's thinner bill is completely red during the breeding season whereas the Common Tern's has a black tip. In comparison to the Common Tern, the Arctic Tern's voice is more abrasive and higher pitched.

RANGE The Arctic Tern has a circumpolar range. In summer, it occurs as far north as there is open water; from northern Alaska and Ellesmere Island, east to British Columbia,

(Continued overleaf)



Range



● Verified since 1978
○ Reported prior to 1978

Breeding Distribution in Massachusetts by Town

1988

northern Manitoba, Quebec, Newfoundland, and along the coast of Maine and Massachusetts. Massachusetts is at the southern edge of its breeding range. The Arctic Tern winters on the Antarctic pack-ice as well as off the South African coast.

MIGRATION In Massachusetts, Arctic Terns arrive on their breeding grounds in mid May and depart as soon as the young can fly which is usually in early August. From Cape Cod they cross the Atlantic Ocean to Africa and then head south to the open water off Antarctica. The Arctic Tern has been called the "champion migrant" flying up to 22,000 miles round trip from its summer nesting sites in the north over the Atlantic and Pacific Oceans to its wintering grounds near the Antarctic Circle. It is thought that this bird sees more daylight than any other animal in existence.

HABITAT IN MASSACHUSETTS The Arctic Tern is found in sandy gravelly areas on islands and barrier spits. Occasionally, they occur on mainland shores.

FEEDING HABITS The Arctic Tern feeds on small fish such as sand lance, capelin, herring, and minnows as well as on invertebrates and small crustaceans. When feeding, this tern will hover over the water and dive from heights of 30 to 40 feet splashing the surface and becoming submerged.

LIFE HISTORY/ECOLOGY The Arctic Tern nests in colonies ranging from several to tens of thousands of pairs. In Massachusetts, they are found with Common and Least Terns. Individuals begin breeding at 3 to 4 years of age. The female Arctic Tern scrapes out a nest in the area beyond the high tide mark and occasionally uses dune grass to line it. Eggs are laid between May 28 and June 15 in Massachusetts and clutches contain 1 or 2 brownish-green eggs. The female is mainly responsible for incubating the eggs, and brooding and feeding the young. Incubation lasts approximately 21 days and the young fledge 21 to 24 days after hatching. Arctic Terns do not renest if their initial brood is lost to predation or storms.

POPULATION STATUS The Arctic Tern is listed as a Species of Special Concern by the Massachusetts Division of Fisheries and Wildlife. Records of this species have been inconsistent in the past due to the difficulty of identifying this bird and distinguishing it from the Common Tern. However, it is generally believed that in Massachusetts, the Arctic Tern was very rare in the late 1800's and required a longer period of time to recover from the deleterious effects of the millinery trade than the Common or Least Terns. On Cape Cod in 1937 and 1938, 60 pairs of Arctic Terns were reported, in 1946 and 1947, 280 pairs were found, and between 1968 and 1972, 110 pairs were reported. These numbers may not reflect an entirely accurate picture of the Arctic Tern population in Massachusetts due to the reasons cited above.

Since the apparent peak in population numbers during the late 1940's, the Arctic Tern has experienced a noticeable decline. In 1986, 24 pairs were recorded increasing to 29 pairs in 1987. It is not known precisely what has caused such a decline in Arctic Terns since legal protection was installed in the early 1900's prohibiting plume taking. As Massachusetts is at the southern edge of the species' breeding range, it is possible that the Arctic Tern will always occur in limited numbers in the state. However, predation and human disturbance have had considerable impact on this tern's success and are partly the cause of the significant decline of Arctic Tern's since the late 1940's. In all 4 sites currently known to contain Arctic Terns, avian, insect, and mammalian predation on eggs and chicks has occurred. Predators such as the Great Black-backed and Laughing Gulls, Great Horned and Short-eared Owls, skunks, rats, and ants have destroyed eggs and chicks at nesting sites. Calamities such as unusually high tides additionally contribute to egg and chick mortality.

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Attenuated Bluet Damselfly

Enallagma daeckii

State Status: **Special Concern**
Federal Status: None

DESCRIPTION: The Attenuated Bluet is a small, semi-aquatic insect of the order Odonata, suborder Zygoptera (the damselflies), and family Coenagrionidae (pond damsels). Like most damselflies, Attenuated Bluets have large eyes on the sides of the head, short antennae, and four heavily veined wings that are held folded together over the back. The Attenuated Bluet is characterized by having an exceptionally long, slender abdomen. On average, it is the longest pond damsel in the United States. The male's thorax (winged and legged section behind the head) is mostly pale blue with thin black stripes on the "shoulders" and top. The abdomen, which is composed of ten segments, is mostly dark brown/black with some blue on the sides of the base of the abdomen and an entirely blue tip (half of segment 7 and all of segments 8-10). Females have thicker abdomens than the males, and are generally brown where the males are blue, though older females may become quite bluish.

Attenuated Bluets range from 1.5 to 1.8 inches (38 mm to 46 mm) in length.

SIMILAR SPECIES: The bluets (genus *Enallagma*) comprise a large group of damselflies, with no less than 20 species in Massachusetts. Identification of the various species can be very difficult and often requires close examination of the terminal appendages on the males (Nikula *et al.* 2003) or the mesostigmal plates (located behind the head) on the females (Westfall & May 1996). The Attenuated Bluet is most similar in appearance to the more common and widespread Slender Bluet (*E. traviatum*). The two species are most safely distinguished by the shape of the terminal appendages on the male and the mesostigmal plates of the females. Attenuated Bluets have much longer abdomens, giving them a lankier appearance than Slender Bluets. However, this feature may require direct comparison between species and there is some variation in size so it is not entirely reliable for identification.

HABITAT: Attenuated Bluets inhabit a variety of wetlands, but seem to be most numerous on highly vegetated lakes and ponds. They have also been found in swamps, shady ponds and vegetated stream backwaters. The nymphs are aquatic and live among aquatic and emergent vegetation and debris.

LIFE-HISTORY/BEHAVIOR: Although little has been published specifically on the life history of the Attenuated Bluet, it is likely similar to other, better-studied species in the genus. All odonates have three life stages: egg, aquatic nymph, and flying adult. The nymphs are slender with three leaf-like appendages extending from the end of the body which serve as breathing gills. They have a large, hinged lower jaw which they are able to extend forward with lightning speed. This feature is used to catch prey, the nymph typically lying in wait until potential prey passes within striking range. They feed on a wide variety of aquatic life, including insects and worms. They spend most of their time clinging to submerged vegetation or other objects, moving infrequently. They transport themselves primarily by walking, but are also capable of swimming with a sinuous, snake-like motion.

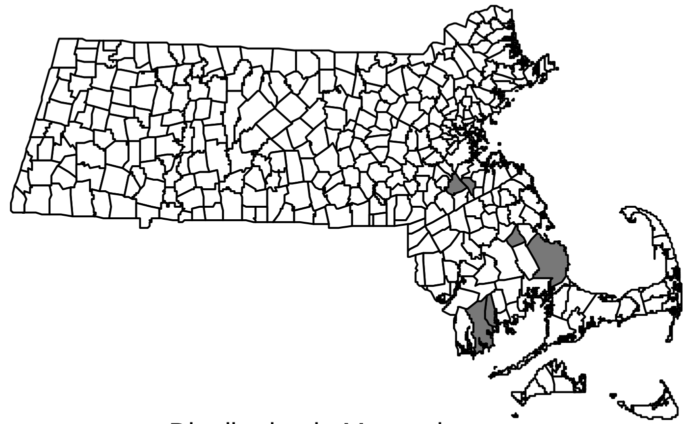
ATTENUATED BLUET FLIGHT PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						■	■				

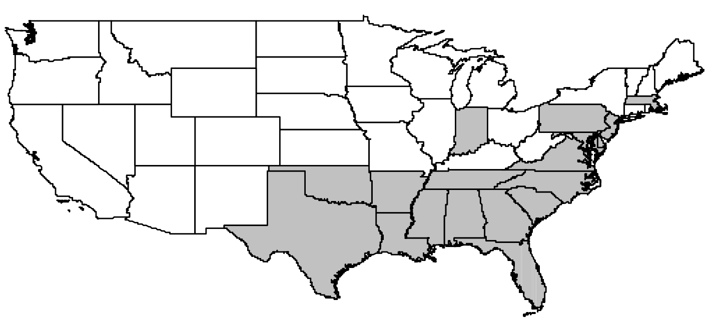
Attenuated Bluets have a one-year life cycle. The eggs are laid in late summer and probably hatch in the fall. The nymphs develop over the winter and spring, undergoing several molts. In early to mid-summer the nymphs crawl up on emergent vegetation and begin their transformation into adults. This process, known as emergence, typically takes a couple of hours, after which the newly developed adults (tenerals) fly weakly off to upland areas where they spend a week or two feeding and maturing. The young adults are very susceptible to predators, particularly birds, ants, and spiders; mortality is high during this stage of the life cycle. The adults feed on a wide variety of smaller insects which they typically catch in flight.

When mature, the males return to the wetlands where they spend most of their time searching for females. When they locate a female, the male attempts to grasp her behind the head with the terminal appendages at the end of his abdomen. If the female is receptive, she allows the male to grasp her, then curls the end of her abdomen up to the base of the male's abdomen where his secondary sexual organs (hamules) are located. This coupling results in the heart-shaped tandem formation characteristic of all odonates. This coupling lasts for a few minutes to an hour or more. The pair generally remains stationary during this mating but, amazingly, can fly, albeit weakly, while coupled.

Once mating is complete, the female begins laying eggs (oviposits) in emergent grasses and rushes, using the ovipositor located on the underside of her abdomen to slice into the vegetation and deposit eggs. Although the female occasionally oviposits alone, in most cases the male remains attached to the back of the females head. This form of mate-guarding is thought to prevent other males from mating with the female before she completes egg-laying. The adult's activities are almost exclusively limited to feeding and reproduction, and their life is short, probably averaging only three to four weeks for damselflies like the Attenuated Bluet.



Distribution in Massachusetts
1977 - 2002
Based on records in Natural Heritage Database



Range of Species in US

RANGE: The Attenuated Bluet ranges from Massachusetts south to Florida and west to Indiana, Oklahoma and Texas. The Attenuated Bluet reaches the edge of its range in New England, and has been recorded only from Massachusetts and Rhode Island.

POPULATION STATUS IN MASSACHUSETTS: The Attenuated Bluet is listed as a Species of Special Concern in Massachusetts. The species is known only from southeastern portions of Massachusetts, primarily from Bristol County. Most Massachusetts sites are well-vegetated lakes or ponds. The majority of records for Attenuated Bluet in Massachusetts are from the 1990s; whether this indicates a population increase and range expansion in the state or simply reflects increased observer effort is unclear.

MANAGEMENT RECOMMENDATIONS: Threats to Attenuated Bluet populations in Massachusetts are similar to those facing other odonates and, indeed, most wetland fauna. These threats include disturbance from human recreational activities, destruction of habitat for residential and other uses, contamination from herbicides, insecticides, and highway run-off, and alteration of water levels through water pumping or other activities. Management should focus on maintaining water quality, protecting wetlands and adjoining upland buffers (crucial to maturing adults), controlling road run-off, limiting the application of herbicides and insecticides, and maintaining sufficient water levels.

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Westfall, M. J. ,Jr., and M. May. 1996. Damselflies of North America. Scientific Publishers.

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Barrens Buckmoth

Hemileuca maia

State Status: **Special Concern**
Federal Status: None

Photo by M.W. Nelson

Description: The Barrens Buckmoth is a day-flying saturniid moth with wings that are black proximally and distally, the median area with a white, semi-translucent band; the reniform and discal spots are yellow and elongate. The male has bright orange on the thorax and the anterior of the abdomen. Wingspan is 50-75 mm, with females larger than males. The larvae are black with a yellow spiracular stripe and/or yellow speckling, and long, branching dorsal spines that can inflict a painful sting. The larva reaches a length of 45-60 mm in the final instar.

Habitat: In Massachusetts the Buckmoth inhabits xeric, open habitats with extensive scrub oak thickets, especially sandplain pitch pine-scrub oak barrens, as well as maritime shrublands.

Life History: Adult moths fly on sunny days from late September through October. Females lay eggs in clustered rings around twigs of scrub oak (*Quercus ilicifolia*), occasionally on other species of shrubby oaks. Eggs overwinter and hatch in May. Larvae feed in gregarious clusters through June into July, when late-instar larvae disperse and become more solitary; they may be found on plants other than oak at this stage. Pupation occurs in late July or early August, and pupae diapause until the fall.

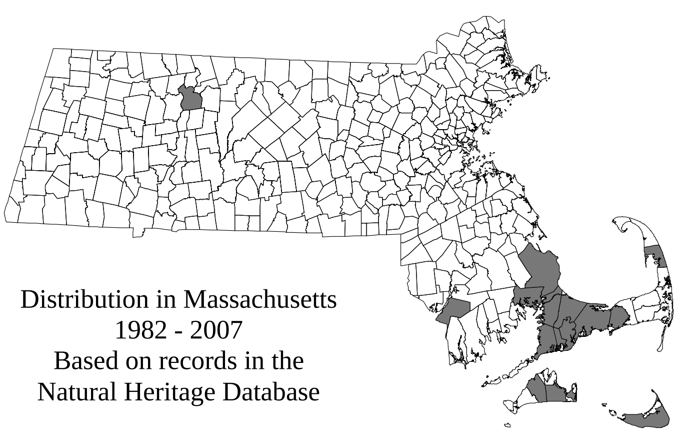
Range: The Buckmoth (*Hemileuca maia*) occurs from southern New England west through New York, Pennsylvania, and Michigan to southeast Wisconsin in scattered, localized populations; it is more widespread from southern New Jersey south to Florida and west to Illinois and Texas. In Massachusetts the Buckmoth is restricted to the southeast coastal plain, with one inland population in the Connecticut River Valley.

Adult Flight Period in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Threats

- Habitat loss
- Fire suppression
- Invasion by exotic plants
- Introduced generalist parasitoids
- Insecticide spraying
- Off-road vehicles



Distribution in Massachusetts
1982 - 2007
Based on records in the
Natural Heritage Database

Updated June 2007
M.W. Nelson

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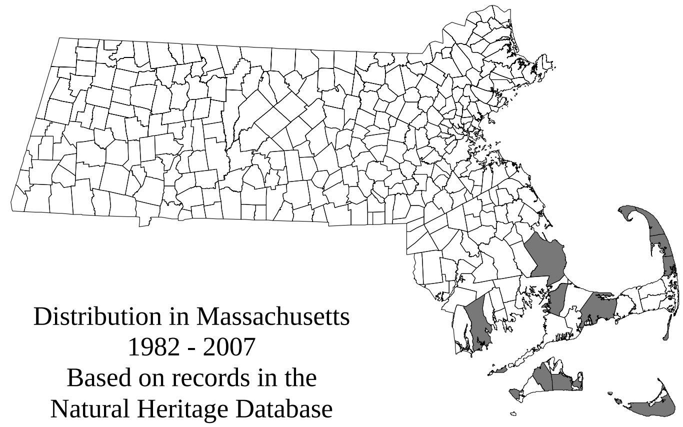
Coastal Heathland Cutworm

Abagrotis nefascia

State Status: **Special Concern**
Federal Status: None



Distribution in Massachusetts
1982 - 2007
Based on records in the
Natural Heritage Database

Description: Coastal Heathland Cutworms are noctuid moths. The forewings are reddish-brown, with bluish-white terminal bands and black costal wedges. The hind wings are grayish-brown, darker towards the terminal area. Wingspan is 30-35 mm. The larva is a smooth-skinned, brownish-gray to brownish-black cutworm, reaching a length of about 30 mm (Crumb 1956).

Habitat: In eastern North America, the Coastal Heathland Cutworm occurs in xeric and open coastal plain habitats on sandy soil. In Massachusetts, this species is associated with sandplain grasslands, dunes and bluffs, coastal heathlands or other maritime shrublands, and occasionally open pitch pine/scrub oak barrens.

Life History: Adult moths emerge mostly in July, with late-emerging or summer-aestivating individuals flying through the end of September. Partially grown larvae overwinter, and resume feeding in the spring. Host plants in Massachusetts are undocumented, but probably consist of a variety of low-growing shrubs. In the western U.S., larvae feed on serviceberry (*Amelanchier*) and wild currant (*Ribes*) (Lafontaine 1998).

Range: Widely distributed across western North America, from southern British Columbia to southern California, east to Alberta and New Mexico; in the East, limited to the Atlantic coastal plain from southern New Hampshire to southern New Jersey (Lafontaine 1998). In Massachusetts, occurs along the coast from Cape Cod and the offshore islands west to Dartmouth and north to Boston.

Adult Flight Period in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Threats

- Habitat loss
- Fire suppression
- Invasion by exotic plants
- Introduced generalist parasitoids
- Insecticide spraying
- Off-road vehicles
- Light pollution

References

Crumb, S.E. 1956. *The Larvae of the Phalaenidae*. Technical Bulletin No. 1135, U.S. Dept. of Agriculture, Washington, D.C.

Lafontaine, J.D. 1998. Noctuoidea, Noctuidae, Noctuini. Fascicle 27.3, *The Moths of North America North of Mexico*. Allen Press, Lawrence, Kansas.

Updated June 2007
M.W. Nelson

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COMMON TERN (*Sterna hirundo*)

State Status: **Special Concern**
Federal Status: None

B. Byrne, MDFW

The Common Tern is a small seabird that returns in the spring from warmer locales to enliven Massachusetts beaches with its raucous cries. It is a gregarious and charismatic creature, joining its neighbors to boldly mob, peck, and defecate on intruders to drive them away from their nests, which are situated on the ground. Probably numbering in the hundreds of thousands in the state before 1870, the Common Tern is considerably more scarce today. Protection, management, and restoration of nesting colonies have allowed populations to gradually increase, but the Common Tern remains a Species of Special Concern in Massachusetts.

Description. The Common Tern measures 31-35 cm in length and weighs 110-145 g. Breeding adults have light gray upperparts, paler gray underparts, a white rump, a black cap, orange legs and feet, and a black-tipped orange bill. The tail is deeply forked and mostly white, and does not extend past the tips of the folded wings. In non-breeding adults, the forehead, lores, and underparts become white, the bill becomes mostly or entirely black, legs turn a dark reddish-black, and a dark bar becomes evident on lesser wing coverts. Downy hatchlings are dark-spotted buff above and white below with a mostly pink bill and legs. Juveniles are variable: they have a pale forehead, dark brown crown and ear coverts, buff-tipped feathers on grayish upperparts resulting in a scaly appearance, white underparts, pinkish or orangish legs, and a dark bill. The voice has a sharp, "irritable" timber, and includes a *keeuri* advertising call and *kee-arrrr* alarm call.

Similar Species in Massachusetts. The Arctic Tern (*Sterna paradisaea*) is similar in size, but has a shorter, blood-red bill, very short red legs, much grayer underparts with contrasting white cheeks, a longer tail that extends past the tips of the folded wings, and a higher-pitched voice (although some calls are similar). The Roseate Tern (*Sterna dougallii*) is also similar in size, but has a mostly or entirely black bill during the breeding season, much paler gray upperparts, white or very pale pink underparts, a very long tail (longer than that of the Arctic Tern), and a distinctively different voice. The Least Tern (*Sterna antillarum*) is markedly smaller, with a yellow-orange bill, a white forehead, and a proportionately much shorter tail.

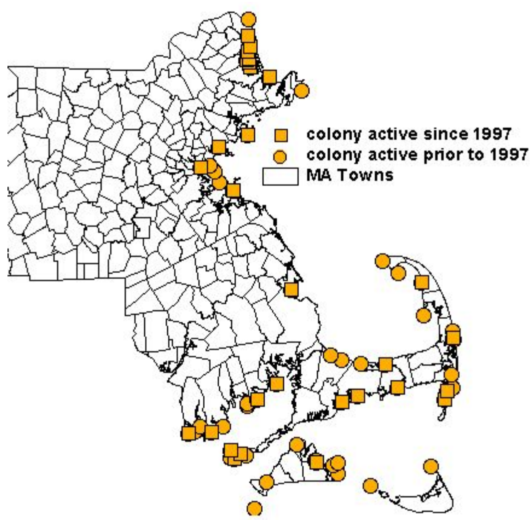

Figure 1. Distribution of present and historic Common Tern nesting colonies in Massachusetts.

Distribution and Migration. Outside the breeding season, the Common Tern is widely distributed primarily at temperate latitudes. It breeds in the northern hemisphere, principally in the temperate zones of Europe, Asia, and North America, and at scattered tropical and sub-tropical locations. In North America, it breeds along the Atlantic Coast from Labrador to South Carolina, and along lakes and rivers as far west as Montana and Alberta. Massachusetts birds arrive in April and May to nest at coastal locations statewide (Fig. 1). The largest populations occur on Cape Cod and in Buzzards Bay (see Status, below). Massachusetts birds depart from breeding colonies in July and August, and concentrate in "staging areas" around Cape Cod to feed before beginning their migratory journeys southward. Birds breeding on the Atlantic coast generally winter on the north and east coasts of South America as far south as northern Argentina.

Breeding and Foraging Habitat. In Massachusetts, the Common Tern generally nests on sandy or gravelly islands and barrier beaches, but also occurs on rocky or cobbly beaches and salt marshes. It prefers areas with scattered vegetation, which is used for cover by chicks. Along the Atlantic coast in the breeding area, it usually feeds within 1 km of shore, often in bays, tidal inlets, or between islands; it may forage as far as 20 km from the breeding colony.

