Large Scale Wind Turbine Siting Map Report

NJ Department of Environmental Protection

September 8, 2009

Introduction

This report documents the methodology and justification used to develop the New Jersey Department of Environmental Protection's (NJDEP) "Large Scale Wind Turbine Siting Map." On September 8, 2009, the Department proposed amendments to the Coastal Permit Program rules and Coastal Zone Management rules to address the development and permitting of wind turbines in the coastal zone. As the height and size of wind turbines increase, so does the potential for adverse impacts to both birds and bats due to the operation of the turbines. The Department has evaluated the land in the coastal zone and prepared the Large Scale Wind Turbine Siting Map (Map) which identifies specific areas where wind turbines 200 feet in height or taller or having a cumulative rotor swept area of greater than 4,000 square feet are unacceptable due to the operational impacts of the turbines on birds and bats (***Figure 1***). In accordance with proposed N.J.A.C. 7:7-7.31 and 7:7E-7.4(r), in order to minimize adverse effects on birds and bats, wind energy facilities located on land shall be sited such that no portion of the wind turbine(s), including blades, towers and site disturbance is located in areas identified on the Map. The map is available for download on the Department's interactive mapping website at www.nj.gov/dep/gis.

The Department's Endangered and Nongame Species Program (ENSP) mapped areas on land of documented bird concentration and nesting for resident threatened and endangered bird species, as well as areas of documented bird concentration and stopover locations for migratory songbirds, migratory raptors, and migratory shorebirds. Regional areas where high migratory bird concentrations are well documented (e.g. the lower Cape May Peninsula and the Delaware Bayshore) were also identified on the Map. Along the Atlantic Coast corridor the rate of migrant bird passage is less well studied and only known concentration areas were included in the Map. The species considered when delineating these regions were those documented to be at risk of colliding with wind turbines and/or those that exhibit flight patterns or behaviors that put them in collision risk.

The Map was created by combining the NJDEP aerial photo-based 2002 land-use/land-cover (2002 LU/LC) data with wildlife locations within the coastal zone where there are high