Food Habits. The Common Tern feeds mainly on a wide variety of small fish; frequently it includes crustaceans and insects in its diet. The primary prey item in most Atlantic coast breeding colonies is the American sand lance. In Massachusetts, silversides, cunner, herring, pipefish, and hake are also important. Over water, it captures food by plunge-diving (diving from heights of 1-6 m and submerging to ≤ 50 cm), diving-to-surface, and contact-dipping; it catches flying insects on the wing. It often forages singly or in small groups, but it may congregate in feeding flocks of ≥ 1000 birds, especially over schools of predatory fish that drive smaller prey to the surface. It commonly feeds in association with Roseate and Arctic Terns, and sometimes gulls.

Breeding.

Phenology. Birds begin arriving in late-April or early-May. They select breeding sites and begin courting. Egg dates are 4 May – 15 August. Incubation lasts about 3 wk, and the nestling period about 3-4 wk. Most birds have departed for winter quarters by mid-October.

Colony. The Common Tern is gregarious, nesting in colonies of a few to thousands of pairs. It often breeds in colonies with Roseate and Arctic Terns, Black Skimmers (*Rynchops niger*) and, rarely, with the Least Tern. Pairs vigorously defend their nesting territory and sometimes also maintain a linear near-shore feeding territory. (See also Predation, below).

Pair bond and parental care. Courtship involves both aerial and ground displays, including High Flights (in which a pair spirals to 30-100 m above ground and then glides down), Low Flights (in which a fish-carrying male is chased by a female), Parading (circling on ground), and Scraping. Males feed females during courtship and early incubation. The Common Tern is socially monogamous, but sometimes seeks extra-pair copulations. While both parents incubate eggs and attend chicks, females do more incubating and brooding (especially at night), and males generally do more feeding. Birds of similar age tend to pair. Mate fidelity is high; data from Germany showed that two-thirds of pair bonds were retained from year-to-year; the rest were broken by death or divorce in approximately equal frequencies. Pair-bond durations of up to 14 years have been documented.

Nests. Nests are depressions or "scrapes" in the substrate, to which nesting material, usually dead vegetation or tide wrack, is added throughout incubation. Nest density is highly variable, but usually in the range of 0.06-0.5 nests/m^2.

Eggs. Eggs are cream, buff, or medium brown (sometimes greenish or olivish) with dark spots or streaks. Markings are often evenly distributed on the egg, but may be concentrated at the blunt end -- especially for the third egg of the clutch, which also may be paler than the first two. Eggs measure approximately 40 x 30 mm, and are subelliptical in shape. Clutch size is usually 2-3 eggs, occasionally 1 or 4. Incubation is sporadic until the clutch is complete. The period between laying and hatching is about 23 d for the first egg and about 22 d for the second and third eggs. Incubation shifts last anywhere from <1 min. to several hours.

Young. Chicks are semi-precocial. At hatching, they are downy and eyes are open. They are able to stand and take food within hours after hatching. They wander away from the nest to seek cover, but still remain in the territory, at 2-3 d. Chicks are brooded/attended most of the day and night for the first few days of life. Parental attendance drops off after that, except for cold, wet, or hot weather. Parents carry prey to chicks in their bills. Feeding rates vary by location, but are usually on the order of 1-2 feedings per chick per hour. Chicks fledge at 22 to > 29 d, but they remain at first within the colony and are still dependent on parents for food. After about a week, they venture out with parents to the feeding grounds, but are unable to catch fish for themselves until 3-4 wk post-fledging. Families leave the colony 10-20 d after chicks fledge and remain together during the staging period. Little is known of family cohesion during migration.

Predation.

Predators. In North America, predators of Common Tern eggs, young, and adults include a wide variety of birds and mammals, snakes, ants, and land crabs. Nocturnal mammals (especially fox, mink, and rat; sometimes skunk, raccoon, feral cat, weasel, and coyote) are the most important predators in mainland or near-shore colonies. Mammalian predation often causes birds to abandon the site. A local example of this is Plymouth Beach: in 1999, a family of foxes hunting on the beach displaced a thriving colony of about 5,000 pairs of mostly Common Terns. At islands further from the mainland, Great Horned Owl and Black-crowned Night-Heron are important predators. Herring and Great Black-backed Gulls, Short-eared Owl, American Crow, Ruddy Turnstone, Great Blue Heron, and Peregrine Falcon can also be significant predators.

Responses to predators and intruders. The Common Tern prefers to nest on islands lacking predatory mammals or reptiles. Eggs and chicks are cryptically colored. Hatched eggshells are removed from the nest site and feces are dispersed (the white of the feces and of the inner shell is obvious).

Behavioral response to diurnal predators is very variable, and depends on predator species and behavior, stage in nesting cycle, and degree of habituation to threat. Hunting Peregrine Falcons cause "panics", during which terns rapidly flee the nesting area and fly over the water; Peregrines may delay colony occupation. Many other diurnal predators (including crows, Herring and Great Black-backed Gulls, Northern Harriers, and Bald Eagles) are "mobbed" (chased and attacked) by terns. Common Terns distinguish between hunting and non-hunting gulls and falcons, and respond to them differently. Common Terns attack human intruders by diving at them, pecking exposed body parts, and defecating on them. Inexperienced birds may merely circle overhead and give alarm calls, whereas more experienced birds may launch intense attacks -- to which many researchers will attest. Common Terns also distinguish between individual humans, and familiar humans are attacked more vigorously. Attacks intensify as chicks begin to hatch, but diminish as chicks mature and become less vulnerable. Adults' alarm calls cause very young chicks (≤3 d) to crouch motionless, while older, more mobile chicks seek cover.

There is little information on how the Common Tern responds to nocturnal mammalian predators; however, nocturnal predation by owls and night-herons causes terns to abandon the colony at night. This has several consequences: prolonged incubation periods for eggs; chick deaths due to exposure; increased predation on eggs and chicks, particularly by night-herons and ants; and sometimes inattentiveness to eggs by day, which increases egg vulnerability to diurnal predators.

Life History Parameters. In Massachusetts, most Common Terns breed annually starting at 3 yr, some at 2 or 4 yr. As birds age, they nest progressively earlier in the season. Only one brood per season is raised, but birds renest 8-12 d after losing eggs or chicks. Productivity is highly variable, and may range from zero to > 2.5 chicks fledged per pair, depending on food availability, degree of flooding, and predation. Productivity increases with age through the lifetime of the bird. Survival from fledging to 4 yr was estimated at about 10% for Massachusetts birds. Annual survival of adults in Massachusetts was estimated about 90%. The oldest documented Common Terns are two individuals that bred at age 26 yr.

Status. The Common Tern is listed as a Species of Special Concern in Massachusetts. Populations are well below levels reported pre-1870, when hundreds of thousands are reported to have bred. Egging probably limited populations throughout the 1700s and 1800s. More seriously, hundreds of thousands were killed along the Atlantic coast by plume-hunters in the 1870s and 1880s, reducing the population to a few thousand at fewer than ten known sites by the 1890s. In Massachusetts, only 5,000 to 10,000 pairs survived, almost exclusively at Penikese and Muskeget Is. The state's population grew to 30,000 pairs by 1920, following protection of the birds in the early part of the century. Populations subsequently declined through the 1970s, reaching a low of perhaps 7,000 pairs, largely as a result of displacement of terns from nesting colonies by Herring Gulls and, later, by Great Black-backed Gulls. Since then, numbers have edged upwards (Figure 2). In 2005, 15,447 pairs nested at 34 sites in the state. About 90% of these birds were concentrated at just three sites: Monomoy National Wildlife Refuge (S. Monomoy and Minimoy Is)., Chatham (9,747 pairs); Bird I., Marion (1,857 pairs); and Ram I., Mattapoisett (2,278 pairs). While populations in the state are relatively well-protected during the breeding season, trapping of birds for food on the wintering grounds may be a source of mortality for Common Terns.

Conservation and Management. Populations in Massachusetts continue to be threatened by predators and displacement by gulls. Also, should established nesting colonies be disrupted, lack of suitable (*i.e.*, predator-free) alternative nesting sites is a serious concern in the state. Most colonies are protected by posting of signs, by presence of wardens, and/or by exclusion of visitors. Lethal gull control (initially), continual gull harassment, and predator control at S. Monomoy and Ram Is. have resulted in thriving tern colonies at these restored sites (see Status, above). Two other tern restoration projects are currently underway, both involving clearing gulls from small portions of islands. At Penikese I., in Buzzards Bay, after a pilot project in 1995, aggressive discouragement of gulls (using harassment by trained dogs and human site occupation) was initiated in 1998. The colony increased from 137 pairs of Common Terns in 1998 to 756 pairs in 2006. Non-lethal gull control at Muskeget I., in Nantucket Sound, began in 2000; however, the budding tern colony is struggling against predators. Tern restoration is a long-term commitment that requires annual monitoring and management to track progress, identify threats, manage vegetation, prevent gulls from encroaching on colonies, and remove predators.

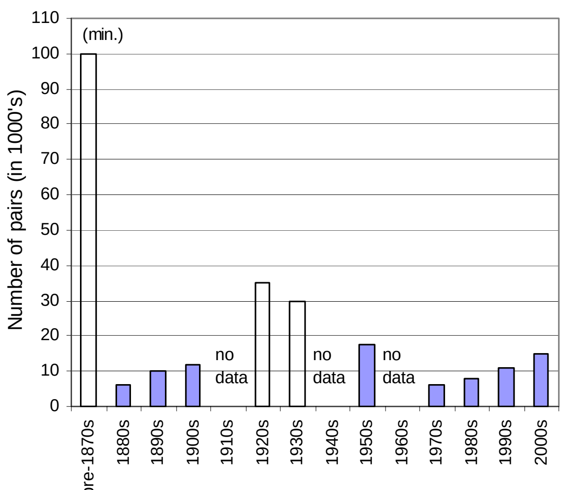

Figure 2. Common Tern population trends in Massachusetts, pre-1870s to 2005 (modified from Blodget and Melvin 1996).

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C. S. Mostello, 2007

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Massachusetts
Natural Heritage
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Natural Heritage & Endangered Species
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Division of Fisheries & Wildlife
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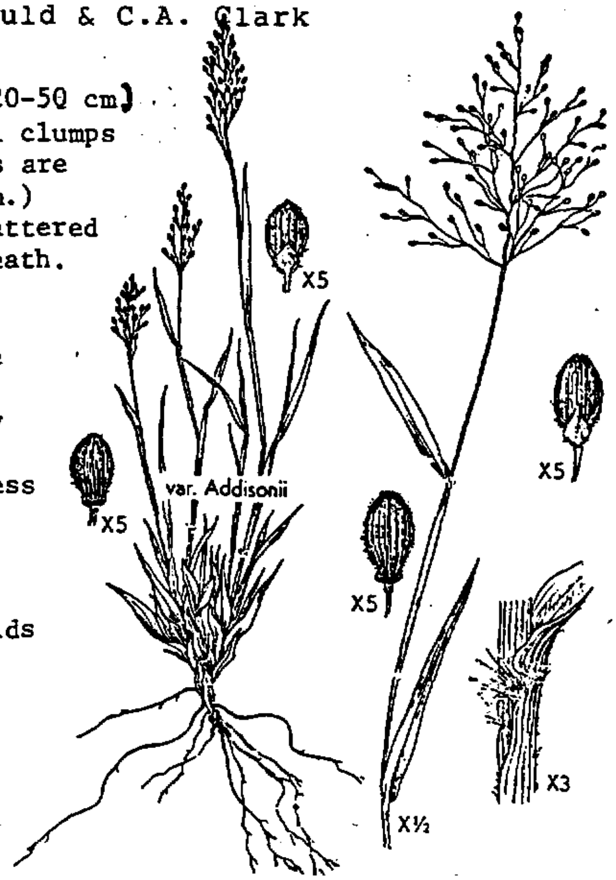
MASSACHUSETTS RARE AND ENDANGERED PLANTS

COMMONS'S PANIC-GRASS

Dichanthelium commonsianum (Nash) Gould & C.A. Clark



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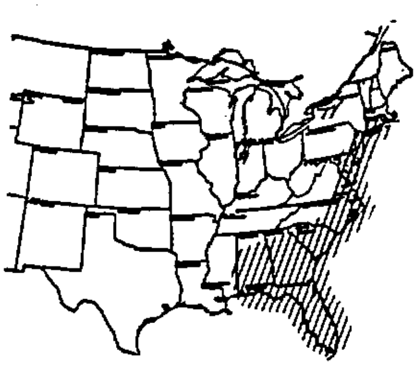
DESCRIPTION

Commons's Panic-grass is a short 8-20 inch (20-50 cm) tufted, perennial grass that is found in small clumps of several flowering stems. Erect leaf blades are 1½-3½ inches (4-9 cm.) long and ¼ inch (3-7 mm.) wide. The blades are smooth or have a few scattered hairs above and smooth to softly hairy underneath. Stems and sheaths (elongate leaf bases which envelop the stem) are clothed with hairs less than ¼ inch long. Relatively open and austere looking panicles (inflorescences with stalked flowers) are produced in late spring and early summer. The panicles have stiffly spreading branches with a few stalked spikelets (each less than an inch (1.7-2 mm.) long).

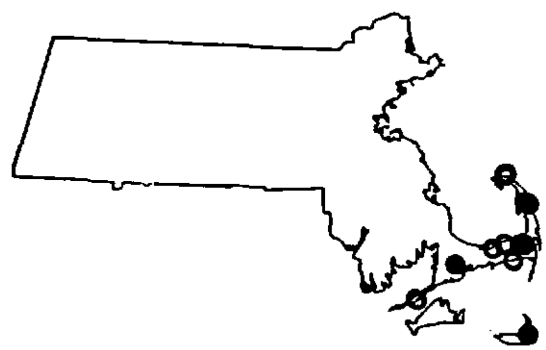
HABITAT IN MASSACHUSETTS

Commons's Panic-grass grows in dry, sandy fields and barrens on the coastal plain. It is also found in dry Pitch Pine/Oak woods, colonizing openings and disturbed soil where there is little or no leaf litter. Associated species include Eragrostis spectabilis (Tumble Grass), Carex pensylvanica (Pennsylvania Sedge), Andropogon scoparius (Little Bluestem) and Pinus rigida (Pitch Pine).

(continued overleaf)



Distribution of Commons's Panic-grass



● Verified since 1978
○ Reported prior to 1978

Distribution in Massachusetts by Town

1985

RANGE

This grass ranges from southeastern Massachusetts, south along the coastal plain to Florida and west to Alabama. Disjunct populations also occur in northwest Indiana and central New York.

POPULATION STATUS

In Massachusetts, Common's Panic-grass is considered a species of "Special Concern". Currently (1978 to present), 8 occurrences have been recorded; historically, 9 other occurrences have been reported. The causes of rarity include loss of habitat due to residential and commercial development, forest succession, and the occurrence of Common's Panic-grass at the extreme northern edge of its range.

Natural Heritage & Endangered Species Program

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Eastern Box Turtle
Terrapene carolina

State Status: **Species of Special Concern**
Federal Status: None

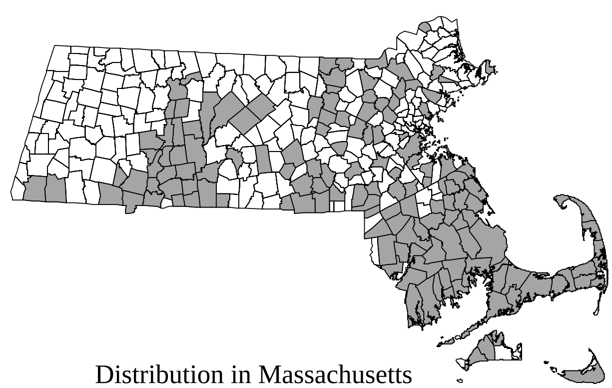
Photo by Liz Willey

DESCRIPTION: The Eastern Box Turtle is a small, terrestrial turtle ranging from 11.4–16.5 cm (4.5–6.6 in.) in length. It is so named because a hinge on the lower shell (plastron) allows it to enclose head, legs, and tail completely within the upper (carapace) and lower shells. The adult box turtle has an oval, high-domed shell with variable coloration and markings. The carapace is usually dark brown or black with numerous irregular yellow, orange, or reddish blotches. The plastron typically has a light and dark variable pattern, but some may be completely tan, brown, or black. The head, neck, and legs also vary in color and markings, but are generally dark with orange or yellow mottling. The Eastern Box Turtle has a short tail and an upper jaw ending in a down-turned beak. The male box turtle almost always has red eyes, and females have yellowish-brown or some times dark red eyes. Males have a moderately concave plastron (female's are flat), the claws on the hind legs are longer and the tail is both longer and thicker than the females. Hatchlings have brownish-gray carapace with a yellow spot on each scute (scale or plate), and a distinct light colored mid-dorsal keel (ridge). The plastron is yellow with a black central blotch, and the hinge is poorly developed.

SIMILAR SPECIES: The Blanding's Turtle (*Emydoidea blandingii*) may be confused with the Eastern Box Turtle. Often referred to as the "semi-box turtle," the Blanding's Turtle has a hinged plastron enabling the turtle to pull into its shell but with less closure than in the Eastern Box Turtle. Both may have yellow markings on the carapace; however, the marking on a Blanding's Turtle are spots or flecks rather than blotches. An adult Blanding's Turtle is larger than the box turtle (15-23 cm; 6-9 in. in shell length). While both will be found nesting in similar habitat, the Blanding's Turtle is essentially aquatic whereas the Eastern Box Turtle is terrestrial. Eastern Box Turtle hatchlings could be confused with Spotted Turtle hatchlings, because both have spots on each scute. However, the Spotted Turtle lacks a mid-dorsal keel.

RANGE: The range of the Eastern Box Turtle is from southeastern Maine; south to northern Florida; and west to Michigan, Illinois, and Tennessee. Although Eastern Box Turtles occur in many towns in Massachusetts, they are more heavily concentrated in the southeastern section of the state.

HABITAT IN MASSACHUSETTS: The Eastern Box Turtle is a terrestrial turtle, inhabiting many types of habitats. It is found in both dry and moist woodlands, brushy fields, thickets, marsh edges, bogs, swales, fens, stream banks, and well-drained bottomland.



Distribution in Massachusetts
1980 - 2006
Based on records in Natural Heritage Database

LIFE CYCLE & BEHAVIOR: The Eastern Box Turtle hibernates in the northern parts of its range from late October or November until mid-March or April depending on the weather. Box Turtles overwinter in upland forest, a few inches under the soil surface, typically covered by leaf litter or woody debris. As soil temperatures drop, the turtles burrow into soft ground. Overwintering is usually not communal, although several may overwinter within close proximity of one another. Some individuals may emerge prematurely during warm spells in winter and early spring. When this occurs they may perish from exposure if there's a sudden cold snap. During the spring, Box Turtles start to forage and mate in the forest and fields.

In summer, adult Box Turtles are most active in the morning and evening, particularly after a rainfall. To avoid the heat of the day, they often seek shelter under rotting logs or masses of decaying leaves, in mammal burrows, or in mud. They often scoop out a "form" (a small domelike space) in leaf litter, grasses, ferns, or mosses where they spend the night. These forms may be used on more than one occasion over a period of weeks. Though known as "land turtles", in hottest weather they frequently enter shaded shallow pools and puddles and remain there for periods varying from a few hours to a few days. In the cooler temperatures of spring and fall, Box Turtles forage at any daylight hour.

The Eastern Box Turtle is omnivorous, feeding on animal matter such as: slugs, insects, earthworms, snails, and even carrion. Box Turtles also have a fondness for mushrooms, berries, fruits, leafy vegetables, roots, leaves, and seeds.

Females reach sexual maturity at approximately 13 years of age. Mating is opportunistic and may take place anytime between April and October. Courtship begins with the male circling, biting, and shoving the female. After which the premounting and copulatory phases take place. Females can store sperm and lay fertile eggs up to four years after mating.

Females nest in June or early July and can travel great distances to find appropriate nesting habitat. They may travel up to approximately 1600 m (1 mile), many crossing roads during their journey. Nesting areas may be in early successional fields, meadows, utility right of ways, woodland openings, roadsides, cultivated gardens, residential lawns, mulch piles, beach dunes, and abandoned gravel pits. Females sometimes exhibit nest site fidelity, laying eggs in close proximity to the previous years' nest. Females typically start nesting in the late afternoon-early evening and continue for up to five hours.

Typically four or five white, elliptical eggs are deposited at intervals of one to six minutes, with the incubation period depending on soil temperature. Hatchlings emerge approximately 87–89 days after laying, usually in September. Juvenile Box Turtles are rarely seen, which is true of other turtle species as well.

During the first four or five years of life, box turtles may grow at a rate of half an inch to about three-quarters of an inch a year. The average life expectancy of a Box Turtle is 40 to 50 years, but it may live to be about 100.

ACTIVE PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

THREATS: There are several reasons the Eastern Box Turtle is threatened in Massachusetts: habitat destruction resulting from residential and industrial development; road mortality; collection by individuals for pets; mowing of fields and early successional habitat during the active season; unnaturally inflated rates of predation in suburban and urban areas; disturbance of nest sites by ATVs; and genetic degradation due to the release of non-native (pet store) turtles. The release of non-native species could also transmit disease, which may become an issue in Massachusetts, but is not currently a problem.

MANAGEMENT RECOMMENDATIONS:
Using NHESP records, Eastern Box Turtle habitat needs to be assessed and prioritized for protection based on the extent, quality, and juxtaposition of habitats and their predicted ability to support self-sustaining populations of Box Turtles. Other considerations should include the size and lack of fragmentation of habitat and proximity and connectivity to other relatively unfragmented habitats, especially within existing protected open space.

Given limited conservation funds, alternatives to outright purchase of conservation land is an important component to the conservation strategy. These can include Conservation Restrictions (CRs) and Agricultural Preservation Restrictions (APRs).