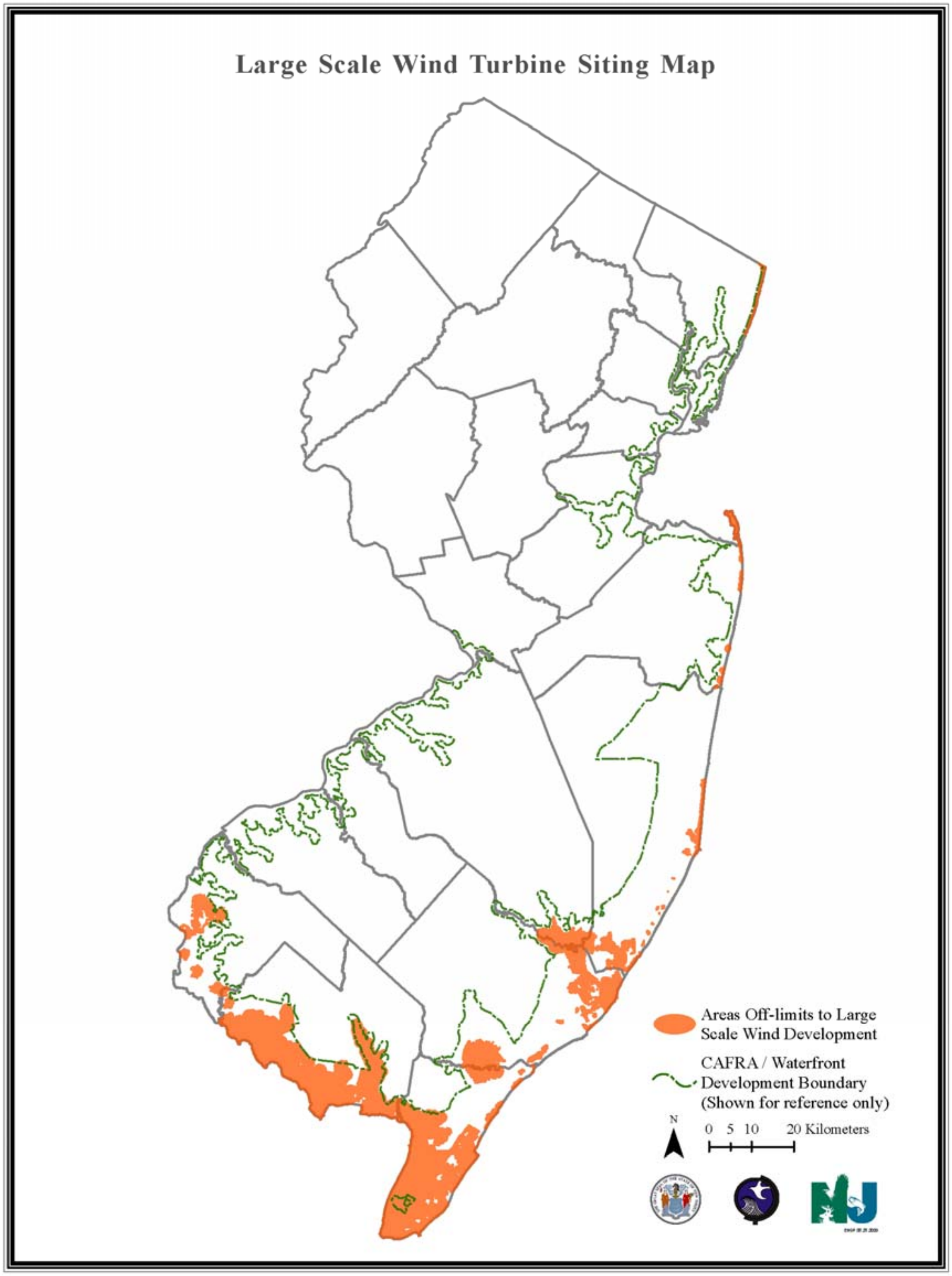


Figure 1. *NJDEP Large Scale Wind Turbine Siting Map*

concentrations of resident and migratory songbirds, raptors, and shorebirds that are considered to be "at risk" of colliding with wind turbines. The 2002 LU/LC depicts the state of the land use and natural land cover statewide in a digital geographic information system (GIS) file, based on aerial photography captured in the spring of 2002. Land use and natural land cover are categorized into TYPE02 and LU02 codes using the Anderson classification system (Anderson et al. 1976). TYPE02 describes the general land-use/land-cover categories and the LU02 codes represent more detailed land-use/land-cover categories (See ***Appendix I*** for a list of 2002 LU/LC categories).

The NJDEP may determine that revisions to the Map are needed in order to minimize adverse effects on birds and bats. Map revisions may be required based on new information on species occurrence or new information on appropriate buffers. In addition, as monitoring is conducted in New Jersey and elsewhere, new information on impacts may become available that leads to a need to change the Map. The proposed rule amendments include provisions addressing revision of the Map.

General Mapping Methodology

Species source feature data for Bald Eagle, Black Skimmer, Least Tern, Black-crowned Night-heron, Yellow-crowned Night-heron, Piping Plover, Red Knot and Migratory Shorebird Concentration Sites were exported from the Biotics database to a file format compatible with GIS. Species-specific buffers (***Table 1***) were applied to these source feature data and were used to clip the 2002 LU/LC. Using the 2002 LU/LC TYPE02 and LU02 codes as a guide, clipped

Common Name	Feature Label	Buffer
Bald Eagle	Nest	1000 meter radius
Black Skimmer	Nesting Colony	400 meter radius
Black-crowned Night-heron	Nesting Colony	300 meter radius
Least Tern	Nesting Colony	400 meter radius*
Migratory Shorebird Concentration Site	Non-breeding - Major	1000 meter radius
Piping Plover	Nest; Nesting Area	400 meter radius
Red Knot	Non-breeding Sighting	1000 meter radius
Yellow-crowned Night-heron	Nesting Colony	300 meter radius

*In some cases an additional 400 meters was added to this buffer to capture flight lines between nesting and foraging areas.

Table 1. *Table showing species and associated buffers.*

areas were evaluated and LU/LC polygons were selected for inclusion in the Map to represent habitat most likely to be utilized by the species. All clipped LU/LC polygons were dissolved with other species and regional (see ***Regional Descriptions*** below) data to form contiguous areas off limits to large scale wind turbine development. Where mapped areas contained more than 50% of a marsh island, the LU/LC polygons that represent the marsh islands were selected and dissolved into the layer. Lastly, all polygons less than one acre were evaluated and those that were both separated from the species source feature by water and on the periphery of a species buffer, were excluded from the Map because they did not protect a significant portion of habitat for the species. For a detailed account of the mapping methodology, consult the species and regional descriptions below.

Species Descriptions

The Department considers the species listed below to be at risk of colliding with wind turbines due to their flight behavior, life history characteristics, and/or because collision events have been documented. Therefore, to avoid adverse impacts to these species as a result of wind-power development, habitats known to be important for the species listed below have been included in the Map and are therefore off limits to large scale wind development.

1) Black Skimmers (nesting colony) and Least Terns (nesting colony):

Explanation of Risk: Black Skimmers and Least Terns are colonial nesting birds (multiple individuals nesting at one location) and both have status as Endangered in the state of New Jersey (N.J.S.A. 23:2A). Least Terns nest primarily on oceanfront beaches on the sandy berm between the high tide line and the toe of the dune (Thompson et al. 1997). Black Skimmers nest on wrack (the dead vegetation that the high tide deposits on the shore) or sandy portions of marsh islands and on sandy oceanfront beaches, generally near inlets (Gochfeld and Burger 1994). Both species are piscivores (fish-eating) and obtain their prey items from the ocean, inlets and bays surrounding their colonies. Capturing fish plays an important role in courtship (males present fish to females) and chick rearing (chicks rely entirely upon the adults for food) so adults make constant foraging commutes between nesting and hunting areas (Atwood and Kelly 1984, Burger and Gochfeld 1990). During these commutes the potential for collisions with wind turbines is high. The courtship behavior in Least Terns includes erratic flights as adults chase potential mates and competing suitors around the nesting colony. These low altitude flights do not have predictable paths and may also contribute to collision risk for this species, when adults are concentrating on courtship and not obstacles in their path (Kisiel, pers. comm., August 2009).

A study conducted on Common, Sandwich and Little Terns (a species that is ecologically similar and taxonomically closely related to Least Terns) in Zeebrugge, Belgium showed these species experienced a relatively high degree of mortality directly related to collisions with wind turbines (Everaert and Stinen 2007). The turbines did not appear to impact the nesting behaviors of the terns, but adults were susceptible to mortal collisions, especially with turbines that were in line with foraging paths. The authors suggested the best strategy to avoid such impacts is to avoid siting turbines in areas between nesting and foraging locations.

Mapping Method: All Black Skimmer and Least Tern nesting colonies contained within the Department's Biotics database were considered for inclusion in the Map. However, only those colonies that met parameters that ENSP identified as significant for the purposes of the Map were included. Significant colonies were defined by three parameters: date since last occupancy, number of years active and number of individuals in the colony. These parameters were applied as follows. Those colonies that were last confirmed as active prior to 1995 were excluded. Colonies active for fewer than three years since 1995 were also excluded, except for those with more than 10 individuals in any one of those years. Colony locations were then evaluated and those surrounded by or within urban areas (LU/LC polygons with TYPE02 coded as "URBAN") were also excluded. Nesting colonies that remained after these criteria were applied were considered significant and were assigned a 400-m buffer. Additionally, for Least Tern nesting colonies, a second 400-m buffer was applied from the outer edge of the initial 400-m buffer, extending a total of 800-m from the colony to capture flight lines between nesting and foraging areas.

The colony buffers were used to clip the 2002 LU/LC. Clipped areas were evaluated and a limited number of LU/LC polygons were selected to represent the actual habitat used by the individual species. Primarily, LU/LC polygons with TYPE02 coded as "BARREN LAND" and "WETLANDS" were selected, as these represent the habitat that Black Skimmers and Least Terns are most likely to utilize. To a lesser degree, polygons with TYPE02 coded as

"AGRICULTURE," "FOREST" and "URBAN" were also selected, often where they were located in foraging flight line paths of Least Terns. Specifically, LU/LC polygons were selected up to 800-m from Least Tern colonies in directions radiating from the colony that represented flight lines between nesting and forging areas where flight lines were directly observed by ENSP biologists. If foraging flight paths were unknown, only LU/LC polygons within the 400-m buffer were selected for inclusion in the Map.

Justification for criteria: Least Terns and Black Skimmers have been closely monitored on an annual basis for over 30 years in New Jersey and the colonies they inhabit have been carefully documented and mapped over that time. Both species show fidelity to nesting areas as long as suitable conditions exist so it is reasonable to assume that any site that has not been used in the past 15 years may not be suitable in its current condition (Gochfeld and Burger 1994, Thompson et al. 1997). Additionally, sites that were active for fewer than three years since 1995 were excluded, unless there were >10 individuals in any one of those years. This form of data filtering was carried out because small, infrequently used colonies are less critical to sustaining the state population and potential impacts of wind turbines are best assessed on a case-by-case basis. Colonies located in urban areas were excluded because it was determined they should be evaluated on a case-by-case basis.

Justification for 400-m buffer: No peer reviewed literature recommending a safe separation distance for Least Tern and Black Skimmer nesting colonies from large wind turbines was found during the development of this document. Although the research conducted in Belgium found that collisions occurred when turbines were located in foraging flight line paths, and the authors suggested avoiding siting turbines in these locations, no recommendation as to suitable set-back distances was presented (Everaert and Stienen 2007). However, the authors did provide a scaled map of the nesting area and the turbine array. Based on the information that could be garnered from this map, ENSP biologists determined that a 400-m buffer, with some areas protected up to 800-m, would be adequate to protect the majority of adults in the area directly around a colony (allowing for safe passage in and out of the colony for foraging and for courtship flights).

Justification for LU/LC: Black Skimmers and Least Terns are both species that nest and forage in natural locations such as beaches and coastal marshes (Atwood and Kelly 1984, Burger and Gochfeld 1990). These habitats are labeled as "BARREN LAND" and "WETLANDS" in the LU/LC 2002 and therefore LU/LC polygons with TYPE02 coded as "BARREN LAND" and "WETLANDS" were selected for inclusion in the Map to represent habitat for these two species. In addition, as highly mobile, flying organisms, Least Terns and Black Skimmers will fly over many different habitat types to commute between foraging and nesting areas, even if they do not directly use those habitats (i.e., "URBAN" or "FOREST"). In the cases where flight paths have been directly observed by ENSP biologists, LU/LC polygons along these flight paths were selected for inclusion in the Map regardless of the TYPE02 code.