Habitat management and restoration guidelines should be developed and implemented in order to create and/or maintain consistent access to nesting habitat at key sites. This is most practical on state-owned conservation lands (i.e. DFW, DCR). However, educational materials should be made available to guide private land-owners on the best management practices for Box Turtle habitat.

Alternative wildlife corridor structures should be considered at strategic sites on existing roads. In particular, appropriate wildlife corridor structures should be considered for bridge and culvert upgrade and road-widening projects within Box Turtle habitat. Efforts should be made to inform local regulatory agencies of key locations where these measures would be most effective for turtle conservation.

Educational materials need to be developed and distributed to the public in reference to the detrimental effects of keeping our native Box Turtles as pets (an illegal activity that slows reproduction in the population), releasing pet store turtles (which could spread disease), leaving cats and dogs outdoors unattended (particularly during the nesting season), mowing of fields and shrubby areas, feeding suburban wildlife (which increases numbers of natural predators to turtles), and driving ATVs in nesting areas from June-October. People should be encouraged, when safe to do so, to help Box Turtles cross roads (always in the direction the animal was heading); however, turtles should never be transported to “better” locations. They will naturally want to return to their original location and likely need to traverse roads to do so.

Increased law enforcement is needed to protect our wild populations, particularly during the nesting season when poaching is most frequent and ATV use is common and most damaging.

Forestry Conservation Management Practices should be applied on state and private lands to avoid direct turtle mortality. Motorized vehicle access to timber harvesting sites in Box Turtle habitat is restricted to the times when the Box Turtle is inactive during the winter, preferably when the ground is frozen. Motorized vehicles should not be used for soil scarification.

Finally, a statewide monitoring program is needed to track long-term population trends in Eastern Box Turtles.

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Four-toed Salamander
Hemidactylium scutatum

State Status: **Species of Special Concern**
Federal Status: None

Photo by Bill Byrne

Description: The four-toed salamander is the smallest salamander found in Massachusetts and is easily identified by three distinctive characteristics: (1) As its name implies, this salamander has only four digits on the front and hind feet, which is unlike most of the other terrestrial salamanders which have four digits on the front and five digits on the hind feet. (2) There a very distinct constriction at the base of the tail posterior to the hind legs, which is an anti-predator strategy (this salamander can voluntarily sheds it tail which then continues to wiggle in an attempt to distract the predator while the salamander escapes). (3) Its belly resembles bright white enamel that is speckled with small black spots.

The body of the four-toed salamander is slender with 13 or 14 costal (ribbed) grooves that meet along the spine in a herringbone pattern and a tail that is greater than 50% of the total body length. The dorsum is reddish brown, fading to gray or almost black in color along the sides; and, as mentioned, the belly is white and covered with black speckles, the size and shape of coarse ground pepper. The males range from 2-3 inches (5.0 -7.6 cm) in total length; females are slightly larger, ranging from 2.8-3.5 inches (6.2-8.9 cm). Mature males are distinguished from females by their smaller size, more slender form, relatively longer tail, and somewhat by color (dorsal surface of the male is slightly darker). Another difference is the shape of the male's snout, which is square-ish and truncated in front with a swollen region of the nasio-labial grooves; additionally, the upper lip overhangs the lower lip. In contrast, the female's snout is rounded and the upper lip does not overhang the lower lip.

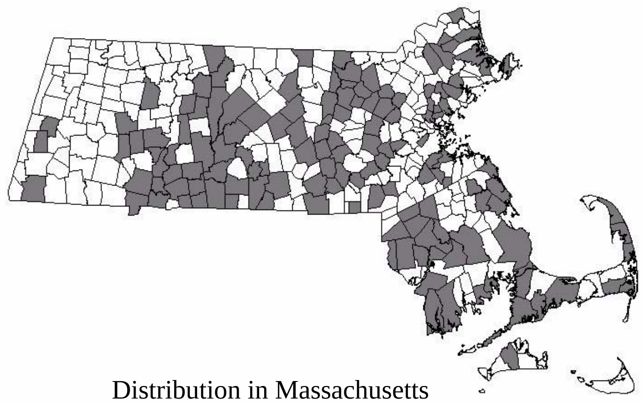
The larvae are somewhat non-descript with a mottled yellow-brown dorsum, a slender build, prominent eyes, and a dorsal fin that extends forward to the head. Juveniles generally resemble adults, but have proportionally shorter tails than the adults.

Etymology: The specific name *Hemidactylium* means "partial digits of partial toes". The name *scutatum* signified "covered with shield-like plates", from Latin scutatus, "armed with a shield". The salamander's costal grooves produce a superficial resemblance to overlapping plates on the dorsum and sides of the body.

Similar species: Like the four-toed salamander, the river-dwelling Mudpuppy (*Necturus m. maculosus*) has only four hind digits; however, the mudpuppy is much larger in size, 8-13 inches (20-33 cm), has external gills, and does not have either the white and black speckled belly pattern nor the constricted tail of the four-toed salamander. Redback salamanders (*Plethodon cinereus*) may be similar in size and general color; however, they have five toes on their hind feet, and also lack the tail constriction and belly pattern of the four-toed salamander.

Range: Four-toed salamanders occur from southern Maine, Quebec, Ontario, and northern Wisconsin southward to North Carolina, South Carolina, Georgia, Alabama, and Tennessee. Disjunct populations occur in Nova Scotia, Missouri, Arkansas, Louisiana, and Florida.

In Massachusetts, four-toed salamanders have been observed in all counties, except on Nantucket Island.



Distribution in Massachusetts
1980-2006
Based on records in Natural Heritage Database

Habitat: Four-toed salamanders live in forested habitats surrounding swamps, bogs, marshes, vernal pools, and other fish-free aquatic sites that are used as breeding sites. Adults are infrequently encountered outside of the spring nesting period. They are associated with mature hardwood or coniferous forests and when encountered can be found under cover objects such as logs, bark and boards on the forest floor. Juvenile and adult male salamanders are primarily terrestrial. Four-toed Salamanders overwinter in forested habitat in holes, channels and other crevices in the ground.

Four-toed salamanders are also associated with aquatic habitats for breeding a few weeks to months in the early spring and summer. Appropriate breeding habitat is in the form of wetlands with hummocks of grasses, sedges or wet moss (usually sphagnum moss) adjacent to slow moving streams or pools of sanding water, is an important factor limiting the occurrence of four-toed salamanders throughout their range.

In Massachusetts, this species breeds in bogs, swamps, marshes, vernal pools or other perennial wetlands with sphagnum or other moss species. As a result of their preference for wetlands dominated by sphagnum, they are quite tolerant of acidic conditions. Larvae are typically found in small pools and slow moving streams associated with appropriate nesting areas. Four-toed salamanders will take refuge in wet moss, under fallen logs and other objects, in rotting wood, under stones or in the leaf litter. Distribution is limited to areas that provide both breeding and upland habitats in close proximity.

Life Cycle / Behavior: The four-toed salamander is inconspicuous, because of its small size and retiring habitats. When one is uncovered, it may slip quickly beneath the humus with lizard-like speed, or lie motionless, relying on cryptic coloration. If threatened, it will curl and raise its lighter-colored tail above its back, offering a piece of tail in exchange for its life. The tail is fragile and easily detached at the constriction near its base. The salamander can even cause the loss of its own tail by pushing against an object. The detached part of the tail wriggles violently for several minutes, a temporary distraction to a potential predator that enables the salamander escape. A new tail is soon regenerated.

The four-toed salamander reaches sexual maturity during its third year. The breeding season for this species lasts from late summer (early August) through fall (October). Mating and courtship take place on land and consist of the male rubbing his snout, lips, or the side of his body against the female's snout. Sperm are then transferred to the female by means of spermatophores (small packages of sperm approximately 2 mm high) which are deposited on the substrate and then picked up by the female and held in her cloaca until the following spring.

The four-toed salamander hibernates in and under rotting wood and leaves as well as in the channels of decaying tree roots. They have a tendency to clump together in small to rather large groups to hibernate, often in association with spring peepers, wood frogs, newts, and other species of salamanders. The four-toed salamander is one of the earliest to emerge from hibernation in the spring appearing from late March to early May. At this time, the females begin to migrate to suitable nesting sites which are generally simple little cavities in the sphagnum moss, but the undersides of stumps, rotten logs, leaf litter, and grass hummocks may also be used. They are invariably placed in the vicinity of water; usually 2-6 inches immediately above it, enabling the larvae to fall directly into the water after hatching. The nest cavity often has the appearance of being formed by turning movements of the female, but in some instances it is evident the female merely takes advantage of a natural opening in the moss or some hollow between the roots of a bog plant.

Eggs are laid from mid-April into June, depending on local climatic conditions. The female turns upside down, grasping rootlets and bits of moss with her feet while slowly forcing the eggs out into the nest cavity which can require several hours to complete. The eggs are laid singly, but adhere in a cluster. The number of eggs per clutch varies from 19 to 50; each egg being 5-6 mm in diameter. Communal nesting may occur with up to 800 eggs laid in a single nest. Females remain with their eggs protecting them from predators throughout the incubation stage, generally 38 to 60 days, and desert the nests prior to hatching. If the nest is communal one, only a few females will attend the eggs. The larvae are about 1.2 cm long when they hatch and wriggle until they free themselves from the nest and drop into the water. The larvae grow to 0.75-1.0 inch (1.8-2.5 cm) over a period of 6 weeks; although the larvae period may last up to 18 weeks depending on pond conditions. At that time, the larvae metamorphose and leave the water.

The diet of adult four-toed salamanders consists of ticks, spiders, springtails, midges, ground beetles, rove beetles, fly larvae, parasitic wasps, ants, earthworms, and snails. Larval four-toed salamanders feed on small zooplankton and other small invertebrates in their aquatic environment.

Population status in Massachusetts: The four-toed salamander is listed as a "Species of Special Concern" in Massachusetts. This species is rare, but rather widespread in the state. There are 144 towns in Massachusetts where four-toed salamanders have been observed. Two-hundred and twenty-eight occurrences have been documented since 1981, as well as 43 historic occurrences that were documented prior to 1981. Some of these historic localities no longer support populations due to urbanization and development. Due to its nocturnal habits and reclusive behavior, this species is difficult to observe and, though rare, additional "populations" may occur in locations not yet recorded.

Management Recommendations: The greatest threat to the four-toed salamander is habitat destruction resulting from road construction, development, and timber harvesting in and around boggy wetlands, peatlands, and forest wetlands. Given the four-toed salamanders preference for nesting sites in bogs with sphagnum moss, every effort must be made to protect the natural state of bog areas throughout Massachusetts. Additional efforts should be made to determine the status of historic "populations" and to look for new occurrences of this species. Protection of both the breeding and adjacent non-breeding habitat is necessary to ensure the survival of the species. In particular, suitable nesting substrate – sphagnum hummocks abutting pools of water deep enough for larval survival – may be limited, even within relatively large wetlands. Every effort should be made to identify areas that could potentially serve as nesting habitat and locate work away from these areas. Besides habitat loss, threats to populations are unknown but may include acid precipitation and flooding. Unlike other salamanders whose reproduction has been adversely affected by acid precipitation, the four-toed salamander may have some tolerance in this area. With its preference for an acidic environment, acid precipitation is less likely to affect significantly the four-toed salamander's reproductive capabilities, but there are limits to its tolerance.

Citizens must be encouraged to recognize and report four-toed salamanders and the locations of their breeding wetlands. Due to the rarity of this species, its ephemeral terrestrial occurrence, and it's very specific habitat requirements, some populations undoubtedly remain undiscovered and therefore under protected.

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Originated: 1994
Updated: 2007

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Gerhard's Underwing

Catocala herodias gerhardi

State Status: **Special Concern**
Federal Status: None

Photo by M.W. Nelson

Description: Gerhard's Underwing is a noctuid moth with a wingspan of 55-65 mm. The forewings are grayish-brown with dark longitudinal streaks along the veins, alternating with white streaks distally, and prominent white shading along the costal margin. The hind wings are banded with black and bright crimson, fringed with white.

Habitat: Xeric, oak-dominated woodland, barrens, and scrub habitats on sandy soil or rocky summits and ridges. In Massachusetts, Gerhard's Underwing inhabits open-canopy pitch pine-scrub oak barrens, especially scrub oak thickets; also open oak woodland on Martha's Vineyard.

Life History: Adult moths fly in July and August. Eggs are laid on the stems of scrub oak (*Quercus ilicifolia*), where they overwinter, hatching in early spring. Larvae feed on the catkins and new leaves of scrub oak, and pupate in June.

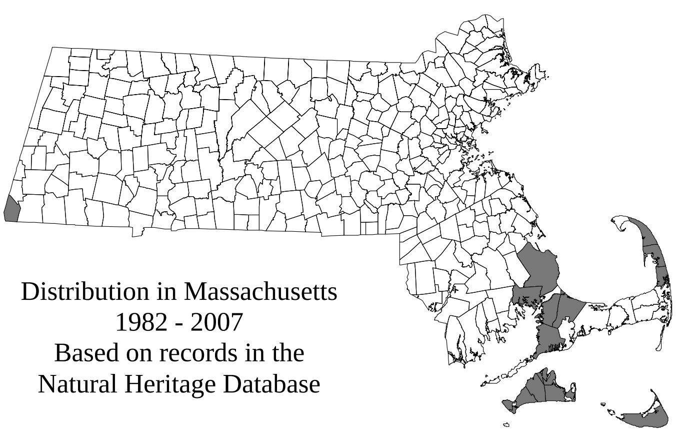
Range: Gerhard's Underwing occurs in sandplain habitats on Cape Cod and the offshore islands of Massachusetts, on eastern Long Island, New York, and in southern New Jersey; as well as on summits and ridges in western Massachusetts and Connecticut, the lower Hudson Valley of New York, and south through the Appalachian mountains to North Carolina.

Adult Flight Period in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						■■	■■				

Threats

- Habitat loss
- Fire suppression
- Invasion by exotic plants
- Introduced generalist parasitoids
- Insecticide spraying
- Off-road vehicles
- Light pollution



Distribution in Massachusetts
1982 - 2007
Based on records in the
Natural Heritage Database

Updated June 2007
M.W. Nelson

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LEAST TERN
(*Sterna antillarum*)

State Status: **Special Concern**

B. Byrne, MDFW

Diminutive yet feisty, the Least Tern is a spring and summer colonial nester on Massachusetts' sandy beaches. For nesting, it favors for sites with little or no vegetation. This preference coincides with humans' most desired spots for recreation and development, resulting in conflicts of use and loss of considerable Least Tern habitat in the past century. Presently, the Least Tern is considered a Species of Special Concern in Massachusetts, and continued management of nesting habitat and colonies is necessary to protect the state's population.

Description. The Least Tern measures 21-23 cm in length and weighs 40-62 g. In breeding plumage, the adult has a black cap and eyestripe, white forehead, pale gray upperparts, white underparts, a black-tipped, yellow-orange bill, and yellow-orange legs. Outside the breeding season, the crown and eyestripe become flecked with white, a dark bar forms on the wing, and the bill and legs darken. Hatchlings are tan or buff speckled black. Juveniles are brown and buff on the back; pale feather edgings give a scaly appearance. Underparts are white, the crown is buff speckled black, and the eyestripe and nape are blackish. The Least Tern's voice is high and shrill. Its repertoire includes *zwreep* and *kit-kit-kit-kit* alarm calls, *k'ee-you-hud-dut* recognition call, and the male's *ki-dik* contact call.

Similar species in Massachusetts. Common (*Sterna hirundo*), Roseate (*Sterna dougallii*), and Arctic (*Sterna paradisaea*) Terns are all much larger, have entirely black foreheads and crowns in breeding plumage, have different colored bills and, proportionately, have much longer tails.

Distribution and Migration. The Least Tern breeds in North, Middle, and South America and the Caribbean. In North America, it breeds on the Atlantic coast from Maine to Florida, along the Gulf coast, on the Pacific coast from California to Mexico, and inland, principally along major tributaries of the Missouri, Ohio, and Mississippi rivers. Massachusetts birds arrive in early-May to nest at coastal locations statewide (Fig. 1). The largest populations occur on Cape Cod and the Islands (see Status below). The Least Tern leaves Massachusetts by early-September (and in some years is gone by early-August) to begin its journey to wintering quarters, which are mainly off the eastern coasts of Central and South America, south to northern Argentina.

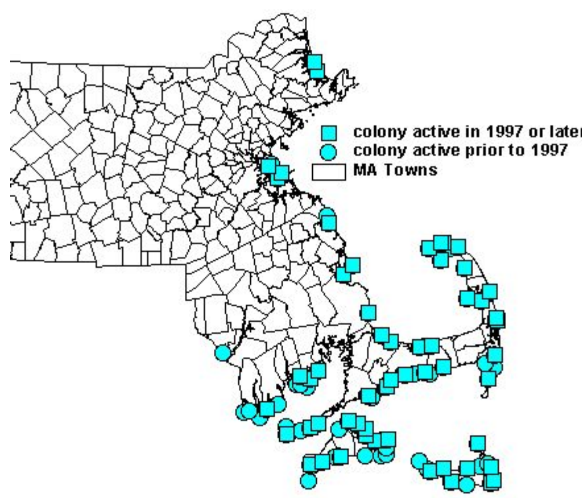

Figure 1. Distribution of present and historic Least Tern nesting colonies in Massachusetts.

Breeding and Foraging Habitat. In Massachusetts, the Least Tern nests on sandy or gravelly beaches periodically scoured by storm tides, resulting in sparse or no vegetation; it also takes advantage of dredge spoils. In other areas of the country, it nests on riverine sandbars, mudflats, and gravel roofs. Along coasts, the Least Tern forages in shallow-water habitats, including bays, lagoons, estuaries, river and creek mouths, tidal marshes, and ponds.

Food habits. The Least Tern primarily consumes small fish, but also takes crustaceans and insects. The most common prey items in Massachusetts are sand lance, herring, and hake. This tern hovers 1-10 m over water, then plunges to the surface to capture prey. Insects are captured on the wing and by skimming the water surface. It may forage singly or in small flocks of 5-20 birds. Foraging generally occurs close to the nesting site, and up to 3 km away from colonies in response to an abundance of prey.

Breeding.

Phenology. Least Terns arrive in Massachusetts in early May. Colony formation and courtship quickly ensue. Egg laying commences a couple weeks later than that of Common and Roseate Terns: dates range from 20 May to 23 August. Incubation lasts about 3 wk, as does the nestling period. The terns have mostly departed for winter locales by early-September, and in some years by early-August.

Colony. The Least Tern is gregarious and nests in colonies of just a few to > 2000 pairs, but colonies usually number < 25 pairs. Currently, the largest colony in Massachusetts numbers about 600 pairs, but in some years this number is much higher depending on the degree of dispersion of the birds. In Massachusetts, the Least Tern often nests in association with the Piping Plover *(Charadrius melodus*), with which it shares similar nesting habitat requirements, but only rarely forms mixed colonies with other tern species.

Pair bond and parental care. The Least Tern is monogamous. In a California study, about half the birds retained the same mate for more than one year. Courtship behavior includes aerial and ground displays. In the aerial display, a fish-carrying male is chased by 1-4 females; the display ends in a stiff-winged glide, during which participants cross each others' paths and bank towards each other repeatedly. Courtship on the ground includes parading and posturing. Males also feed females during courtship and throughout incubation. Incubating and chick-rearing duties are shared by both parents, but not equally: females typically do about 80% of the incubating, and more of the brooding/attending; males may do more feeding of chicks.

Nest. The nest, which is often just slightly above the high tide line, is a shallow scrape in the substrate to which vegetation, shell, or pebbles may be added. Considerable nest loss can be attributed to storms, given the low-lying nature of many nests. Mean internest distance at a New Jersey colony was about 9 m by the end of incubation.

Eggs. Eggs are oval or sub-elliptical, and measure about 31 x 23 mm. Color and markings are very variable, but eggs generally have a beige or light olive-brown ground color with dark spots and splotches. Clutch size is 2 or (especially for interior Least Terns) 3; sometimes 1. Incubation, which is inconsistent until the clutch is complete, lasts about 21-23 days in Massachusetts.

Young. Chicks are semi-precocial. At hatching, they are downy and eyes are open. Parents brood chicks for the first 1-2 days, after which time chicks leave the nest and usually wander up to 200 m from nest site (up to 1 km in response to disturbance). Parents carry prey to chicks in their bills at a rate of about 2 fish/h. While adults forage, chicks seek shelter in vegetation or near debris; older chicks may wait at the water's edge. Fledging occurs after about 3 wk. Young disperse from the natal site within 3 wk of fledging, and are still fed by parents for up to 8 wk after fledging. Family units are thought to migrate together.

Predation.

Predators. A wide variety of birds and mammals, crabs, and fish are predators of Least Tern eggs, chicks, and adults. Avian predators include crows, gulls, Great Blue Heron, Black-crowned Night-Heron, Ruddy Turnstone, Sanderling, Great Horned Owl, Peregrine Falcon, American Kestrel, and Northern Harrier, among others. Mammalian predators include fox, coyote, raccoon, skunk, opossum, feral hog, cat, dog, and rat.

Responses to predators and intruders. Within the colony, nesting is fairly synchronous as compared to that of Massachusetts' larger terns; this may be a strategy to reduce the amount of time the Least Tern colony is vulnerable to predation. Least Terns eggs and chicks are cryptically colored. Hatched eggshells are removed from the nest site (the white inner shell is obvious). When eggs and chicks are vulnerable (for instance, to most avian and human intruders), adults give alarm calls, dive, defecate on, and attack intruders. When adults are vulnerable (for instance, to canids), they desert the nest or fly high over the predator. Repeated intrusions by nocturnal predators, in particular, may cause the colony to desert the site. Shifts between different nesting sites within the breeding season in response to disturbance are common for this species. Terns become more defensive as the season progresses. Birds experienced with human intruders are more aggressive than inexperienced birds, and occasionally will even strike humans, earning the Least Tern the nickname, "little striker".