2) Black-crowned Night-heron (nesting colony), Yellow-crowned Night-herons (nesting colony):

Explanation of Risk: Black- and Yellow-crowned Night-herons are colonial nesting birds (multiple individuals nesting at one location) and both have status as Threatened in the State of New Jersey (N.J.S.A. 23:2A). The majority of night-herons in New Jersey are located in the Atlantic coastal marshes where they nest in Atlantic red cedars, marsh elders and phragmites (Kisiel, pers. comm.). There are also smaller colonies located in residential areas throughout the coastal region, especially for Yellow-crowned Night-herons (Kisiel, pers. comm.). Night-herons consume a wide range of aquatic based prey items, although Yellow-crown Night-herons focus on crustaceans (Kushlan 1978, Watts 1995). To obtain their prey, adults will make foraging commutes between nesting and foraging areas (Davis 1993, Watts 1995). These commutes are where the potential for collisions with turbines may become a concern. Although no direct studies have detailed the potential for collision with night-herons, the possibility of collisions exists. This is especially true for young of the year who are inexperienced fliers. At a heronry at Armacost Park, Avalon, NJ, there were reports of several young Great and Snowy Egrets that were killed when they struck utility wires immediately adjacent to the colony (C. David Jenkins, Jr., pers. comm. August 2009). Furthermore, night-herons derive their name from their habits of being crepuscular (active at dawn and dusk) and nocturnal (active at night), when low light conditions make objects less visible (Davis 1993, Watts 1995). This behavior may further increase the potential collision risk for these species.

Mapping Method: All Black- and Yellow-crowned Night-heron nesting colonies contained within the Department's Biotics database were considered for inclusion in the Map. However, only those colonies that met parameters that ENSP identified as significant for the purposes of the Map were included. Significant colonies were defined by three parameters: date since last occupancy, number of years active and number of individuals in the colony. These parameters were applied as follows. Any nesting colonies documented to be active on at least three aerial surveys conducted by ENSP since 1995 (surveys of long-legged wading birds, including Black- and Yellow-crowned Night-herons, were conducted by ENSP in 1995, 2001, 2004, 2005 and 2008), regardless of number of individuals observed, were included in the Map. Colonies that were only active for two aerial surveys since 1995 were included only if the sum of the Black- and/or Yellow-crowned Night-heron individual count (these two species frequently nest in the same colonies) was more than 10 in any single survey. Finally, any colonies that were located in residential or urban areas were excluded. Nesting colonies that remained after these criteria were applied were considered significant and assigned a 300-m buffer.

The colony buffers were used to clip the 2002 LU/LC. Clipped areas were evaluated and a limited number of LU/LC polygons were selected to represent the actual habitat used by the individual species. Primarily, LU/LC polygons with TYPE02 coded as "WETLANDS" were selected, as these represent the habitat that Black- and Yellow-crowned Night-herons are most likely to utilize for nesting and roosting. LU/LC polygons with TYPE02 coded as "BARREN LAND" and "FOREST" were also selected, as they represent habitats that herons use, albeit to a lesser degree than they use wetlands.

Justification for criteria: Black- and Yellow-crowned Night-herons have been closely monitored on a regular basis for over 30 years in New Jersey and the colonies they inhabit have been carefully documented and mapped over that time. Colony turnover is characteristic of these species but it is reasonable to assume that any site that has not been used in the past 15 years may not be suitable in its current condition (Davis 1993, Watts 1995). Sites noted as active on fewer than three aerial surveys since 1995 were not used, unless there were more than 10 individual Black- and/or Yellow-crowned Night-herons observed during two surveys during this time period. This was because small, infrequently used colonies are less critical to sustaining the state population and potential impacts of wind turbines are best assessed on a case-by-case basis. Colonies located in residential or urban areas were excluded because it was determined they should be evaluated on a case-by-case basis through the permitting process.

Justification for 300-m buffer: At the time of this publication, there were no recommendations relating to the impact of wind turbines on night-herons available in the literature. Night-heron behavior differs from other State-listed avian species, such as Least Terns, since night-heron foraging and courtship behaviors do not include erratic flight patterns. Instead, night-heron courtship generally takes place at the nesting colony and they forage from the ground using a stalking technique that is much different from the hover and plunge method employed by terns foraging over water. Night-herons may therefore be less susceptible to collisions with large turbines than terns.

Absent studies documenting the specific impacts of wind turbines on these species ENSP biologists used best professional judgment to select a 300-m buffer around a breeding colony. This will provide a turbine-free area immediately around the colony to ensure that the night-herons will be able to safely enter and leave their nesting colonies when travelling to and from foraging areas. For the areas located around colonies, but outside the prohibitive zone, applicants should perform an evaluation of flight patterns to and from the colony and/or perform site-specific evaluations regarding the available foraging habitat around the colony to help properly site the wind turbine(s).

Justification for LU/LC: The LU/LC polygons selected were those that represented the habitat utilized by these two species for nesting and foraging. Although it is assumed the species fly over urban and other land-use/land-cover types when commuting between nesting and foraging areas, not enough data exists to map those corridors. Therefore, LU/LC polygons were not selected along assumed flight paths in this version of the map.

3) Piping Plover (nest and nesting area):

Explanation of Risk: Piping Plovers are a federally listed Threatened species on the Atlantic coast and a state listed Endangered species in New Jersey (N.J.S.A. 23:2A, N.J.A.C. 7:25-4.13). They defend a nesting area against other individuals and lay their eggs on the sandy berm between the high tide line and the toe of the dune (Elliot-Smith and Haig 2004). Piping Plover numbers in New Jersey have not significantly increased since the time of listing in 1984 (Pover 2008). The US Fish and Wildlife Service recovery plan for the Atlantic Coast population of Piping Plover indicates that the species has been shown to be highly susceptible to human disturbance, and that additional pressure on the population, such as the potential for adult mortality from collisions with turbines, are not acceptable (USFWS 1996). Furthermore, Piping Plovers engage in low altitude courtship flights around their nesting areas and a nearby turbine could pose a collision risk to adults engaged in courtship flights (Kisiel, pers. comm., August 2009).

Mapping Method: All Piping Plover nesting areas contained within the Department's Biotics database were considered for inclusion in the Map. However, only those nesting areas that met parameters that ENSP identified as significant for the purposes of the Map were included. Significant nesting areas were defined by three parameters: date since last occupancy, number of years active, and number of individuals in the nesting area. These parameters were applied as follows. Those areas that were last documented as active prior to 1995 were excluded. Any nesting areas that were active for fewer than three years since 1995 were also excluded unless they had more than two pairs of nesting Piping Plovers in any one of those years. Nesting areas that remained after these criteria were applied were considered significant and assigned a 400-m buffer.

The nesting area buffers were used to clip the 2002 LU/LC. Clipped areas were evaluated and a limited number of LU/LC polygons were selected to represent the actual habitat used by this species. Primarily, LU/LC polygons with TYPE02 coded as "BARREN LAND" and "WETLANDS" were selected, as these represent the habitat that Piping Plovers are most likely to utilize during the breeding season.

Justification for filter: Piping Plovers have been closely monitored on an annual basis for over 20 years in New Jersey. Site occupation is highly correlated with the presence of suitable habitat. Adults will abandon sites when conditions are no longer favorable for nesting (Kisiel 2009). Therefore, sites that have not been active in the last 15 years are likely to be unsuitable for nesting in their current condition. Additionally, sites that were active for fewer than three years since 1995 were not included in the map, unless there were more than two pairs in any one of those years. Piping Plovers display a high degree of site fidelity and infrequently used sites with few pairs are not likely to become significant nesting areas in the state (Kisiel 2009).

Justification for 400-m buffer: In addition to its state status as endangered, the Atlantic Coast population of Piping Plover is federally listed as threatened. There are no published studies that have established the impact of wind turbines on Piping Plovers, nor have any recommendations been made by the federal agencies responsible for setting the management guidelines for this species. Therefore, until such data is available, a 400-m buffer, based on a general estimate of the core area a Piping Plover will utilize during the breeding season and the best professional judgment of ENSP biologists, was applied to protect the nesting habitat of this species from the uncertain impact of wind turbines. This distance will provide a conflict-free area between the nesting areas that the plovers spend the majority of their time breeding and foraging in and the location of a turbine.

Justification for LU/LC: Piping Plovers are more highly tied to their nesting locations within the breeding season than some other species included in this map. The breeding territories they defend generally include both their foraging and nesting areas. In New Jersey, foraging areas are typically located short distances (on average 40-400 m from nests, although broods have rarely been documented traveling as many as 2,000+ m) from nesting areas and the two are often adjacent to one another (Kisiel, pers. comm.). This species does not typically participate in the types of foraging commutes that some of species represented on this map do, such as Least Terns. Therefore, based on the 2002 LU/LC TYPE02 codes and LU02 codes, only suitable LU/LC polygons located within the buffer were selected.

4) Red Knot (non-breeding sighting) and Migratory Shorebird Concentration Site (major):

Explanation of Risk: The abundance and density at which migratory shorebirds and Red Knot concentrate in New Jersey (especially during spring migration) elevates the Department's concern that these species will be impacted by wind turbines in some areas of the coastal zone. Each spring, the Delaware Bay and some Atlantic coast sites host large concentrations of migrant shorebirds of six major species (>500,000 - 1,000,000 individuals). Large numbers of birds coupled with a high frequency of flights (day and night) across Delaware Bay and southern Atlantic Coast wetlands (Sitters 2001, 2003, 2005) increase the risk for collisions with wind turbines because their density and flight behavior (e.g., low altitude and nocturnal flights) would create high exposure to wind facilities if such facilities were constructed near shorebird concentration sites.