Life History Parameters. Most Least Terns breed annually starting at 3 yr, some at 2 yr. One brood per season is raised, but Least Terns may renest up to 3 times if eggs or chicks are lost early enough in the season. Annual productivity, which is difficult to estimate because of the high mobility of chicks shortly after hatching, is very variable, but was estimated at about half a chick per pair at several locations in the country. There are no data from Massachusetts, but elsewhere survival from fledging to 2-3 yr was estimated as about 80%, and annual survival of adults was estimated at over 85%. The oldest Least Tern on record was 24 yr – 1 mo. It was banded in Massachusetts and recovered in New Jersey.

Status. The Least Tern suffered the same fate as Massachusetts' larger terns at the end of the 19th century – they were slaughtered for use as decorations for hats. By the early 20th century, only about 250 pairs of Least Terns remained in the state. Following legal protection, numbers increased to the 1,500 pair level by the 1950s, but declined again (perhaps as a result of increased recreational use of beaches) to perhaps 900 pairs by the early 1970s (Fig. 2). More aggressive protection of breeding colonies since then has contributed to a fairly steady increase in numbers. In 2001, 3,420 pairs nested in the state, a record high for the past 100 years. Currently nesting at 54 breeding sites, the Least Tern is Massachusetts' most widely distributed tern. The largest colonies in 2001 occurred at: Dunbar Point (Kalmus Park), Barnstable (599 pairs); Tuckernuck Island, Nantucket (432); Sylvia State Beach, Oak Bluffs (370); and Dead Neck-Sampsons Island, Barnstable (257). Favored breeding sites remain in flux, however, due to the species' sensitivity to disturbance, and because of its preference for nesting on unvegetated beaches. The Least Tern is a Species of Special Concern in Massachusetts.

Conservation and Management. Since the 1970s, most sites have been fenced and posted with signs to discourage human intrusion into colonies. At many sites, Piping Plover and Least Tern management is integrated due to the species similar nesting habitat requirements and threats. Because of the Least Tern's propensity for nesting on mainland and barrier beaches (in contrast to offshore islands), disturbance of colonies by humans and predators remains a chronic problem. The principal conservation challenge confronting wildlife managers in protecting Least Terns is to maintain adequate separation between people on the beaches and the nesting colonies to enable the birds to successfully reproduce. Humans (and their dogs) in close proximity to colonies may keep adult birds off their nests, contributing to chick and egg mortality due to temperature extremes; dogs also kill chicks. Off-road vehicles (ORV's) crush tern eggs and chicks and destroy habitat – ruts created by tires trap chicks, preventing normal movements and further exposing them to interactions with vehicles. Garbage left on the beaches by humans may attract predators to colonies and cause birds to shift to alternate breeding sites. Given the habitat that the Least Tern selects, intensive and ongoing management of colonies will always be necessary if this species is going to be adequately shielded from disturbance. Efforts to limit coastal development are also critical to protecting the viability of the state's population.

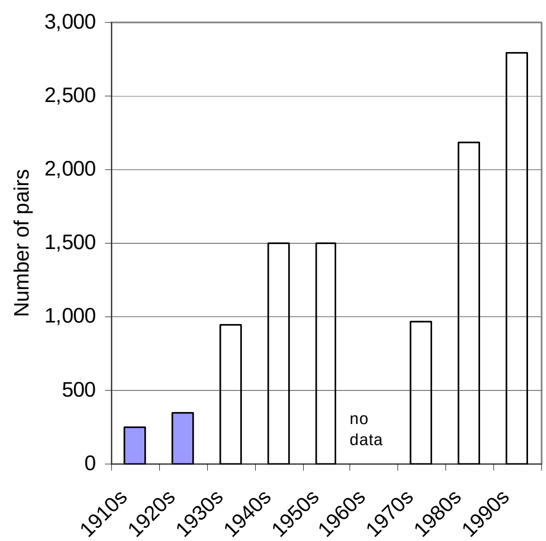

Figure 2. Least Tern population trends in Massachusetts, 1910s to 1990s (modified from Blodget and Melvin 1996).

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C. S. Mostello, 2002

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New England Bluet Damselfly

Enallagma laterale

State Status: **Special Concern**
Federal Status: None

DESCRIPTION OF ADULT: The New England Bluet is a small, semiaquatic insect of the order Odonata, suborder Zygoptera (the damselflies), and family Coenagrionidae (pond damsels). Like most damselflies, New England Bluets have large eyes on the sides of the head, short antennae, and four heavily veined wings that are held folded together over the back. The male's thorax (winged and legged section behind the head) is mostly blue with black stripes on the "shoulders" and top. The New England Bluet has a long, slender abdomen composed of ten segments. The abdominal segments are blue with black markings on segments 1 through 7. Segments 6 and 7 are almost entirely black on top. Segments 8 and 9 are entirely blue, except segment 8 has a horizontal black dash on each side of the segment. This mark is always present but varies greatly in size. The top of segment 10 is black. Females have thicker abdomens than the males, and are generally brown where the males are blue, though older females may become quite blueish.

New England Bluets average just over one inch (25 mm to 28 mm) in length.

SIMILAR SPECIES The bluets (genus *Enallagma*) comprise a large group of damselflies, with no fewer than 20 species in Massachusetts. Identification of the various species can be very difficult and often requires close examination of the terminal appendages on the males (Nikula *et al.* 2003) or the mesostigmal plates (located behind the head) on the females (Westfall & May 1996). The New England Bluet is most similar in appearance to the Pine Barrens Bluet (*E. recurvatum*), a Threatened species in Massachusetts. Both species are found in coastal plain ponds and do occur together. The two species are most safely distinguished by the shape of the terminal appendages on the male and the mesostigmal plates of the females. The black dash on the sides of segment 8 is generally larger in the New England Bluet; however this feature is highly variable and should not be used for definitive identification.

HABITAT: New England Bluets have been found in a variety of lentic habitats, including swampy open water in north-central Massachusetts, though they are most common at coastal plain ponds. The nymphs are aquatic and live among aquatic vegetation and debris. The adults inhabit emergent vegetation in wetlands and also fields and forest near wetlands.

LIFE-HISTORY/BEHAVIOR: The flight season of the New England Bluet is somewhat longer than that of the closely related Pine Barrens Bluet, although the majority of records are also restricted to the month of June. Emergence generally occurs during the last week of May and adults can be seen into early July. Although little has been published specifically on the life history of the New England Bluet, it is likely similar to other, better-studied species in the genus. All odonates have three life stages: egg, aquatic nymph, and flying adult. The nymphs are slender with three leaf-like appendages extending from the end of the body which serve as breathing gills. They have a large, hinged lower jaw which they are able to extend forward with lightning speed. This feature is used to catch prey, the nymph typically lying in wait until potential prey passes within striking range. They feed on a wide variety of aquatic life, including insects and worms. They spend most of their time clinging to submerged vegetation or other objects, moving infrequently. They transport themselves primarily by walking, but are also capable of swimming with a sinuous, snake-like motion.

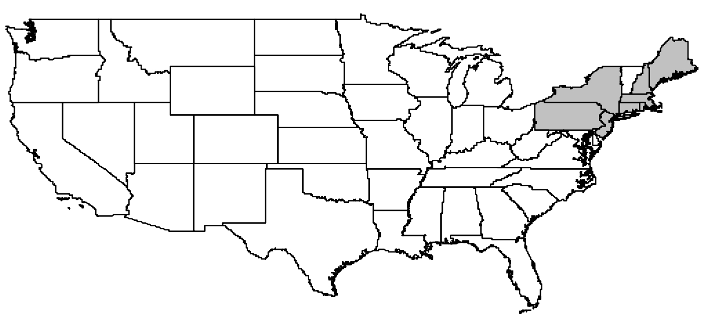
NEW ENGLAND BLUET FLIGHT PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

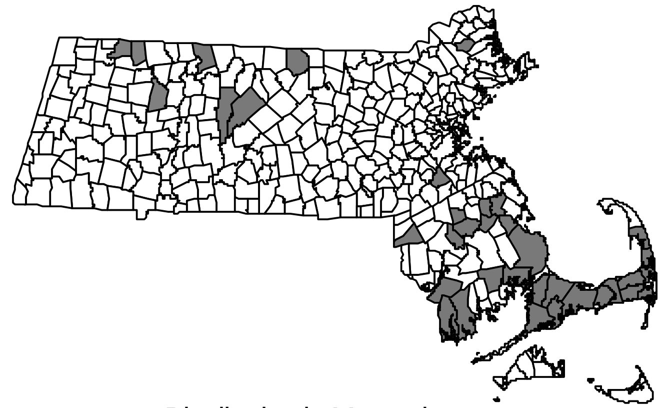
New England Bluets have a one-year life cycle. The eggs are laid in the early summer and probably hatch in the fall. The nymphs develop over the winter and spring, undergoing several molts. In early to mid-summer the nymphs crawl out of the water up onto emergent vegetation and transform into adults. This process, known as emergence, typically takes a couple of hours, after which the newly emerged adults (tenerals) fly weakly off to upland areas where they spend a week or two feeding and maturing. The young adults are very susceptible to predators, particularly birds, ants, and spiders; mortality is high during this stage of the life cycle. The adults feed on a wide variety of smaller insects which they typically catch in flight.

When mature, the males return to the wetlands where they spend most of their time searching for females. When they locate a female, the male attempts to grasp her behind the head with the terminal appendages at the end of his abdomen. If the female is receptive, she allows the male to grasp her, then curls the end of her abdomen up to the base of the male's abdomen where his secondary sexual organs ("hamules") are located. This coupling results in the heart-shaped tandem formation characteristic of all odonates. This coupling lasts for a few minutes to an hour or more. The pair generally remains stationary during this mating but, amazingly, can fly, albeit weakly, while coupled.

Once mating is complete, the female begins laying eggs (oviposits) in emergent grasses and rushes, using the ovipositor located on the underside of her abdomen to slice into the vegetation where the eggs are deposited. Although the female occasionally oviposits alone, in most cases the male remains attached to the back of the female's head. This form of mate-guarding is thought to prevent other males from mating with the female before she completes egg-laying. The adult's activities are almost exclusively limited to feeding and reproduction, and their life is short, probably averaging only three to four weeks for damselflies like the New England Bluet.



Range of Species in US



Distribution in Massachusetts
1977 - 2002
Based on records in Natural Heritage Database

RANGE: The New England Bluet is a regional endemic and has a range restricted to scattered locations in the northeastern United States, from southwestern Maine to New Jersey and Pennsylvania. In New England they have been found in every state except Vermont, but are most common from eastern Massachusetts southwestward to Connecticut.

POPULATION STATUS IN MASSACHUSETTS: The New England Bluet is listed as a Species of Special Concern in Massachusetts. It is found throughout eastern portions of the state, with a few records west of the Connecticut River (perhaps reflecting limited field work in that area).

MANAGEMENT RECOMMENDATIONS: The major threat to the New England Bluet at this time is most likely the destruction of its breeding habitat. Threats to their habitat include construction and development, artificial drawdown by pumping stations, and run-off from roadways and sewage. In addition, high-impact recreational use such as Off Road Vehicles driving through pond shores, which may destroy breeding and nymphal habitat, and motor boats, whose wakes swamp delicate emerging adults, are threats. Because New England Bluets, like many species of damselflies, spend a period of several days or more away from the water maturing, it is important to maintain natural upland habitats near the ponds.

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Updated May 2003

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Oak Hairstreak

Satyrium favonius

State Status: **Special Concern**
Federal Status: None

Description: The Oak Hairstreak has dark brown wings above, often with a round, rust-colored patch in the middle of the forewing and small spot of the same color at the outer angle of the hind wing. On the underside, the wings are tan with a white and black postmedial line crossing both wings and forming a "W" near the inner margin of the hind wing; the hind wing has orange submarginal spots and an iridescent blue patch flanked by two black spots at the costal margin. Wingspan is 26-32 mm. The larva is of the typical slug-like lycaenid form, covered with short, dense setae, green with a faint lateral line and oblique dorsolateral dashes.

Habitat: In Massachusetts, the Oak Hairstreak inhabits xeric and open oak woodland and barrens on rocky uplands and sandplains. Adults butterflies are often found nectaring in weedy or scrub areas within or near such habitat, including old fields, clearings, powerline or pipeline cuts, abandoned gravel pits, etc. New Jersey tea (*Ceanothus americanus*), dogbane (*Apocynum*), and milkweed (*Asclepias*) are favored nectar sources, although others are used.

Life History: Adult butterflies fly in late June and early July. Eggs are laid on oaks (*Quercus*); the particular oak species used in Massachusetts have not been documented. Eggs overwinter and hatch in the spring; larvae feed on catkins and new foliage, pupating by early June.

Range: The Oak Hairstreak is spottily distributed from southern New England south to Florida and west to Illinois, Colorado, and Arizona. This species occurs in southeast and south-central Massachusetts, and in western Massachusetts in the Connecticut River Valley and the southern Berkshires.

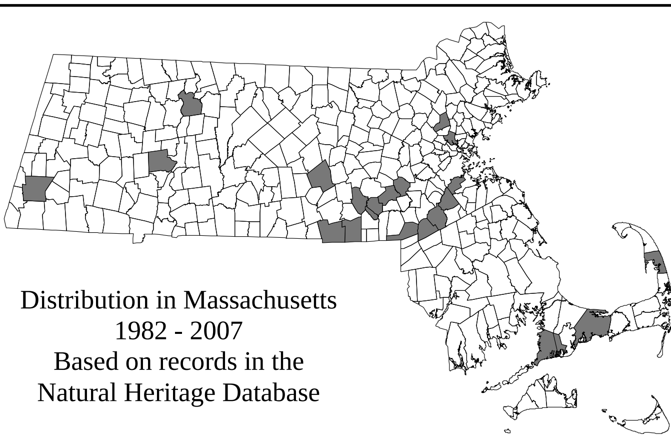
Photo by M.W. Nelson

Adult Flight Period in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Threats

- Habitat loss
- Fire suppression
- Introduced generalist parasitoids
- Insecticide spraying
- Clearcut timber harvest



Distribution in Massachusetts
1982 - 2007
Based on records in the
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Pale Green Pinion Moth

Lithophane viridipallens

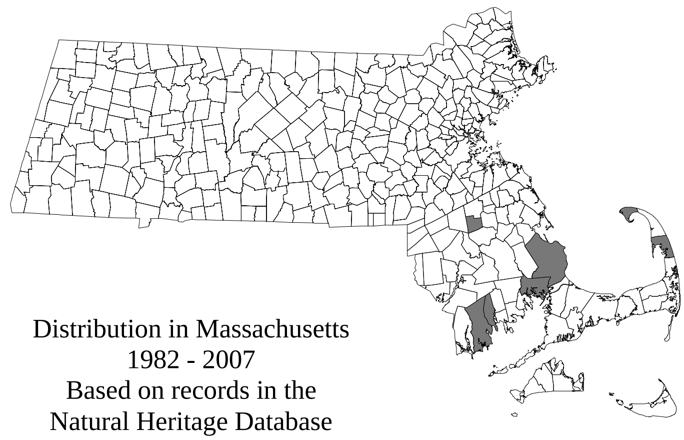
State Status: **Special Concern**
Federal Status: None

Description: The Pale Green Pinion is a noctuid moth. The forewings are pale, silvery gray with a greenish hue, the area between the reniform and orbicular spots shaded with black; the hind wings are nondescript, grayish-brown in color. Wingspan is 38-42 mm.

Habitat: In Massachusetts, the Pale Green Pinion Moth inhabits acidic, shrubby wetlands on the coastal plain, including wooded swamps, shrub swamps, shrubby bogs, and coastal plain pondshores.

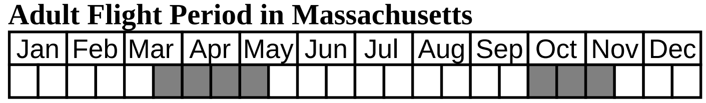
Life History: Adult moths emerge in October and early November and overwinter, flying on warm nights in late winter and early spring. Eggs are laid in spring on the larval host plants, which have not been documented in Massachusetts, but probably include a variety of acidic wetland shrubs such as holly (*Ilex*), chokeberry (*Aronia*), sweet pepper-bush (*Clethra alnifolia*), swamp-fetterbush (*Leucothoe racemosa*), maleberry (*Lyonia ligustrina*), and highbush blueberry (*Vaccinium corymbosum*). Larvae feed from late April through early June; pupae diapause through the summer and early fall.

Range: The Pale Green Pinion is spottily distributed along the coastal plain from southern New England south to New Jersey, with a more continuous range along the coastal plain from southern New Jersey south to Florida and west to Texas. In Massachusetts this species occurs on the coastal plain in the southeast part of the state.



Distribution in Massachusetts
1982 - 2007
Based on records in the
Natural Heritage Database

Adult Flight Period in Massachusetts



Threats

- Habitat loss
- Hydrologic alteration
- Invasion by exotic plants
- Introduced generalist parasitoids
- Insecticide spraying
- Light pollution

Updated June 2007
M.W. Nelson

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Pink Sallow Moth

Psectraglaea carnosa

State Status: **Special Concern**
Federal Status: None

Description: The Pink Sallow Moth has bright, reddish-pink forewings, solid in color except for faint yellow outlines of the reniform spot, orbicular spot, and postmedian line; the hind wings are cream-colored, shaded with pink. Wingspan is 34-38 mm.

Habitat: The Pink Sallow Moth inhabits sandplain pitch pine/scrub oak barrens and heathlands; it is associated with ericaceous vegetation.

Life History: Adult moths fly in late September and October. Eggs overwinter, hatching in the spring. Larvae feed from spring through early summer, pupating by July and diapausing until the fall. The larval host plant(s) used by this species in nature have not been conclusively documented, but lowbush blueberries (*Vaccinium*) are probable.

Range: The Pink Sallow Moth is endemic to northeastern North America, ranging from southern Maine west through southern Quebec and Ontario to Michigan and Wisconsin, and south to northeastern Pennsylvania and southern New Jersey. Many historic populations have disappeared, and it is now rare and spottily distributed throughout this range. In Massachusetts this species occurs mainly on the southeast coastal plain, with a few additional inland populations.

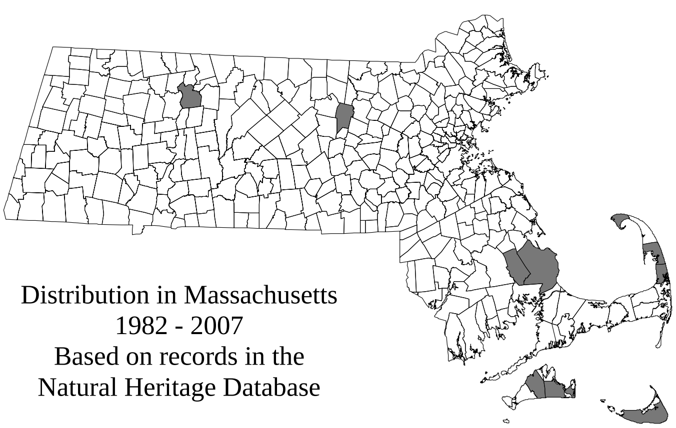
Photo by M.W. Nelson

Adult Flight Period in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
□□	□□	□□	□□	□□	□□	□□	□□	□■	■■	□□	□□

Threats

- Habitat loss
- Fire suppression
- Invasion by exotic plants
- Introduced generalist parasitoids
- Insecticide spraying
- Off-road vehicles
- Light pollution



Distribution in Massachusetts
1982 - 2007
Based on records in the
Natural Heritage Database

Updated June 2007
M.W. Nelson

Natural Heritage &
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Program

Natural Heritage & Endangered Species Program
Division of Fisheries & Wildlife
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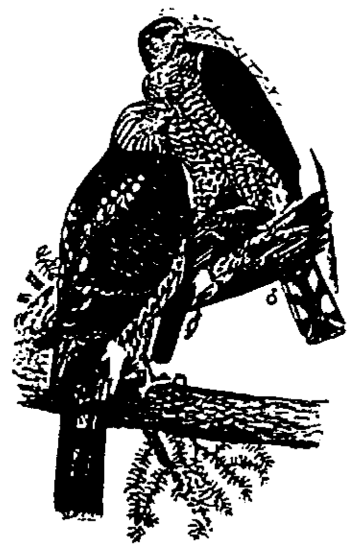
MASSACHUSETTS SPECIES OF SPECIAL CONCERN

Sharp-shinned Hawk
(Accipiter striatus)

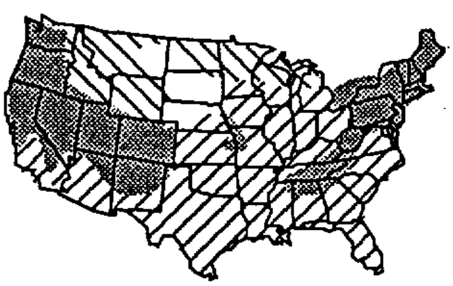


The National Geographic Society. Field Guide to the Birds of North America. Washington, D.C.: The National Geographic Society, 1987.

ETYMOLOGY: "Sharp-shinned" refers to the raised ridge on the inside front of the tarsus (not actually a "shin"). Accipiter is Latin for "bird of prey" probably derived from accipere, "to take" or from the Greek aci, "swift" and pteron, "wing." Striatus is Latin for "striped," referring to the underparts of the immature bird.