Shorebirds are known to move among roosting and foraging areas at night as they follow the rising and falling of the tide (Sitters 2001, 2003, 2005). Nighttime flight behavior elevates concerns about collision risk because turbines placed in the flight paths of birds will be less visually apparent and avoidance of the rotor-swept area may be more difficult for these species at night. This risk is amplified by the fact that many shorebird species, including Red Knot, make low-altitude flights (from just above the water to ~150-m) between and among foraging and roosting areas in the region (A. Dey, pers. obs., 2005-2009), and remain mobile during poor weather conditions such as rain or fog. In fact, poor weather conditions that cause physical stress to migrating birds and increase their need to feed (Burger and Olla1984) and thus require their movements among tidal foraging areas. Poor visibility caused by precipitation and/or fog, especially at night, greatly increases the risk of collisions with turbines (Erickson et al. 2001, Johnson et al. 2002, Drewitt and Langston 2006).

Mapping Method: All Red Knot non-breeding sightings and Major Migratory Shorebird Concentration Sites contained within the Department's Biotics database were initially considered for inclusion in the Map. Excluded from the Map were: 1) single sightings of one Red Knot at a given location constituting the only data for that location, and 2) where recent data were not available to validate current use of historic, Major Migratory Shorebird Concentration Sites documented before 1983. Major Migratory Shorebird Concentration Sites are defined as "Sites that provide foraging, resting, and roosting habitat for migrating and wintering shorebirds on an annual basis." These sites typically support hundreds to tens-of-thousands of shorebirds (>30 species) during periods of north- and south-bound migration, and hundreds to >6,000 wintering shorebirds (≥ six species) (NJ DFW, unpublished data, 2004-2008). Delaware Bay beaches annually support >500,000 spring migrant shorebirds, and together with adjacent marsh, the Bay is estimated to support ≥ 1,000,000 shorebirds (≥ six major species; see Clark et al. 2009 in Appendix II). Red Knot non-breeding sightings and Major Migratory Shorebird Concentration Sites were assigned a 1-km buffer.

The Red Knot non-breeding sighting and Major Migratory Shorebird Concentration Site buffers were used to clip the 2002 LU/LC. Clipped areas were evaluated and a limited number of LU/LC polygons were selected to represent suitable habitats. Suitable habitats are those that Red Knot and other shorebirds have been documented to use for foraging, roosting, resting and sheltering (Clark et al. 1993, Burger et al. 1997, Meyer 1999, Niles et al. 2008) and include linear beaches; inlets with associated sand beach, sand spits, tidal sand flats; wetlands and associated tidal mud flats (Clark et al. 1993, Burger et al. 1997, Meyer 1999, Niles et al. 2008). Accordingly, LU/LC polygons with TYPE02 coded as "BARREN LAND" and "WETLANDS" were primarily selected for inclusion in the Map. Generally, LU/LC polygons with TYPE 02 coded as "URBAN" were excluded, except in cases where they directly separated the Major Migratory Shorebird Concentration Sites or the Red Knot non-breeding sightings from Delaware Bay or Atlantic Ocean (NJ DFW unpublished resightings data, NJ DFW unpublished survey data) or in cases where urban areas were within the direct flight path documented by telemetry study of radio-tagged red knots (Sitters 2001, 2003, 2005). In these limited situations, LU/LC polygons with TYPE02 coded as "URBAN" were selected for inclusion in the Map.

Justification for 1-km buffer: Shorebird movements between foraging and roosting habitats are integrally linked to tidal cycles. Birds make frequent flights between habitats to take advantage of food resources on falling tides, roost areas on rising tides, to avoid human disturbance, and escape predators (Burger and Olla1984, Clark et al. 1993, Meyer 1999, Niles et al. 2008).

The 1-km buffer around Major Migratory Shorebird Concentration Sites, Red Knot (non-breeding) occurrences is a conservative approach that ENSP biologists believe will protect these important sites from operational disturbance of turbines and may reduce potential for direct impacts (i.e., strikes) where large numbers of shorebirds concentrate. The 1-km buffer is conservative because it is based on minimum movement distances of fall migrant shorebirds on the Atlantic Coast where migration movements have been less well studied (see below). Where direct observational data on movements of individuals, and direct flight paths from telemetry, between habitats exist, these data were used to delineate polygons. The inclusion of the lower 20-km of the Cape May Peninsula and the entirety of the Delaware Bay shore in the Map was supported by 25 years of ENSP aerial and ground surveys, studies on movements of marked red knots between Delaware Bay and Atlantic coast habitats (spring and fall), and radio telemetry data used to value land areas (e.g., the lower 20 km of Cape May Peninsula) that lie on the direct flight path between Major Migratory Shorebird Concentration Sites that receive high use (flyovers) by very large numbers of shorebirds (spring; see Clark et al. 2009 in Appendix II). Where direct observational data on movements and flight paths did not exist, a 1-km buffer was applied to Major Migratory Shorebird Concentration Sites and Red Knot (non-breeding) occurrences.