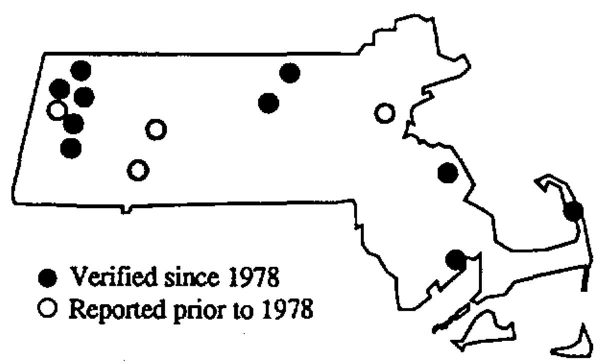
DESCRIPTION: The Sharp-shinned Hawk, which is slightly larger than a blue jay, is the smallest member of the Accipiter Family, measuring 25-36 cm (10-14 in) in length. It has a slim body; short, broad wings rounded at the tips, ranging from 51-69 cm (20-27 in) when extended; and a long, narrow, and usually notched or square-tipped tail. The adult plumage is dark slate-grey above with white underparts finely barred with red-brown. Its head is slate-grey down to the eye-line; white thinly streaked with brown below the eyeline; and red-brown cheeks. The tail has three or four bands of dark and light brown of equal width both above and below; white undertail coverts; and a narrow greyish-white tip (terminal band). The eyes of the adult Sharp-shinned Hawk are red and its long stick-like legs are a bright yellow. The sexes have similar plumage but the females are less bluish above, lighter below, and are noticeably larger that the males. The juveniles and immature adults have brown upperparts splotched with white. Underparts are white splotched with brown.

The Sharp-shinned, or "Sharpie," has a distinctive flight pattern characterized by a series of steady rapid wingbeats followed by a short interval of gliding (e.g., Flap, Flap, Flap...Sail), and intermittent soaring, usually in small circles. It is buoyant in flight; uses its tail as a rudder to maneuver; and is capable of great bursts of speed to capture its prey.



Summer (breeding range)
Winter range
Year-round range

Range of the Sharp-shinned Hawk



● Verified since 1978
○ Reported prior to 1978

Breeding Distribution in Massachusetts

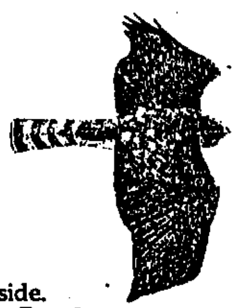
The call of the Sharp-shinned Hawk is a series of very rapid cackles, given when the bird is alarmed. The common note sounds like a "kek, kek, kek" with a slight nasal quality, the male's voice being much weaker than the female's.

POPULATION STATUS: The Sharp-shinned Hawk is listed as a Species of Special Concern by the Massachusetts Division of Wildlife and Fisheries. In the 19th and 20th centuries, Sharp-shinned Hawks were slaughtered in tremendous numbers by people who erroneously believed that this hawk affected songbird populations. When legal measures were implemented in the early 1900's to protect the Sharp-shinned Hawk, populations increased noticeably. However, when DDT and its associated pesticides were introduced into the environment in the 1950's, the Sharp-shinned faced a serious threat to its well-being. As the pesticides accumulated in the Sharp-shinneds' prey and were magnified through the food chain, reproductive failure of predatory birds like the Sharp-shinned resulted. Eggs were destroyed as the shells became too thin to withstand incubation. By the late 1970's, Sharp-shinned Hawks appeared to have made a significant comeback from the nationwide decline of the early 1970's.

However, records show that since 1985, the Sharp-shinned Hawk population is once again experiencing serious decline in its Northeastern breeding range of Quebec, the Canadian maritime provinces, New England, and to a lesser extent, Eastern Ontario (Kerlinger, 1991). Studies done during the past two years show that the decline is spreading inland, occurring in Central Canada as well. It is believed that this decline may be attributed to reproductive failure as a result of acid rain and the control of the spruce budworm with the spraying of Fenitrothion. DDT and environmental contaminants have been detected in some birds, possibly as a result of eating pesticide-laden migrant birds returning from South America, but this does not explain why only eastern populations and not midwestern population are effected. In examining the changes in the forests of the Canadian maritime provinces and New England during the past 20 to 50 years, it was noted that the two most evident changes are increased acid rain and the control of spruce budworm (Kerlinger,1991). These forest areas are the breeding grounds for the Sharp-shinned Hawk as well as declining neotropical and non-tropical songbird migrants.

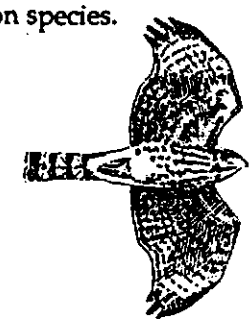
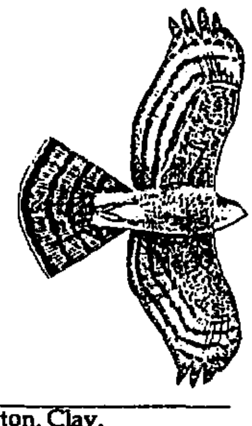
Another theory regarding the rarity of the Sharp-shinned Hawk in Massachusetts may be due to the lack of appropriate coniferous forests required to support a large population. The red spruce (Picea rubens) habitat that this bird prefers is limited to the north central and western regions of the state. Since 1978, only six confirmed and four suspected breeding pairs have been reported in Massachusetts. The secretive and retiring nature of this hawk makes it very difficult to locate, and current population data may not accurately reflect the actual number breeding in the state.

MANAGEMENT RECOMMENDATIONS: Management recommendations for the Sharp-shinned Hawk are difficult and complex. Continued monitoring of population abundance and population changes throughout its entire range is critical, as is the monitoring of reproductive performance and the factors affecting this performance. Since accipiters depend on forest for breeding habitat, studies into the regional, large scale land-use impacts on populations are also of great importance in the management of this species (Mosher,1981). Recommendations would be to investigate such complex areas as: effects of forest maturation on species abundance; ways that forest management and agricultural practices impact populations; the age and species composition trends in eastern forests and the impact of these trends on raptors; and the mechanisms that control the year-to-year fluctuations in reproduction; and to continue research in breeding and habitat studies and migration (Mosher, 1981). Until these various studies are explored further, it is difficult to establish a course of action. Most important at this time is that there is recognition of the frightening decline of a once-common species.

Sharp-shinned Hawk, upperside.
(A) Adult male (B) Immature Female

Dunne, Pete; Sibley, David; and Sutton, Clay. Hawks in Flight. Boston: Houghton Mifflin Company, 1988.

Sharp-shinned Hawk, underside.
(A) Immature (B) Adult

Dunne, Pete; Sibley, David; and Sutton, Clay. Hawks in Flight. Boston: Houghton Mifflin Company, 1988.

Partially funded by a grant from DEM Forest Stewardship Program

SIMILAR SPECIES IN MASSACHUSETTS: The Sharp-shinned Hawk is almost identical in plumage to the Cooper's Hawk (Accipiter cooperii). The Sharp-shinned can be distinguished from the Cooper's Hawk by its smaller size, though the female Sharp-shinned is often equal in size to the male Cooper's Hawk; its buoyant flight; and by its square or slightly notched tail with a narrow greyish-white terminal band at the tip. The Cooper's Hawk has a rounded tail with a wide bright white terminal band at the tip; a large head; slower wingbeats appearing almost arthritic; and it generally soars more.

RANGE: The breeding range of the Sharp-shinned Hawk extends from Newfoundland west through Canada to northwestern Alaska. Less commonly, this species also breeds south to northern Florida, and west to west central California. Wintering quarters range from the southern United States to Panama and the Bahamas. Some northerly breeding populations winter north to central Michigan and Nova Scotia.

HABITAT IN MASSACHUSETTS: The Sharp-shinned Hawk prefers extensive mixed woodlands and coniferous forests containing spruce. In Massachusetts, the Sharp-shinned has been found among red spruce (Picea rubens) with periodic occurrences of white birch (Betula papyrifera). Breeding habitat is usually near open areas and in the vicinity of water.

LIFECYCLE/BEHAVIOR: In Massachusetts, juvenile Sharp-shinned Hawks begin migrating south by late September with the adult birds following in October or early November. The spring flight to and through New England to their northern breeding grounds usually occurs in early April. Sharp-shinneds migrate by day. They hunt early in the day, travel during the warmer hours of rising air currents (thermals) and hunt again toward evening. Adult Sharp-shinneds tend to migrate inland while juveniles tend to follow the coast. They frequently travel in pairs or in groups of three, four, five, or more birds.

Courtship rituals take place over and between the branches of the trees as well as at significant heights above the canopy. Nesting pairs are solitary. The nests are relatively large (up to 2 ft. in diameter) considering the size of this species and are generally well concealed and difficult to find. Nests are placed in the denser portion of the lower canopy at heights of 10 to 60 ft. against the trunk or in a notch of the tree. Preferred nesting sites are in coniferous woods and in groves containing white pine, pitch pine, spruce, hemlock, and white cedar, but deciduous trees, such as oaks, elms, birches and basswood are sometimes chosen. Nests are broad platforms built from sticks and twigs and sometimes strips of bark; moss, grass or leaves are rarely used. Both sexes gather nesting material, but the female does most or all of the building. Usually, a new nest is built yearly. Sharp-shinneds are not committed to a specific nesting territory from year to year. possibly as a result of their relatively short life expectancy (approx. 5 yrs.), the shifting abundance and scarcity of food, and competition with earlier nesting raptors, such as the Cooper's Hawk, for nesting sites.

The eggs, numbering 4-5 per clutch, are bluish-white or greenish-white speckled with browns and lavender forming wreaths at either end. Incubation takes 35 days, with the young fledging 21 to 35 days later; usually with the males leaving first. Nestlings are fed by both parents, consuming up to 3 small birds per day per nestling. The rearing of young coincides with an abundance of nestling small birds and young of small mammals that can be readily captured. The Sharpie nests later than the Cooper's Hawk and much later than the Goshawk, therefore lessening the competition for food. If the food supply is depleted, nestlings are fed such items as locust, cicadas, and large beetles. Nestlings are fed by both parents; usually one guards the nest while the other searches for food. Young continue their dependence on the adults up to six weeks after hatching. Families break up at the start of the fall migration.

Sharp-shinned Hawks hunt by perching inconspicuously on a branch and darting after their prey; gliding close to the ground; or, by making low sallies from perch to perch on the chance that something will be flushed. The Sharpie's short broad wings and long narrow tail are well adapted for maneuverability when hunting in forested areas. It feeds primarily on small birds but occasionally preys on mice, shrews, bats, frogs, and large insects when birds are scarce. Females, due to their larger size, may take doves and quail. Mature birds require about 4 or 5 small birds per day. Fledged juveniles feed mostly on bird nestlings but have been observed trying unsuccessfully to prey on larger birds (such as pheasants) while still in the learning stages of hunting. When feeding, the Sharp-shinned Hawk devours the entire carcass, bones and all. As with all accipiters, the prey is squeezed, and the needle-sharp talons can penetrate and cause fatal damage. Its prey dies as a result of shock, suffocation, or penetration and is typically plucked before being eaten, usually at a favorite "plucking post."

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(Accipiter striatus)

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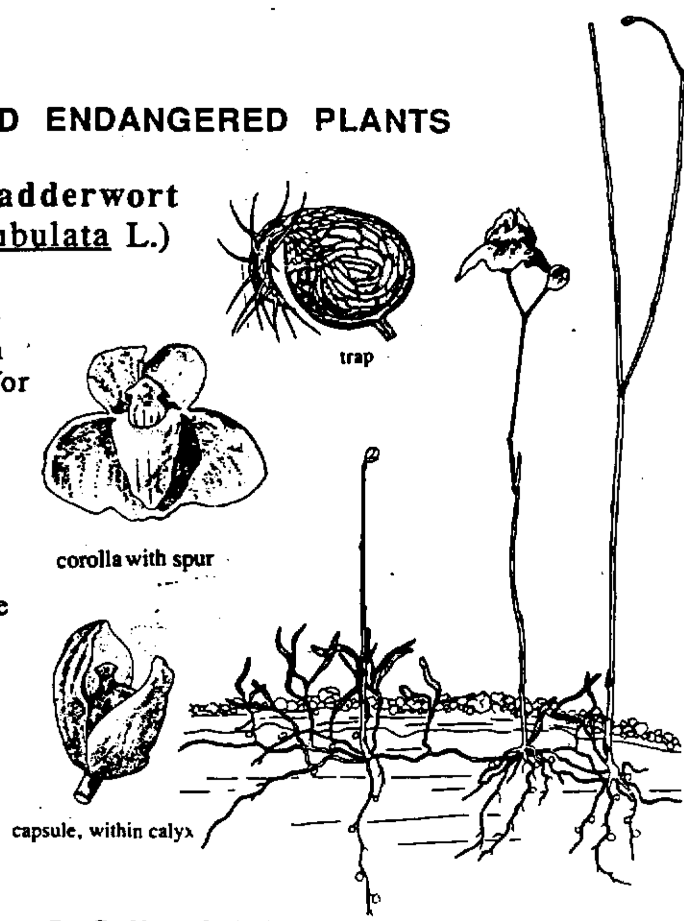
MASSACHUSETTS RARE AND ENDANGERED PLANTS

Subulate Bladderwort
(Utricularia subulata L.)

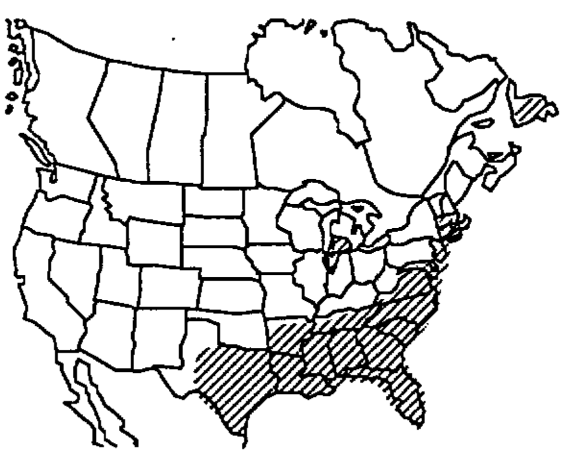


R. Godfrey & J. Wooten, Aquatic & Wetland Plants of S. E. United States. Univ. of Georgia Press. 1981.

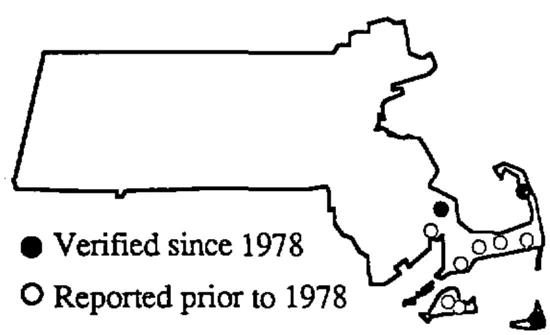
Description: Subulate Bladderwort is a tiny semi-aquatic plant composed of a sub-terranean system of delicate, unbranched, bladder-bearing (traps for invertebrates) stems from which thread-like, leafless flower scapes emerge 4 to18 cm (1.5-6 in.) above the substrate. Small, uncut, leaf-like branchlets may also be present, borne on the underground stems as shown in the illustration. The tiny yellow flowers, commonly 2-4 per stalk, appear from early June to late summer. They have a bilabiate (two-lipped) corolla, the upper lip smaller and rounded, the lower one large, broad and shallowly 3-lobed with a short spur pressed beneath it. More often, however, the flowers lack any well-developed petals and look simply like fruiting capsules. These cleistogamous ("hidden") flowers are fertilized without the flower ever expanding. A colony of them looks like tiny hatpins stuck in the sand or mud.

Range: Southeastern Massachusetts and southern Nova Scotia represent the northern limit of this species' range which extends south along the coastal states to Florida, westward to Texas, inland to Arkansas and Tennessee, and then skips to n. Indiana and s. Michigan. It also found throughout South America, tropical Africa, Madagascar, Thailand, and Borneo.

(cont. overleaf)



Range of Subulate Bladderwort



Distribution in Massachusetts by Town
1990

(**Subulate Bladderwort cont.**)

Similar Species: Subulate Bladderwort is similar to two other yellow-flowered bladderworts, the Fibrous Bladderwort (U. fibrosa) and the Two-flowered Bladderwort (U. biflora). Both are larger overall and have floating or creeping branches with many finely dissected leaves and scattered bladders, seperately or together, while Subulate Bladderwort has only underground bladders and few, if any, simple (undivided) leaves. Subulate Bladderwort is usually found stranded away from current water levels, whereas the other two are usually emergent at the water's edge.

Habitat in Massachusetts: This species primarily grows in wet, sandy to peaty soils on the margins of shallow Coastal Plain freshwater ponds which undergo pronounced seasonal fluctuations in water level. These permanent bodies of water were created from buried blocks of glacial ice and are found scattered throughout the glacial outwash which was deposited over much of southeastern Massachusetts. A rich community of specially adapted species, many rare and threatened, are able to thrive because the encroachment of trees and shrubs is prevented by the recurring high water levels. in these ponds. Subulate Bladderwort is also found in boggy depressions and on peaty scrapes where saturated and sunny conditions are also condusive to the growth of certain low, herbaceous species. Commonly found growing with Subulate Bladderwort are Thread-leaved sundew (Drosera filiformis), Yellow-eyed grass (Xyris difformis), Bog Buttons (Eriocaulon septangulare), White Beak-sedge (Rhynchospora alba), and Redroot (Lachnanthes caroliana), another listed plant species which happens to reach its northern range limit at the same location as Subulate Bladderwort.

Population Status: Subulate Bladderwort is listed as a species of Special Concern in Massachusetts. It is also listed in Indiana, Michigan, New York, Rhode Island, and Nova Scotia. Extensive populations of Subulate Bladderwort occur at several Massachusetts sites and in 3 of the 10 currently known stations it is protected. Historically (proir to 1978) it was more prevalent, documented from 21 sites in the state. But through recent development and recreational use of many of the region's coastal ponds, this species' habitat has significantly decreased.

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Terete Arrowhead

Sagittaria teres

State Status: **Special Concern**
Federal Status: None

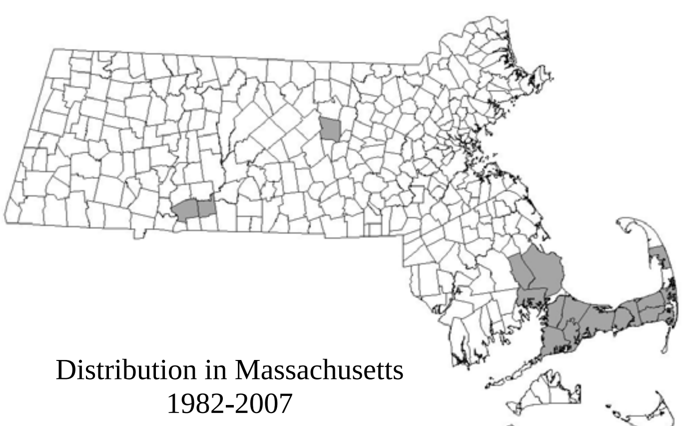
Hellquist, C.B. and G.E. Crow. 1981. *Aquatic Vascular Plants of New England: Part 3. Alismataceae*. New Hampshire Agricultural Experiment Station, University of New Hampshire, Durham.

Description: Terete Arrowhead (*Sagittaria teres*) is a perennial emergent aquatic plant of the water-plantain family (Alismataceae), which grows in shallow water along the margins of coastal plain ponds. It has linear basal leaves and white flowers, which bloom from July to September.

Aids to identification: Terete Arrowhead, unlike several other arrowheads, has linear, terete (rounded in cross section), and tapering leaves rather than sagittate, or arrow-shaped leaves. The leaves arise from a rhizome in a rosette; they vary in length, ranging from 1.2 to 8 inches (3–20 cm). The stem is erect, slender, and leafless, reaching 12 to 15 inches (30–38 cm) in height. The flowers, which have white petals and yellow centers, are 0.75 inch (2 cm) wide, and are borne in two to four whorls at the top of the stem. Fruits of this species are achenes (hard, one-seeded fruits), less than 0.1 inch (2–3 cm), with one to three prominent wings on each face.

Similar species: Most arrowheads in Massachusetts have some sagittate leaves present, thus differentiating them from Teret Arrowhead. One other state-listed species, River Arrowhead (*S. subulata*) (Endangered), and the more common Grass-leaved Arrowhead (*S. graminea*) most resemble Terete Arrowhead because of their linear, unlobed leaves. Both of these species however have flat, rather than terete leaves.

Habitat in Massachusetts: In Massachusetts, Terete Arrowhead inhabits muddy, sandy, or peaty soils in shallow water along the margins of acidic ponds, primarily coastal plain ponds. Associated species include Pipewort (*Eriocaulon aquaticum*), Water-lobelia (*Lobelia dortmanna*), bladderworts (*Utricularia* spp.), Golden Hedge-hyssop (*Gratiola aurea*), Pond-shore Rush (*Juncus pelocarpus*), and spike-sedges (*Eleocharis* spp.). Several rare species may be associated with Terete Arrowhead, including Resupinate Bladderwort (*Utricularia resupinata*) (Threatened), Plymouth Gentian (*Sabatia kennedyana*) (Special Concern), Torrey's Beak-sedge (*Rhynchospora torreyana*) (Endangered), Long-beaked Bald-sedge (*R. scirpoides*) (Special Concern), and Short-beaked Bald-sedge (*R. nitens*) (Threatened).



Distribution in Massachusetts
1982-2007
Based on records in Natural Heritage Database

Flowering time in Massachusetts

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						■	■	■			

Please allow the Natural Heritage & Endangered Species Program to continue to conserve the biodiversity of Massachusetts with a contribution for 'endangered wildlife conservation' on your state income tax form as these donations comprise a significant portion of our operating budget.

Range: Terete Arrowhead occurs along the coastal regions of New Hampshire, New York, New Jersey, and North Carolina.

Threats: Terete Arrowhead is threatened by any activity that changes the hydrologic regime, water quality, or soil integrity of the coastal plain pond it inhabits. Region-wide, coastal plain ponds are imperiled due to shoreline development, water table drawdown (from wells), eutrophication (resulting from fertilizers and septic systems), and soil disturbance from heavy recreational use (ORV, horse, and foot traffic; wading and swimming; camping; boat-launching; raking and digging).

Population status in Massachusetts: Terete Arrowhead is listed under the Massachusetts Endangered Species Act as a species of Special Concern. All listed species are legally protected from killing, collection, possession, or sale, and from activities that would destroy habitat and thus directly or indirectly cause mortality or disrupt critical behaviors. Terete Arrowhead is currently known from Barnstable, Plymouth, Hampden, and Worcester Counties, and is historically known from Middlesex County.

Management recommendations: Management of Terete Arrowhead requires protection of the hydrology, water quality, and soil integrity of its habitat. Like many other coastal plain pondshore plant species, Terete Arrowhead requires pronounced water-level fluctuations, acidic, nutrient-poor water and substrate, and an open, exposed shoreline, free from major soil disturbance.

Terete Arrowhead populations should be monitored regularly to identify possible threats. This species is most likely to be observed in mid to late summer during low water years.

Protection of Terete Arrowhead habitat may require exclusion of new wells and septic systems, prohibitions on fertilizer use, and restrictions on recreational use of the coastal plain pondshore. Recreational activities such as swimming, fishing, and boat-launching should be diverted from the plant population location by providing alternative locations for the activities.

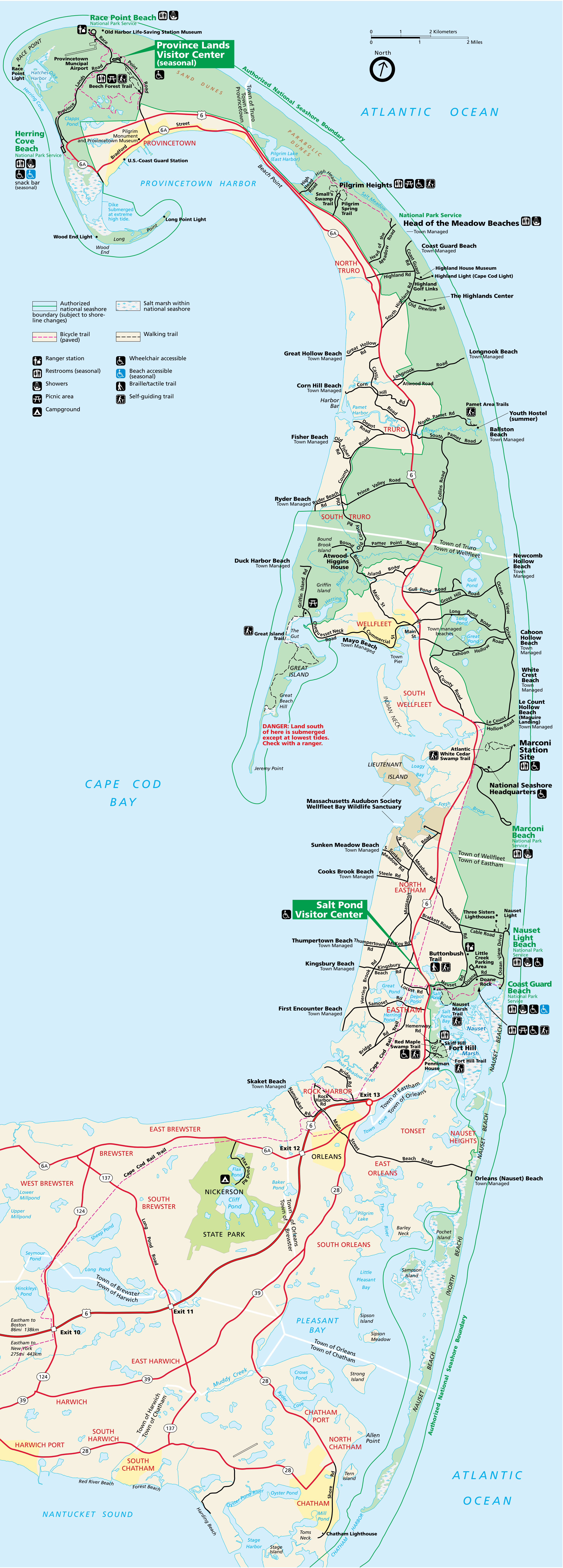
Also, habitat sites should be monitored to enable early detection of exotic plant species invasions. The nature of coastal plain ponds makes them generally inhospitable for many exotic invasive plants, but invasives could become established at sites that have received heavy soil disturbance or nutrient inputs. Exotic species that could establish along the shoreline of coastal plain ponds include Common Reed (*Phragmites australis* ssp. *australis*), Gray Willow (*Salix cinerea*), and Purple Loosestrife (*Lythrum salicaria*).

Boats are a very common vehicle for aquatic plant introductions, and habitat sites with boat access should be carefully monitored for introductions of non-native aquatic species, such Variable Water-milfoil (*Myriophyllum heterophyllum*) and Inflated Bladderwort (*Utricularia inflata*).

To avoid inadvertent harm to rare plants, all active management of rare plant populations (including exotic species removal) should be planned in consultation with the Massachusetts Natural Heritage and Endangered Species Program.

Updated June 2007

Appendix C. Cape Cod National Seashore Map



Race Point Beach
National Park Service
Old Harbor Life-Saving Station Museum
RACE POINT
Race Point Light
Hatches Harbor
Herring Cove
Provincetown Municipal Airport
Race Point Road
Beech Forest Trail
Province Lands Visitor Center (seasonal)
SAND DUNES
Clapps Pond
Province Lands
Herring Cove Beach
National Park Service
snack bar (seasonal)
Pilgrim Monument and Provincetown Museum
Bradford
Street
PROVINCETOWN
U.S.-Coast Guard Station
PROVINCETOWN HARBOR
Dike Submerged at extreme high tide.
Long Point Light
Long Point
Wood End Light
Wood End
Authorized National Seashore Boundary
Town of Provincetown
Town of Truro
PARABOLIC DUNES
Pilgrim Lake (East Harbor)
Beach Point
High Head Road
Pilgrim Heights
Small's Swamp Trail
Pilgrim Spring Trail
Salt Meadow
ATLANTIC OCEAN
0 1 2 Kilometers
0 1 2 Miles
North
National Park Service
Head of the Meadow Beaches
Town Managed
Head of the Meadow Road
Coast Guard Beach
Town Managed
Coast Guard Rd
Highland House Museum
Highland Light (Cape Cod Light)
Highland Rd
Highland Golf Links
The Highlands Center
NORTH TRURO
South Highland Rd
Old Dewline Rd
Authorized national seashore boundary (subject to shoreline changes)
Salt marsh within national seashore
Bicycle trail (paved)
Walking trail
Ranger station
Restrooms (seasonal)
Showers
Picnic area
Campground
Wheelchair accessible
Beach accessible (seasonal)
Braille/tactile trail
Self-guiding trail
Great Hollow Beach
Town Managed
Great Hollow Rd
Longnook Beach
Town Managed
Longnook Road
Atwood Road
Castle Rd
Corn Hill Beach
Town Managed
Corn Hill Rd
Harbor Bar
Pamet Harbor
Pamet Area Trails
Youth Hostel (summer)
North Pamet Rd
South Pamet Road
Ballston Beach
Town Managed
Depot Road
TRURO
Pamet River
Fisher Beach
Town Managed
Old Fisher Rd
County Road
Collins Road
Prince Valley Road
Ryder Beach
Town Managed
Ryder Beach Rd
Old County Rd
SOUTH TRURO
Bound Brook Island
Bound Brook Rd
Pamet Point Road
Town of Truro
Town of Wellfleet
Newcomb Hollow Beach
Town Managed
Duck Harbor Beach
Town Managed
Atwood-Higgins House
Griffin Island Rd
Griffin Island
Herring River
Island Road
Gull Pond Road
Gull Pond
Gross Hill Road
Ocean View Drive
Long Pond Road
Long Pond
Great Pond
WELLFLEET
Great Island Trail
The Gut
Chequesset Neck Road
Commercial St
Main St
Town managed beaches
Mayo Beach
Town Managed
Town Pier
Cahoon Hollow Road
Cahoon Hollow Beach
Town Managed
GREAT ISLAND
Great Beach Hill
Old County Road
White Crest Beach
Town Managed
SOUTH WELLFLEET
INDIAN NECK
Le Count Hollow Beach (Maguire Landing)
Town Managed
Le Count Hollow Road
DANGER: Land south of here is submerged except at lowest tides. Check with a ranger.
Marconi Station Site
Atlantic White Cedar Swamp Trail
Jeremy Point
LIEUTENANT ISLAND
Loagy Bay
National Seashore Headquarters
CAPE COD BAY
Massachusetts Audubon Society Wellfleet Bay Wildlife Sanctuary
Fresh Brook
Marconi Beach
National Park Service
Sunken Meadow Beach
Town Managed
S. Sunken Meadow Rd
N. Sunken Meadow Rd
Town of Wellfleet
Town of Eastham
Cooks Brook Beach
Town Managed
Steele Rd
NORTH EASTHAM
Massasoit Rd
Nauset Rd
Three Sisters Lighthouses
Nauset Light
Brackett Road
Cable Road
Salt Pond Visitor Center
Nauset Light Beach
National Park Service
Thumpertown Beach
Town Managed
Thumpertown Rd
McKoy Rd
Buttonbush Trail
Little Creek Parking Area
Ocean View Drive
Kingsbury Beach
Town Managed
Kingsbury Beach Rd
Herring Brook Rd
Locust Rd
Nauset Rd
Doane Rock
Doane Rd
Coast Guard Beach
National Park Service
Great Pond
Depot Pond
Salt Pond
Samoset Rd
First Encounter Beach
Town Managed
Herring Pond
EASTHAM
Nauset Marsh Trail
Salt Pond Bay
Nauset Marsh
Hemenway Rd
Bridge Rd
Cape Cod Rail Trail
Red Maple Swamp Trail
Skiff Hill
Fort Hill
Fort Hill Trail
Penniman House
NAUSET BEACH
Skaket Beach
Town Managed
Boat Meadow River
Bridge Rd
ROCK HARBOR
Rock Harbor Rd
Nauset Rd
Exit 13
Town of Eastham
Town of Orleans
Town Cove
TONSET
NAUSET HEIGHTS
EAST BREWSTER
BREWSTER
Exit 12
ORLEANS
Main Street
Beach Road
Orleans (Nauset) Beach
Town Managed
EAST ORLEANS
WEST BREWSTER
Lower Millpond
Upper Millpond
Cape Cod Rail Trail
SOUTH BREWSTER
NICKERSON STATE PARK
Flax Pond
Cliff Pond
Baker Pond
Town of Brewster
Town of Orleans
Long Pond Road
Pilgrim Lake
The River
Barley Neck
Pochet Island
SOUTH ORLEANS
Sheep Pond
Seymour Pond
Long Pond
Hinckleys Pond
Town of Brewster
Town of Harwich
Exit 11
Little Pleasant Bay
Sampson Island
(NORTH BEACH)
Eastham to Boston 86mi 138km
Exit 10
Eastham to New York 275mi 443km
PLEASANT BAY
Sipson Island
Sipson Meadow
Town of Orleans
Town of Chatham
EAST HARWICH
Strong Island
Muddy Creek
Crows Pond
Authorized National Seashore Boundary
NAUSET BEACH
HARWICH
Town of Harwich
Town of Chatham
Ryder Cove
CHATHAM PORT
SOUTH HARWICH
NORTH CHATHAM
Allen Point
HARWICH PORT
SOUTH CHATHAM
Tern Island
Red River Beach
Forest Beach
Shore Rd
ATLANTIC OCEAN
Oyster Pond River
Oyster Pond
NANTUCKET SOUND
Harding Beach
CHATHAM
Mill Pond
Toms Neck
Chatham Lighthouse
CHATHAM HARBOR
Stage Harbor
Stage Island

Appendix D. Photo Simulations

Black & Veatch prepared photo simulations for both a single turbine project at the northern location and for a three turbine project. These simulations are based on photographs taken off the back deck of a nearby home adjacent to Ocean View Drive and from the Marconi Wireless Station viewing area. Since both turbine models considered for this project are similar in size, a single simulation was considered sufficient to represent either model. The locations of the simulations and turbines are shown in Figure D-2.

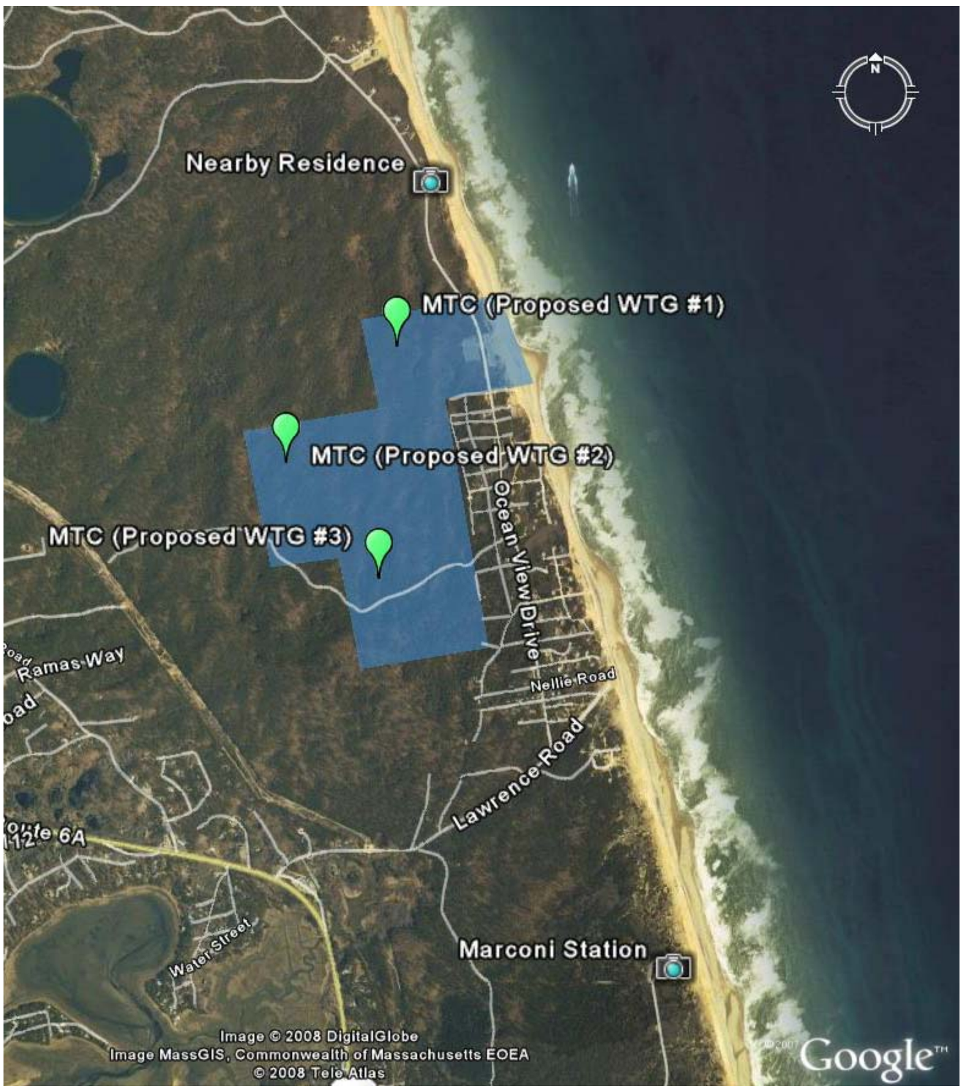


Figure D-2. Photo Simulation Locations.

Black & Veatch has additional photographs taken from several other houses in the area, if additional views are required.

Nearby Residence

These simulations are based on two photographs taken from the nearest residence to the north off of Ocean View Drive, looking south down the road. The coordinates of this location are approximately 41°56'23.0" N, 69°58'47.5" W (WGS84).

Figure D-3. Single Turbine from Nearby Residence.

Figure D-4. Three Turbines from Nearby Residence.

Marconi Wireless Station

These simulations are based on a photograph taken at the Marconi Wireless Station viewing area, looking north along the coast. The coordinates of this location are approximately 41°54’48.1” N, 69°58’18.4” W (WGS84).

Figure D-5. Single Turbine from Marconi Station.

Figure D-6. Three Turbines from Marconi Station.

Appendix E. FAA Determinations

Federal Aviation Administration
Air Traffic Airspace Branch, ASW-520
2601 Meacham Blvd.
Fort Worth, TX 76137-0520

Aeronautical Study No.
2007-ANE-1418-OE

Issued Date: 10/01/2007

Chris Clark
Massachusetts Technology Collaborative
75 North Drive
Westborough, MA 01581

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Wind Turbine Wellfleet Wind Turbine No. 1
Location:	Barnstable, MA
Latitude:	41-56-3.00 N NAD 83
Longitude:	69-59-3.00 W
Heights:	397 feet above ground level (AGL) 463 feet above mean sea level (AMSL)

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is marked and/or lighted in accordance with FAA Advisory circular 70/7460-1 K Change 2, Obstruction Marking and Lighting, white paint/synchronized red lights - Chapters 4,12&13(Turbines).

It is required that the enclosed FAA Form 7460-2, Notice of Actual Construction or Alteration, be completed and returned to this office any time the project is abandoned or:

_____ At least 10 days prior to start of construction (7460-2, Part I)
__X__ Within 5 days after the construction reaches its greatest height (7460-2, Part II)

See attachment for additional condition(s) or information.
This determination expires on 04/01/2009 unless:

(a) extended, revised or terminated by the issuing office.
(b) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE POSTMARKED OR DELIVERED TO THIS OFFICE AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE.

This determination is based, in part, on the foregoing description which includes specific coordinates, heights, frequency(ies) and power. Any changes in coordinates, heights, and frequencies or use of greater power will void this determination. Any future construction or alteration, including increase to heights, power, or the addition of other transmitters, requires separate notice to the FAA.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

A copy of this determination will be forwarded to the Federal Communications Commission if the structure is subject to their licensing authority.

If we can be of further assistance, please contact our office at (718) 553-2560. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2007-ANE-1418-OE.

Signature Control No: 529915-100740411 (DNE)
William Merritt
Specialist

Attachment(s)
Additional Information
Case Description
Map(s)

7460-2 Attached

Additional information for ASN 2007-ANE-1418-OE

The Northeast Air Defense Sector and AFNORTH recommends moving these turbines out past 20NM of the identified radar to minimize screening and effects they have on the radar. The radar facility is the North Turo radar latitude and longitude follow: 42 2 3.90N 70 3 15.30 W.
This is only a US Air Force recommendation.

Case Description for ASN 2007-ANE-1418-OE

Installation of three Vestas V82 wind turbines just west of White Crest Beach in Wellfleet, MA. The turbines will each have an 82 meter (269 ft) rotor diameter, an 80 meter (262 ft) tower, and will be marked with red and white aviation lights. The maximum rating of the turbine is 1,800 kW.

Sectional Map for ASN 2007-ANE-1418-OE

Federal Aviation Administration
Air Traffic Airspace Branch, ASW-520
2601 Meacham Blvd.
Fort Worth, TX 76137-0520

Aeronautical Study No.
2007-ANE-1419-OE

Issued Date: 10/01/2007

Chris Clark
Massachusetts Technology Collaborative
75 North Drive
Westborough, MA 01581

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Wind Turbine Wellfleet Wind Turbine No. 2
Location:	Barnstable, MA
Latitude:	41-55-49.00 N NAD 83
Longitude:	69-59-21.00 W
Heights:	397 feet above ground level (AGL)
	436 feet above mean sea level (AMSL)

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is marked and/or lighted in accordance with FAA Advisory circular 70/7460-1 K Change 2, Obstruction Marking and Lighting, white paint/synchronized red lights - Chapters 4,12&13(Turbines).

It is required that the enclosed FAA Form 7460-2, Notice of Actual Construction or Alteration, be completed and returned to this office any time the project is abandoned or:

_____ At least 10 days prior to start of construction (7460-2, Part I)
__X__ Within 5 days after the construction reaches its greatest height (7460-2, Part II)

See attachment for additional condition(s) or information.
This determination expires on 04/01/2009 unless:

(a) extended, revised or terminated by the issuing office.
(b) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE POSTMARKED OR DELIVERED TO THIS OFFICE AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE.

This determination is based, in part, on the foregoing description which includes specific coordinates, heights, frequency(ies) and power. Any changes in coordinates, heights, and frequencies or use of greater power will void this determination. Any future construction or alteration, including increase to heights, power, or the addition of other transmitters, requires separate notice to the FAA.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

A copy of this determination will be forwarded to the Federal Communications Commission if the structure is subject to their licensing authority.

If we can be of further assistance, please contact our office at (718) 553-2560. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2007-ANE-1419-OE.