A 1-km buffer represents minimum movement distances of Red Knots studied on the Atlantic Coast in fall migration. In 2007, a pilot study on movements of marked Red Knots in Hereford Inlet, NJ (Stone Harbor Point and North Wildwood) showed that birds spent significant time at this stopover in the fall and readily moved between Stone Harbor Point and North Wildwood. Surveys of marked Red Knots at Hereford Inlet on eight survey days (July 30 to December 18, 2007) showed the stopover duration of 21 marked Red Knots ranged from 1 to 91 days (mean 27 days), and at least six marked individuals were observed on both sites (mean minimum distance travelled was 2.5 km).

5) Bald Eagle (nest):

Explanation of Risk: Eagles are large birds with relatively high wing loading (the ratio of body weight to wing area – how much "load" each unit area of wing must carry; Able 2001) and are therefore less able to maneuver around obstructions compared to smaller, more agile birds. One of the leading causes of Bald Eagle (*Haliaeetus leucocephalis*) mortality is impact injuries: of 1,428 Bald Eagles necropsied by the USGS National Wildlife Health Center, 1963-1984, 23% died from trauma, primarily impacts with wires and vehicles (as cited in Buehler 2000). Similarly, 24% of bald eagles in Maryland, 1988-2004, died of collision-type trauma, for those with a known cause of death (Driscoll et al. 2004). Bald Eagles are also susceptible to collision with powerlines, causing injury and death due to impact or from electrocution (Buehler 2000, Driscoll et al. 2004). Fifty-four Golden Eagles (*Aquila chrysaetos*) were killed by turbines in the Altamont Pass in California, 1998-2003, accounting for 10% of all raptors killed (Smallwood and Thelander 2008). While Bald Eagles differ somewhat in their flying and hunting behaviors, they are like Golden Eagles in overall size and dimensions.

Bald eagles use the open waters of Delaware Bay, creeks and rivers for foraging, and the Bayshore forests and woodlands for roosting (Paturzo and Clark 2003, NJ DEP Biotics database July 2009). The U.S. Fish and Wildlife Service (USFWS 2007), in its Bald Eagle Management Guidelines, makes this specific recommendation: "Minimize potentially disruptive activities and development in the eagles' direct flight path between their nest and roost sites and important foraging areas."

Mapping Method: Important Bald Eagle nesting, foraging and wintering areas were included in the Map primarily through a regional mapping approach. Refer to the regional sections for *Little Egg, Brigantine Inlets, and Mullica River Region*; *Stow Creek and Mannington Meadows; Great Egg Harbor*; and *Cape May Peninsula and Delaware Bay Shore* (Sections 2, 5, 6 and 8 below). All Bald Eagle nests contained within the Department's Biotics database that were outside of the regionally mapped areas were considered for inclusion in the Map. However, only a limited number of nests along the upper Delaware Bay were included. Specifically, nests in the following areas of Salem and Cumberland counties were selected for inclusion in the Map: Mannington-Canton, Lower Salem-Supawna, Mill Creek/Elsinboro, Alloways Creek, and Lower Stow Creek. These Bald Eagle nests were assigned a 1-km buffer. The habitats in these nest areas were identified in the Map for their importance to the State's Bald Eagle population, and because their general locations could be identified without undue concern for the security of the nest and its continued use by eagles. Other Bald Eagle nest areas where turbines will be prohibited were not included in the Map due to the necessity of protecting nest areas from general discovery and the human disturbance that often accompanies such sites.

The nest buffers were used to select intersecting 2002 LU/LC. Intersecting LU/LC was evaluated and a limited number of LU/LC polygons were selected to represent the actual habitat used by this species. Generally, LU/LC polygons with TYPE02 coded as "URBAN" were excluded, except in cases where low-density "URBAN" polygons were located fully within the 1-km buffer and surrounded by suitable habitat, or where "URBAN" polygons were located directly in the path between a nest and foraging habitat.