Signature Control No: 529916-100740412 (DNE)
William Merritt
Specialist

Attachment(s)
Additional Information
Case Description
Map(s)

7460-2 Attached

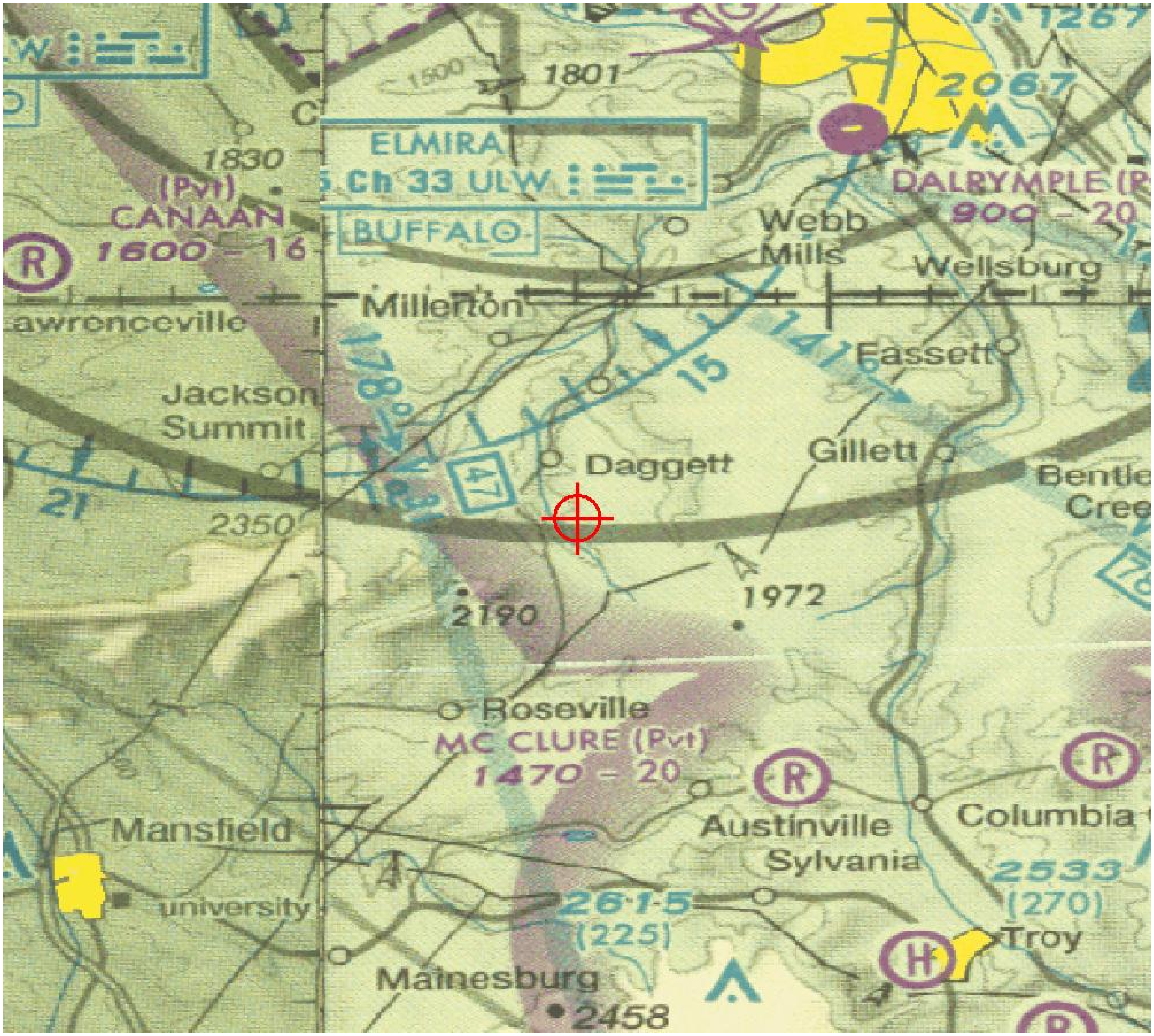
Additional information for ASN 2007-ANE-1419-OE

The Northeast Air Defense Sector and AFNORTH recommends moving these turbines out past 20NM of the identified radar to minimize screening and effects they have on the radar. The radar facility is the North Turo radar latitude and longitude follow: 42 2 3.90N 70 3 15.30 W.
This is only a US Air Force recommendation.

Case Description for ASN 2007-ANE-1419-OE

Installation of three Vestas V82 wind turbines just west of White Crest Beach in Wellfleet, MA. The turbines will each have an 82 meter (269 ft) rotor diameter, an 80 meter (262 ft) tower, and will be marked with red and white aviation lights. The maximum rating of the turbine is 1,800 kW.

Sectional Map for ASN 2007-ANE-1419-OE



Federal Aviation Administration
Air Traffic Airspace Branch, ASW-520
2601 Meacham Blvd.
Fort Worth, TX 76137-0520

Aeronautical Study No.
2007-ANE-1420-OE

Issued Date: 10/01/2007

Chris Clark
Massachusetts Technology Collaborative
75 North Drive
Westborough, MA 01581

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Wind Turbine Wellfleet Wind Turbine No. 3
Location:	Barnstable, MA
Latitude:	41-55-35.00 N NAD 83
Longitude:	69-59-6.00 W
Heights:	397 feet above ground level (AGL) 443 feet above mean sea level (AMSL)

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is marked and/or lighted in accordance with FAA Advisory circular 70/7460-1 K Change 2, Obstruction Marking and Lighting, white paint/synchronized red lights - Chapters 4,12&13(Turbines).

It is required that the enclosed FAA Form 7460-2, Notice of Actual Construction or Alteration, be completed and returned to this office any time the project is abandoned or:

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__X__ Within 5 days after the construction reaches its greatest height (7460-2, Part II)

See attachment for additional condition(s) or information.
This determination expires on 04/01/2009 unless:

(a) extended, revised or terminated by the issuing office.
(b) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE POSTMARKED OR DELIVERED TO THIS OFFICE AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE.

This determination is based, in part, on the foregoing description which includes specific coordinates, heights, frequency(ies) and power. Any changes in coordinates, heights, and frequencies or use of greater power will void this determination. Any future construction or alteration, including increase to heights, power, or the addition of other transmitters, requires separate notice to the FAA.

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This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

A copy of this determination will be forwarded to the Federal Communications Commission if the structure is subject to their licensing authority.

If we can be of further assistance, please contact our office at (718) 553-2560. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2007-ANE-1420-OE.

Signature Control No: 529917-100740413 (DNE)
William Merritt
Specialist

Attachment(s)
Additional Information
Case Description
Map(s)

7460-2 Attached

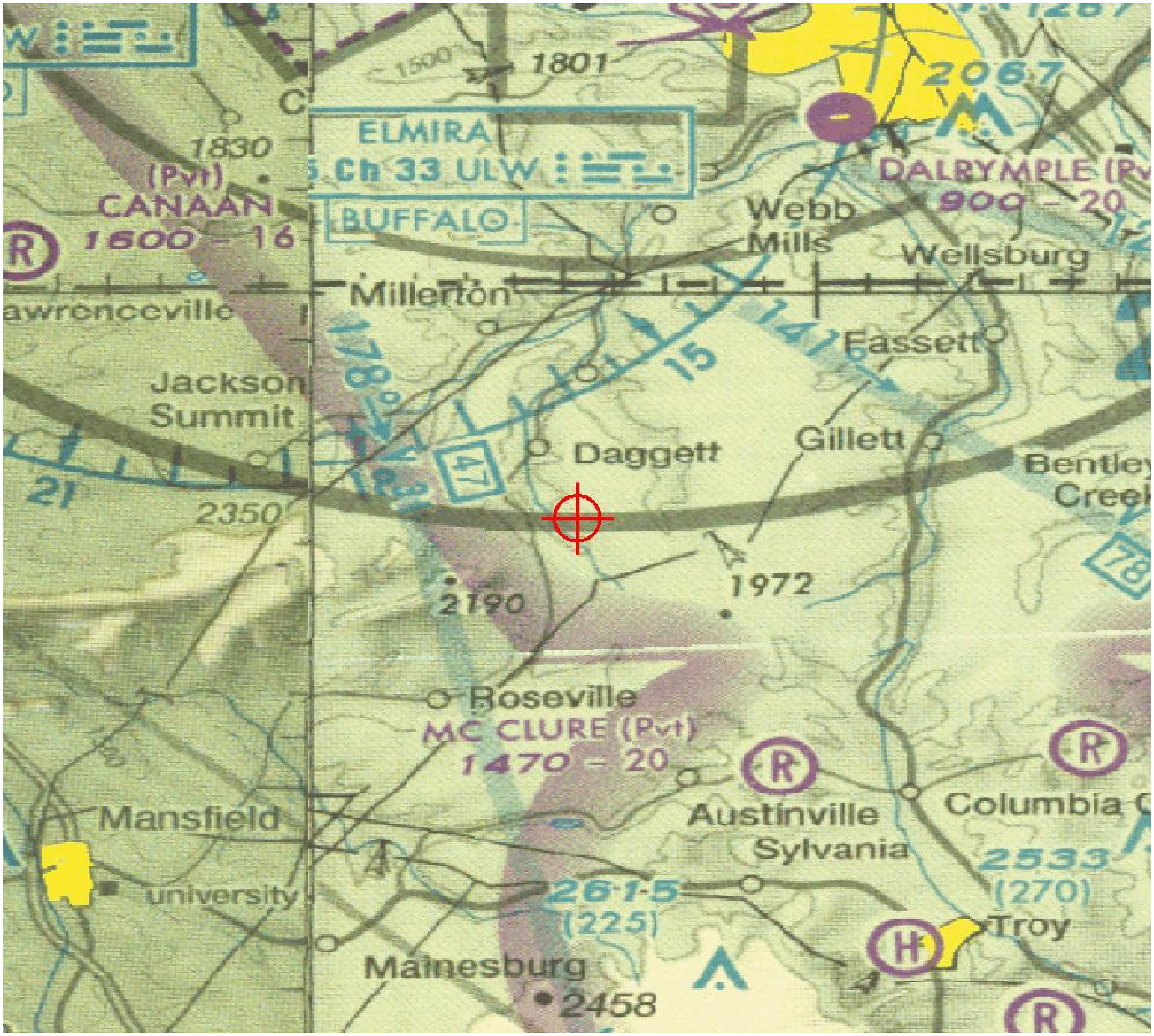
Additional information for ASN 2007-ANE-1420-OE

The Northeast Air Defense Sector and AFNORTH recommends moving these turbines out past 20NM of the identified radar to minimize screening and effects they have on the radar. The radar facility is the North Turo radar latitude and longitude follow: 42 2 3.90N 70 3 15.30 W.
This is only a US Air Force recommendation.

Case Description for ASN 2007-ANE-1420-OE

Installation of three Vestas V82 wind turbines just west of White Crest Beach in Wellfleet, MA. The turbines will each have an 82 meter (269 ft) rotor diameter, an 80 meter (262 ft) tower, and will be marked with red and white aviation lights. The maximum rating of the turbine is 1,800 kW.

Sectional Map for ASN 2007-ANE-1420-OE



Appendix F. Wellfleet Windmill Bylaws

with the following conditions:

6.4.1 Retail Store and Service Establishments - For each retail store or service establishment with gross floor area of from 3,000 to 8,000 square feet at least one berth. Additional berths at the rate of one berth for each additional 8,000 square feet or nearest multiple thereof.

6.4.2 Manufacturing, Industrial and Other Commercial Use - One berth shall be provided for floor area up to 8,000 square feet and for larger floor areas additional berths as required by the Board of Appeals.

6.5 WINDMILLS

6.5.1 Windmills shall be permitted by a special permit from the Board of Appeals. No special permit for a windmill shall be granted unless the Board of Appeals makes a finding that the windmill complies with the following conditions:

6.5.1.1 The minimum setback distance for all windmills from any abutter's property line shall be at least equal to the maximum height of the machine from grade plus twenty (20) feet. Set backs will be measured to the center of the tower base.

6.5.1.2 The maximum tower height shall be sixty-five (65) feet from grade to the center of the rotor.

6.5.1.3 Climbing access to the windmill tower shall be limited either by (I) the installation of a fence with locked gate around tower base or by (II) limiting tower climbing apparatus to no lower than ten (10) feet from the ground. If a fence is used, it shall be no lower than five (5) feet and constructed in such a manner as to restrict passage through said fence, including such construction as stockade, woven wood, chain link, etc., but excluding split rail.

6.5.1.4 The diameter of a rotor may not exceed thirty-five (35) feet. The minimum height of the rotor shall not be less than fifteen (15) feet from the ground as measured from the lowest point of the arc of the rotor.

6.5.1.5 The windmill shall not generate excessive noise, cause interruption of television or radio station reception or otherwise constitute a public nuisance.

6.5.2 A windmill will be considered abandoned if not operated for a period of two years or if it is designated as a safety hazard or a public nuisance by the Building Inspector. Once a windmill is designated as abandoned, the owner shall be required to immediately dismantle it.

6.5.3 For the purposes of the by-law the following definitions shall be applied: (I) windmill - a device which converts wind energy to mechanical or electrical energy; (II) rotor - the blades plus the hub to which the blades of a windmill tower are attached.

6.5.4 Before applying for a special permit under this section, the applicant shall obtain the Building Inspector's approval of the proposed windmill. The Building Inspector shall approve the proposed windmill upon making the determination that it (I) will not constitute a safety hazard of a public nuisance and (II) complies with the State Building Code and any other applicable law. The Building Inspector's approval required herein shall be in addition to the building permit required by Section 8.2 of this by-law.

6.6 CLUSTER RESIDENTIAL DEVELOPMENTS - The Planning Board is hereby designated the special permit granting authority for all cluster residential developments and shall have the power to hear and decide applications for special permits as provided by this section.

6.6.1 Objective - to allow intensive use of land while at the same time maintaining existing character; preserve open space for conservation and recreation; introduce variety and choice into residential development; meet housing needs; and facilitate economical and efficient provision of public services.

6.6.2 Application - Applicants shall submit five (5) copies of an application and plans which shall comply with the requirements of the Wellfleet Subdivision Control Regulations and which shall also indicate proposed land and building area, location of common open space and upland area. A registered land surveyor or equivalent licensed professional shall prepare the plans. Preliminary subdivision plans, if any, should be submitted to the Planning Board prior to the application for a special permit. The definitive subdivision plan shall be submitted with the special permit application. The Planning Board shall transmit copies of the application and plans to the Board of Health, Conservation Commission, Fire Department or any other agencies whose review is sought. Those agencies shall submit reports to the Planning Board within 35 days of the referral and the Planning Board shall make no decision upon the application until receipt of all such reports or until 35 days have elapsed. The Planning Board may hold public hearings under Ch. 41, the Subdivision Control Law and the special permit simultaneously.

6.6.3 Other Materials - The application materials shall indicate each landowners interest in the land to be developed, the form of organization proposed to own and maintain the open space and any common facility, the substance of covenants and grants of easements to be imposed upon the use of land or structures, and a development schedule.

6.6.4 Minimum Area/Number of Dwelling Units - A cluster development shall encompass at least 15 acres of contiguous land. The maximum number of dwelling units per cluster development shall equal the total upland area (minus land for road construction) divided by the minimum lot size in that district; if the development includes land in more than one district, the largest lot size shall be used to

Appendix G. Massachusetts Model Wind Facility Bylaws

Model Amendment to a Zoning Ordinance or By-law: Allowing Wind Facilities by Special Permit

Prepared by:
Massachusetts Division of Energy Resources
Massachusetts Executive Office of Environmental Affairs

1.0 Purpose

The purpose of this by-law is to provide by special permit for the construction and operation of wind facilities and to provide standards for the placement, design, construction, monitoring, modification and removal of wind facilities that address public safety, minimize impacts on scenic, natural and historic resources of the city or town and provide adequate financial assurance for decommissioning.

1.1 Applicability

This section applies to all utility-scale and on-site wind facilities proposed to be constructed after the effective date of this section. It does not apply to single stand-alone turbines under 60 kilowatts of rated nameplate capacity.

Any physical modifications to existing wind facilities that materially alters the type or increases the size of such facilities or other equipment shall require a special permit.

2.0 Definitions

Utility-Scale Wind Facility: A commercial wind facility, where the primary use of the facility is electrical generation to be sold to the wholesale electricity markets.

On-Site Wind Facility: A wind project, which is located at a commercial, industrial, agricultural, institutional, or public facility that will consume more than 50% of the electricity generated by the project on-site.

Height: The height of a wind turbine measured from natural grade to the tip of the rotor blade at its highest point, or blade-tip height.

Rated Nameplate Capacity: The maximum rated output of electric power production equipment. This output is typically specified by the manufacturer with a “nameplate” on the equipment.

Special Permit Granting Authority: The special permit granting authority shall be the board of selectmen, city council, board of appeals, planning board, or zoning administrator as designated by zoning ordinance or by-law for the issuance of special permits, or by this section for the issuance of special permits to construct and operate wind facilities.

Substantial Evidence: Such evidence as a reasonable mind might accept as adequate to support a conclusion.

Wind Facility: All equipment, machinery and structures utilized in connection with the conversion of wind to electricity. This includes, but is not limited to, transmission, storage, collection and supply equipment, substations, transformers, service and access roads, and one or more wind turbines.

Wind Monitoring or Meteorological Tower: A temporary tower equipped with devices to measure wind speeds and direction, used to determine how much wind power a site can be expected to generate.

Wind turbine: A device that converts kinetic wind energy into rotational energy that drives an electrical generator. A wind turbine typically consists of a tower, nacelle body, and a rotor with two or more blades.

3.0 General Requirements

3.1 Special Permit Granting Authority

No wind facility over 60 kilowatts of rated nameplate capacity shall be erected, constructed, installed or modified as provided in this section without first obtaining a permit from the special permit granting authority. The construction of a wind facility shall be permitted in any zoning district subject to the issuance of a Special Permit and provided that the use complies with all requirements set forth in sections 3, 4, 5 and 6. All such wind energy facilities shall be constructed and operated in a manner that minimizes any adverse visual, safety, and environmental impacts. No special permit shall be granted unless the special permit granting authority finds in writing that:

- **(a)** the specific site is an appropriate location for such use;
- **(b)** the use is not expected to adversely affect the neighborhood;
- **(c)** there is not expected to be any serious hazard to pedestrians or vehicles from the use;
- **(d)** no nuisance is expected to be created by the use; and
- **(e)** adequate and appropriate facilities will be provided for the proper operation of the use.

Such permits may also impose reasonable conditions, safeguards and limitations on time and use and may require the applicant to implement all reasonable measures to mitigate unforeseen adverse impacts of the wind facility, should they occur.

Wind monitoring or meteorological towers shall be permitted in all zoning districts subject to issuance of a building permit for a temporary structure and subject to reasonable regulations concerning the bulk and height of structures and determining yard-size, lot area, setbacks, open space, parking, and building coverage requirements

3.2 Compliance with Laws, Ordinances and Regulations

The construction and operation of all such proposed wind facilities shall be consistent with all applicable local, state and federal requirements, including but not limited to all applicable safety, construction, environmental, electrical, communications and aviation requirements.

3.3 Proof of Liability Insurance

The applicant shall be required to provide evidence of liability insurance in an amount and for a duration sufficient to cover loss or damage to persons and structures occasioned by the failure of the facility.

3.4 Site Control

At the time of its application for a special permit, the applicant shall submit documentation of actual or prospective control of the project site sufficient to allow for installation and use of the proposed facility. Documentation shall also include proof of control over setback areas and access roads, if required. Control shall mean the legal authority to prevent the use or construction of any structure for human habitation within the setback areas.

4.0 General Siting Standards

4.1 Height

Wind facilities shall be no higher than 400 feet above the current grade of the land, provided that wind facilities may exceed 400 feet if:

(a) the applicant demonstrates by substantial evidence that such height reflects industry standards for a similarly sited wind facility;

(b) such excess height is necessary to prevent financial hardship to the applicant, and

(c) the facility satisfies all other criteria for the granting of a special permit under the provisions of this section.

4.2 Setbacks

Wind turbines shall be set back a distance equal to 1.5 times the overall blade tip height of the wind turbine from the nearest existing residential or commercial structure and 100 feet from the nearest property line and private or public way.

4.2.1 Setback Waiver

The special permit granting authority may reduce the minimum setback distance as appropriate based on site-specific considerations, if the project satisfies all other criteria for the granting of a special permit under the provisions of this section.

5.0 Design Standards

5.1 Color and Finish

The special permit granting authority shall have discretion over the turbine color, although a neutral, non-reflective exterior color designed to blend with the surrounding environment is encouraged.

5.2 Lighting and Signage

5.2.1 Lighting

Wind turbines shall be lighted only if required by the Federal Aviation Administration. Lighting of other parts of the wind facility, such as appurtenant structures, shall be limited to that required for safety and operational purposes, and shall be reasonably shielded from abutting properties.

5.2.2 Signage

Signs on the wind facility shall comply with the requirements of the town's sign regulations, and shall be limited to:

(a) Those necessary to identify the owner, provide a 24-hour emergency contact phone number, and warn of any danger.

(b) Educational signs providing information about the facility and the benefits of renewable energy.

5.2.3 Advertising

Wind turbines shall not be used for displaying any advertising except for reasonable identification of the manufacturer or operator of the wind energy facility.

5.2.4 Utility Connections

Reasonable efforts shall be made to locate utility connections from the wind facility underground, depending on appropriate soil conditions, shape, and topography of the site and any requirements of the utility provider. Electrical transformers for utility interconnections may be above ground if required by the utility provider.

5.3 Appurtenant Structures

All appurtenant structures to such wind facilities shall be subject to reasonable regulations concerning the bulk and height of structures and determining yard sizes, lot area, setbacks, open space, parking and building coverage requirements. All such appurtenant structures, including but not limited to, equipment shelters, storage facilities, transformers, and substations, shall be architecturally compatible with each other and shall be contained within the turbine tower whenever technically and economically feasible. Structures shall only be used for housing of equipment for this particular site. Whenever reasonable, structures should be shaded from view by vegetation and/or located in an underground vault and joined or clustered to avoid adverse visual impacts.

5.4 Support Towers

Monopole towers are the preferred type of support for the Wind Facilities.

6.0 Safety, Aesthetic and Environmental Standards

6.1 Emergency Services

The applicant shall provide a copy of the project summary and site plan to the local emergency services entity, as designated by the special permit granting authority. Upon request the applicant shall cooperate with local emergency services in developing an emergency response plan.

6.1.1 Unauthorized Access

Wind turbines or other structures part of a wind facility shall be designed to prevent unauthorized access.

6.2 Shadow/Flicker

Wind facilities shall be sited in a manner that minimizes shadowing or flicker impacts. The applicant has the burden of proving that this effect does not have significant adverse impact on neighboring or adjacent uses through either siting or mitigation.

6.3 Noise

The wind facility and associated equipment shall conform with the provisions of the Department of Environmental Protection's, Division of Air Quality Noise Regulations (310 CMR 7.10), unless the Department and the Special Permit Granting Authority agree that those provisions shall not be applicable. A source of sound will be considered to be violating these regulations if the source:

(a) Increases the broadband sound level by more than 10 dB(A) above ambient, or
(b) Produces a "pure tone" condition – when an octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more.

These criteria are measured both at the property line and at the nearest inhabited residence. Ambient is defined as the background A-weighted sound level that is exceeded 90% of the time measured during equipment hours. The ambient may also be established by other means with consent from DEP. An analysis prepared by a qualified engineer shall be presented to demonstrate compliance with these noise standards.

The special permit granting authority, in consultation with the Department, shall determine whether such violations shall be measured at the property line or at the nearest inhabited residence.

6.4 Land Clearing, Soil Erosion and Habitat Impacts

Clearing of natural vegetation shall be limited to that which is necessary for the construction, operation and maintenance of the wind facility and is otherwise prescribed by applicable laws, regulations, and ordinances.

7.0 Monitoring and Maintenance

7.1 Facility Conditions

The applicant shall maintain the wind facility in good condition. Maintenance shall include, but not be limited to, painting, structural repairs, and integrity of security measures. Site access shall be maintained to a level acceptable to the local Fire Chief and Emergency Medical Services. The project owner shall be responsible for the cost of maintaining the wind facility and any access road, unless accepted as a public way, and the cost of repairing any damage occurring as a result of operation and construction.

7.2 Modifications

All material modifications to a wind facility made after issuance of the special permit shall require approval by the special permit granting authority as provided in this section.

8.0 Abandonment or Decommissioning

8.1 Removal Requirements

Any wind facility which has reached the end of its useful life or has been abandoned shall be removed. When the wind facility is scheduled to be decommissioned, the applicant shall notify the town by certified mail of the proposed date of discontinued operations and plans for removal. The owner/operator shall physically remove the wind facility no more than 150 days after the date of discontinued operations. At the time of removal, the wind facility site shall be restored to the state it was in before the facility was constructed or any other legally authorized use. More specifically, decommissioning shall consist of:

(a) Physical removal of all wind turbines, structures, equipment, security barriers and transmission lines from the site.

(b) Disposal of all solid and hazardous waste in accordance with local and state waste disposal regulations.

(c) Stabilization or re-vegetation of the site as necessary to minimize erosion. The special permit granting authority may allow the owner to leave landscaping or designated below-grade foundations in order to minimize erosion and disruption to vegetation.

8.2 Abandonment

Absent notice of a proposed date of decommissioning, the facility shall be considered abandoned when the facility fails to operate for more than one year without the written consent of the special permit granting authority. The special permit granting authority shall determine in its decision what proportion of the facility is inoperable for the facility to be considered abandoned. If the applicant fails to remove the wind facility in accordance with the requirements of this section within 150 days of abandonment or the proposed date of decommissioning, the town shall have the authority to enter the property and physically remove the facility.

8.3 Financial Surety

The special permit granting authority may require the applicant for utility scale wind facilities to provide a form of surety, either through escrow account, bond or otherwise, to cover the cost of removal in the event the town must remove the facility, of an amount and form determined to be reasonable by the special permit granting authority, but in no event to exceed more than 125 percent of the cost of removal and compliance with the additional requirements set forth herein, as determined by the applicant. Such surety will not be required for municipally or state-owned facilities. The applicant shall submit a fully inclusive estimate of the costs associated with removal, prepared by a qualified engineer. The amount shall include a mechanism for Cost of Living Adjustment.

9.0 Term of Special Permit

A special permit issued for a wind facility shall be valid for 25 years, unless extended or renewed. The time period may be extended or the permit renewed by the special permit granting authority upon satisfactory operation of the facility. Request for renewal must be submitted at least 180 days prior to expiration of the special permit. Submitting a renewal request shall allow for continued operation of the facility until the special permit granting authority acts. At the end of that period (including extensions and renewals), the wind facility shall be removed as required by this section.

The applicant or facility owner shall maintain a phone number and identify a responsible person for the public to contact with inquiries and complaints throughout the life of the project.

10.0 Application Process & Requirements

10.1 Application Procedures

10.1.1 General

The application for a wind facility shall be filed in accordance with the rules and regulations of the special permit granting authority concerning special permits.

10.1.2 Application

Each application for a special permit shall be filed by the applicant with the city or town clerk pursuant to section 9 of chapter 40A of the Massachusetts General Laws.

10.2 Required Documents

10.2.1 General

The applicant shall provide the special permit granting authority with ___ copies of the application. All plans and maps shall be prepared, stamped and signed by a professional engineer licensed to practice in Massachusetts. Included in the application shall be:

10.2.2 Name, address, phone number and signature of the applicant, as well as all co-applicants or property owners, if any.

10.2.3 The name, contact information and signature of any agents representing the applicant.

10.2.4 Documentation of the legal right to use the wind facility site, including the requirements set forth in 10.3.2(a) of this section

10.3 Siting and Design

The applicant shall provide the special permit granting authority with a description of the property which shall include:

10.3.1 Location Map ***(Modify for On-Site Wind Facilities)***

Copy of a portion of the most recent USGS Quadrangle Map, at a scale of 1:25,000, showing the proposed facility site, including turbine sites, and the area within at least two miles from the facility. Zoning district designation for the subject parcel should be included; however a copy of a zoning map with the parcel identified is suitable.

10.3.2 Site Plan
A one inch equals 200 feet plan of the proposed wind facility site, with contour intervals of no more than 10 feet, showing the following:

(a) Property lines for the site parcel and adjacent parcels within 300 feet.
(b) Outline of all existing buildings, including purpose (e.g. residence, garage, etc.) on site parcel and all adjacent parcels within 500 feet. Include distances from the wind facility to each building shown.
(c) Location of all roads, public and private on the site parcel and adjacent parcels within 300 feet, and proposed roads or driveways, either temporary or permanent.
(d) Existing areas of tree cover, including average height of trees, on the site parcel and adjacent parcels within 300 feet.
(e) Proposed location and design of wind facility, including all turbines, ground equipment, appurtenant structures, transmission infrastructure, access, fencing, exterior lighting, etc.
(f) Location of viewpoints referenced below in 10.3.3 of this section.

10.3.3 Visualizations *(Modify for On-Site Wind Facilities)*
The special permit granting authority shall select between three and six sight lines, including from the nearest building with a view of the wind facility, for pre- and post-construction view representations. Sites for the view representations shall be selected from populated areas or public ways within a 2-mile radius of the wind facility. View representations shall have the following characteristics:

(a) View representations shall be in color and shall include actual pre-construction photographs and accurate post-construction simulations of the height and breadth of the wind facility (e.g. superimpositions of the wind facility onto photographs of existing views).
(b) All view representations will include existing, or proposed, buildings or tree coverage.
(c) Include description of the technical procedures followed in producing the visualization (distances, angles, lens, etc…).

10.4 Landscape Plan (*Utility-Scale Wind Facilities Only)*
A plan indicating all proposed changes to the landscape of the site, including temporary or permanent roads or driveways, grading, vegetation clearing and planting, exterior lighting, other than FAA lights, screening vegetation or structures. Lighting shall be designed to minimize glare on abutting properties and except as required by the FAA be directed downward with full cut-off fixtures to reduce light pollution.

10.5 Operation & Maintenance Plan
The applicant shall submit a plan for maintenance of access roads and storm water controls, as well as general procedures for operational maintenance of the wind facility.

10.6 Compliance Documents

If required under previous sections of this by-law, the applicant will provide with the application:

(a) a description of financial surety that satisfies 8.3 of this section,
(b) proof of liability insurance that satisfies Section 3.3 of this section,
(c) certification of height approval from the FAA,
(d) a statement that satisfies Section 6.3, listing existing and maximum projected noise levels from the wind facility.

10.7 Independent Consultants – (*Utility-Scale Wind Facilities Only)*

Upon submission of an application for a special permit, the special permit granting authority will be authorized to hire outside consultants, pursuant to section 53G of chapter 44 of the Massachusetts General Laws. As necessary, the applicant may be required to pay not more than 50% of the consultant's costs.

Appendix H. Project Revenues

Table H-1. Single GE 1.5sle, Status Quo.				
Year	Operating Revenue ($)			
	Energy Savings	Energy Sales	REC Sales	Total
1	$0	$330,281	$188,732	$519,013
2	$0	$336,887	$188,732	$525,619
3	$0	$343,624	$188,732	$532,356
4	$0	$350,497	$188,732	$539,229
5	$0	$357,507	$188,732	$546,239
6	$0	$364,657	$188,732	$553,389
7	$0	$371,950	$188,732	$560,682
8	$0	$379,389	$188,732	$568,121
9	$0	$386,977	$188,732	$575,709
10	$0	$394,716	$188,732	$583,448
11	$0	$402,611	$188,732	$591,343
12	$0	$410,663	$188,732	$599,395
13	$0	$418,876	$134,157	$553,033
14	$0	$427,254	$70,775	$498,029
15	$0	$435,799	$70,775	$506,574
16	$0	$444,515	$70,775	$515,290
17	$0	$453,405	$70,775	$524,180
18	$0	$462,473	$70,775	$533,248
19	$0	$471,723	$70,775	$542,498
20	$0	$481,157	$70,775	$551,932

Table H-2. Single GE 1.5sle, Net Metering.

Year	Operating Revenue ($)			
	Energy Savings	Energy Sales	REC Sales	Total
1	$703,970	$0	$188,732	$892,702
2	$718,050	$0	$188,732	$906,782
3	$732,411	$0	$188,732	$921,143
4	$747,059	$0	$188,732	$935,791
5	$762,000	$0	$188,732	$950,732
6	$777,240	$0	$188,732	$965,972
7	$792,785	$0	$188,732	$981,517
8	$808,641	$0	$188,732	$997,373
9	$824,813	$0	$188,732	$1,013,545
10	$841,310	$0	$188,732	$1,030,042
11	$858,136	$0	$188,732	$1,046,868
12	$875,299	$0	$188,732	$1,064,031
13	$892,805	$0	$134,157	$1,026,962
14	$910,661	$0	$70,775	$981,436
15	$928,874	$0	$70,775	$999,649
16	$947,451	$0	$70,775	$1,018,226
17	$966,400	$0	$70,775	$1,037,175
18	$985,728	$0	$70,775	$1,056,503
19	$1,005,443	$0	$70,775	$1,076,218
20	$1,025,552	$0	$70,775	$1,096,327

Table H-3. Single Vestas V82, Status Quo.

Year	Operating Revenue ($)			
	Energy Savings	Energy Sales	REC Sales	Total
1	$0	$372,939	$213,108	$586,047
2	$0	$380,398	$213,108	$593,506
3	$0	$388,006	$213,108	$601,114
4	$0	$395,766	$213,108	$608,874
5	$0	$403,681	$213,108	$616,789
6	$0	$411,755	$213,108	$624,863
7	$0	$419,990	$213,108	$633,098
8	$0	$428,390	$213,108	$641,498
9	$0	$436,957	$213,108	$650,065
10	$0	$445,697	$213,108	$658,805
11	$0	$454,611	$213,108	$667,719
12	$0	$463,703	$213,108	$676,811
13	$0	$472,977	$118,683	$591,660
14	$0	$482,436	$79,916	$562,352
15	$0	$492,085	$79,916	$572,001
16	$0	$501,927	$79,916	$581,843
17	$0	$511,965	$79,916	$591,881
18	$0	$522,205	$79,916	$602,121
19	$0	$532,649	$79,916	$612,565
20	$0	$543,302	$79,916	$623,218

Table H-4. Single Vestas V82, Net Metering.

Year	Operating Revenue ($)			
	Energy Savings	Energy Sales	REC Sales	Total
1	$794,893	$0	$213,108	$1,008,001
2	$810,791	$0	$213,108	$1,023,899
3	$827,007	$0	$213,108	$1,040,115
4	$843,547	$0	$213,108	$1,056,655
5	$860,418	$0	$213,108	$1,073,526
6	$877,626	$0	$213,108	$1,090,734
7	$895,178	$0	$213,108	$1,108,286
8	$913,082	$0	$213,108	$1,126,190
9	$931,344	$0	$213,108	$1,144,452
10	$949,971	$0	$213,108	$1,163,079
11	$968,970	$0	$213,108	$1,182,078
12	$988,349	$0	$213,108	$1,201,457
13	$1,008,116	$0	$118,683	$1,126,799
14	$1,028,279	$0	$79,916	$1,108,195
15	$1,048,844	$0	$79,916	$1,128,760
16	$1,069,821	$0	$79,916	$1,149,737
17	$1,091,218	$0	$79,916	$1,171,134
18	$1,113,042	$0	$79,916	$1,192,958
19	$1,135,303	$0	$79,916	$1,215,219
20	$1,158,009	$0	$79,916	$1,237,925

Table H-5. Three GE 1.5sles.

Year	Operating Revenue ($)			
	Energy Savings	Energy Sales	REC Sales	Total
1	$0	$975,982	$557,704	$1,533,686
2	$0	$995,502	$557,704	$1,553,206
3	$0	$1,015,412	$557,704	$1,573,116
4	$0	$1,035,720	$557,704	$1,593,424
5	$0	$1,056,434	$557,704	$1,614,138
6	$0	$1,077,563	$557,704	$1,635,267
7	$0	$1,099,114	$557,704	$1,656,818
8	$0	$1,121,097	$557,704	$1,678,801
9	$0	$1,143,518	$557,704	$1,701,222
10	$0	$1,166,389	$557,704	$1,724,093
11	$0	$1,189,717	$394,184	$1,583,901
12	$0	$1,213,511	$209,139	$1,422,650
13	$0	$1,237,781	$209,139	$1,446,920
14	$0	$1,262,537	$209,139	$1,471,676
15	$0	$1,287,788	$209,139	$1,496,927
16	$0	$1,313,543	$209,139	$1,522,682
17	$0	$1,339,814	$209,139	$1,548,953
18	$0	$1,366,610	$209,139	$1,575,749
19	$0	$1,393,943	$209,139	$1,603,082
20	$0	$1,421,821	$209,139	$1,630,960

Table H-6. Three Vestas V82s.

Year	Operating Revenue ($)			
	Energy Savings	Energy Sales	REC Sales	Total
1	$0	$1,102,038	$629,736	$1,731,774
2	$0	$1,124,079	$629,736	$1,753,815
3	$0	$1,146,560	$629,736	$1,776,296
4	$0	$1,169,492	$629,736	$1,799,228
5	$0	$1,192,881	$629,736	$1,822,617
6	$0	$1,216,739	$629,736	$1,846,475
7	$0	$1,241,074	$629,736	$1,870,810
8	$0	$1,265,895	$629,736	$1,895,631
9	$0	$1,291,213	$629,736	$1,920,949
10	$0	$1,317,037	$612,141	$1,929,178
11	$0	$1,343,378	$236,151	$1,579,529
12	$0	$1,370,246	$236,151	$1,606,397
13	$0	$1,397,651	$236,151	$1,633,802
14	$0	$1,425,604	$236,151	$1,661,755
15	$0	$1,454,116	$236,151	$1,690,267
16	$0	$1,483,198	$236,151	$1,719,349
17	$0	$1,512,862	$236,151	$1,749,013
18	$0	$1,543,119	$236,151	$1,779,270
19	$0	$1,573,982	$236,151	$1,810,133
20	$0	$1,605,461	$236,151	$1,841,612

Appendix I. Overview of Wind Energy Technology

The design of the typical wind turbine has changed greatly over the past twenty years. Although many types of wind turbine designs were initially developed, the "Danish" design of a three-bladed, up-wind horizontal axis turbine has emerged as the standard of the industry.

Although the size and complexity of wind turbines has increased, their basic operating principles have remained virtually unchanged. Figure I-1 from the U.S. Department of Energy shows the typical layout of equipment in a turbine's nacelle, which is the "pod" of equipment at the top of the tower to which the turbine's blades are connected. Wind energy is captured by the wind turbine blades, causing the rotor to rotate the turbine's low-speed shaft. This shaft will rotate at a speed of about 15 to 20 revolutions per minute (RPM). The low speed shaft is then connected to a gearbox, which transfers the energy to the high-speed shaft connected to the generator. The speed of the high-speed shaft depends on the generator type and electrical frequency of the site, but for the U.S. typical speeds are 1,800 and 3,600 RPM. The electrical output of the generator is then transferred to the base of the wind turbine via electrical droop cables. At the base, these cables connect to a transformer, which increases the voltage of the power from the low voltage of the generator (480 or 600 VAC) to the distribution voltage of the plant (anywhere from 12 kV to 46 kV). The orientation of the wind turbine is kept into the wind by a yaw drive, with the wind direction determined by a wind vane located on top of the nacelle. The turbine's controller has independent control of the wind turbine's operation, without requiring commands from a user or central control center. If the controller senses a problem, the wind speed increases beyond the turbine's operational range, or a shut-down command is given manually, the turbine will come to a stop by means of electrical, mechanical, and aerodynamic brakes (the design of which depend on the turbine).

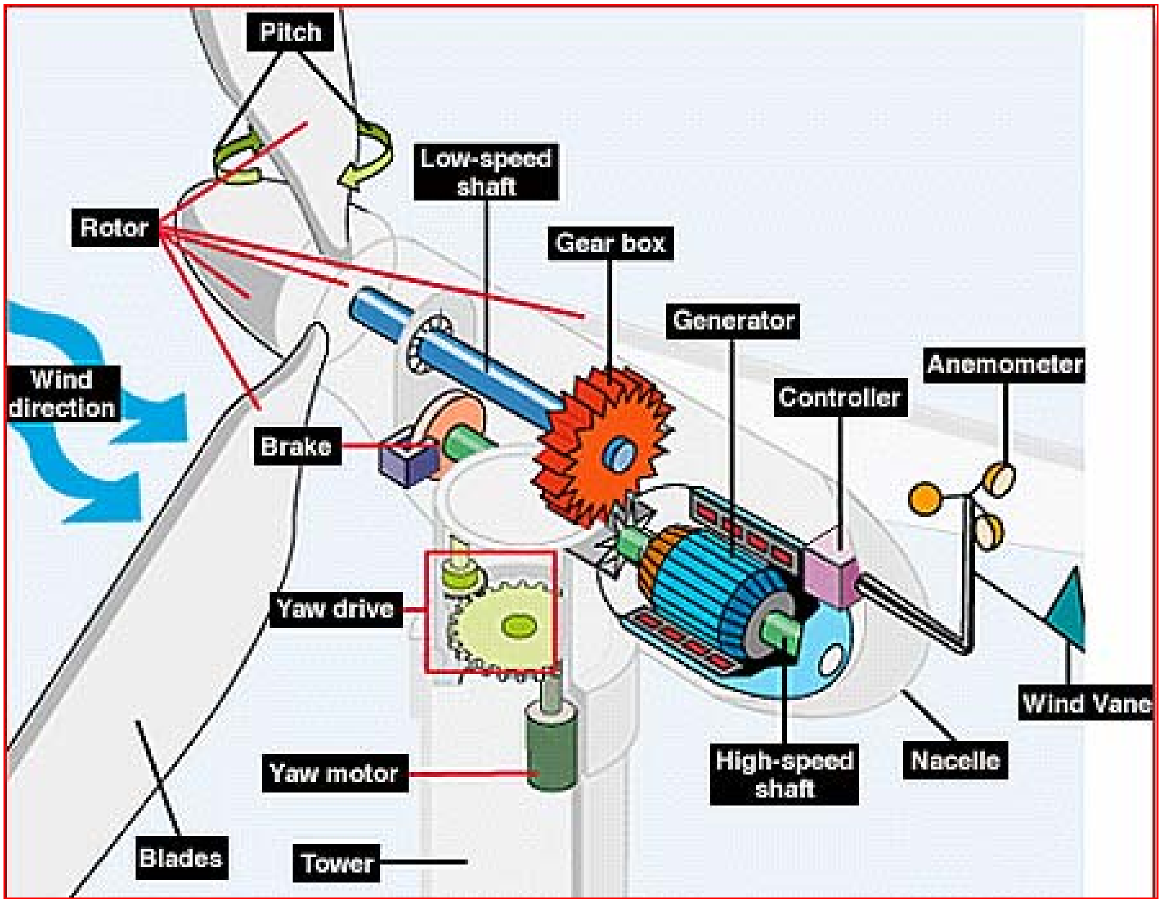


Figure I-1. Wind Turbine Components (from US Dept. of Energy).

Obviously, the output of the wind turbine is dependent upon wind speed. The relationship of a wind turbine's electrical output as a function of wind speed is given in its power curve. A typical curve will show power production beginning when the wind speed increases beyond the turbine's minimum (cut-in) wind speed. As wind speed increases, the output power also increases in a roughly linear manner until the turbine's rated power is reached. The minimum wind speed at which a wind turbine delivers this nameplate output power is called its rated wind speed. For most modern wind turbines, winds higher than the rated wind speed will not produce any additional power, and turbine will continue to output its rated power. If the wind speed increases beyond the safe operating limits of the turbine (cut-out), the turbine will automatically shutdown and wait for the wind speeds to decrease. The wind speeds and power amounts for the above values depend mostly on the size of the wind turbine and the design of the blade airfoils. On average, larger wind turbines have lower cut-in wind speeds, have higher rated power, and reach that power at lower winds.