6) Osprey:

Explanation of Risk: The habits of nesting Ospreys (*Pandion haliaetus*) make them vulnerable to collision with turbines placed within the same airspace (altitudes less than 150 m). Most Osprey nest structures are human-made specifically for Ospreys, which in the salt marsh tend to be <7 m high. Ospreys also nest on other human-made structures like channel markers (less than 7 m high) and cell towers (~70 m high). They tend to hunt the shallow waters of the Atlantic Coast back bays and tributaries. In hunting, they nearly always fly (as opposed to perching and waiting), and often circle and hover while in flight at altitudes less than 150 m (Poole 1989). Ospreys may fly higher (100-300 m) while searching for schools of fish, but drop down again before diving to attempt a catch (as described in Poole 1989). Three raptors (two Ospreys and one Peregrine Falcon) are known to have been killed at the five wind turbine array located in the wetlands near Atlantic City after one year of monitoring as a result of colliding with turbines (Mizrahi et al. 2008). The Osprey that was killed in 2007 was an adult that was banded as a nestling in 1999. This bird was therefore eight years of age, was an experienced bird, and was likely to have been nesting in the area. That Osprey mortality occurred in an area of relatively sparse Osprey nesting density and much less dense than the regions ENSP defined in mapping. The risk of collision and mortality is much higher in the dense nesting colonies identified on the Map.

Mapping Method: Important Osprey nesting areas were included in the Map through a regional mapping approach. Refer to the regional sections for *Hereford Inlet and the back-bay areas west of Stone Harbor*; *Little Egg, Brigantine Inlets, and Mullica River Region*; *Sedge Island and Island Beach State Park; Gateway National Recreation Area - Sandy Hook Unit; Great Egg Harbor*; and *Cape May Peninsula and Delaware Bay Shore* (Sections 1, 2, 3, 4, 6 and 8 below).

7) Northern Harrier:

Explanation of Risk: The habits of nesting and foraging Northern Harriers (*Circus cyaneus*) make them vulnerable to collision with turbines placed within the same airspace (<100 m). Harriers nest on the ground in high marsh (i.e., salt marsh that lies above normal high tide levels), and forage over marshes, fields, bushes and edges with low vegetation (Liguori 2003).

During the nesting season, females (in particular) tend to hunt within the marsh patch, while males, in addition to foraging in the marsh, often seek prey along upland edges or fields and may fly considerably further than females (Liguori 2003). Harriers hunt exclusively in flight, and generally fly at low altitude (less than 30 m) in a back-and-forth manner known as "quartering" over the marsh, and often circle and hover as they seek prey (Bent 1961). In early spring, harriers may fly above 160 m in the course of courtship displays, although courtship flights normally average approximately 20 m (Bent 1961). Their similarity to Ospreys in flight habits make harriers similarly vulnerable to collision with turbines and it is clear that Ospreys are vulnerable to collisions with turbines because two Ospreys were found dead at the Atlantic City Utilities Authority wind turbine site in one year of post-construction surveys, 2007-2008 (Mizrahi et al. 2008). Harriers occupy similar habitats throughout the year, so the large patches of marsh identified in mapping support nesting, migrant and wintering harriers.

Mapping Method: Important Northern Harrier habitats and flight paths were included in the Map through a regional mapping approach. Refer to the regional sections for *Little Egg, Brigantine Inlets, and Mullica River Region*; *Great Egg Harbor*; and *Cape May Peninsula and Delaware Bay Shore* (Sections 2, 6, and 8 below).

8) Peregrine Falcon:

Explanation of Risk: Peregrine Falcons, like other raptors, are vulnerable to collision with turbines (Barrios and Rodriguez 2004, Driscoll et al. 2004, Smallwood and Thelander 2008). Underscoring the findings of those studies, Mizrahi et al. (2008) documented one peregrine killed at the Atlantic City Utilities Authority's five-turbine array in 2007. A peregrine's means of hunting included pursuing other birds in flight at high speed, throughout the airspace of 0-200 m (White et al. 2002). This puts them at high risk of collision and impact injuries with wires, poles, buildings and other structures, and is the main cause of injury and death for peregrine falcons (White et al. 2002). Some Peregrine Falcons nest on Hudson River cliffs, but the core of the State's population nests on man-made structures in the coastal zone (Clark 2008). Maintaining secure Peregrine Falcon nesting in this zone is essential to maintaining the peregrine population in the State.

Mapping Method: Important Peregrine Falcon habitats were included in the Map through a regional mapping approach. Refer to the regional sections for *Little Egg, Brigantine Inlets, and Mullica River Region*; *Great Egg Harbor*; and *Palisades*; (Sections 2, 6, and 7 below).

Regional Descriptions

The regions described below represent areas within the New Jersey coastal zone where birds are known to concentrate or where rare species nest. The species considered in the delineation of these regions were those species documented to be at risk of colliding with wind turbines and/or species that exhibit flight patterns or behaviors that put them in collision risk. These regions were included in Large Scale Wind Turbine Siting Map because the Department determined that the development of large wind turbines in these regions was unacceptable due to the potential for operational impacts to birds and/or bats.

1) *Hereford Inlet and the back-bay areas west of Stone Harbor:*

Mapping Method: A polygon was digitized to capture all known Osprey nests in the back bays and marshes west of Stone Harbor and Avalon. This polygon was used to select NJDEP 2002 LU/LC polygons containing suitable habitat for osprey; these polygons were then dissolved to create the region (***Figure 2***).

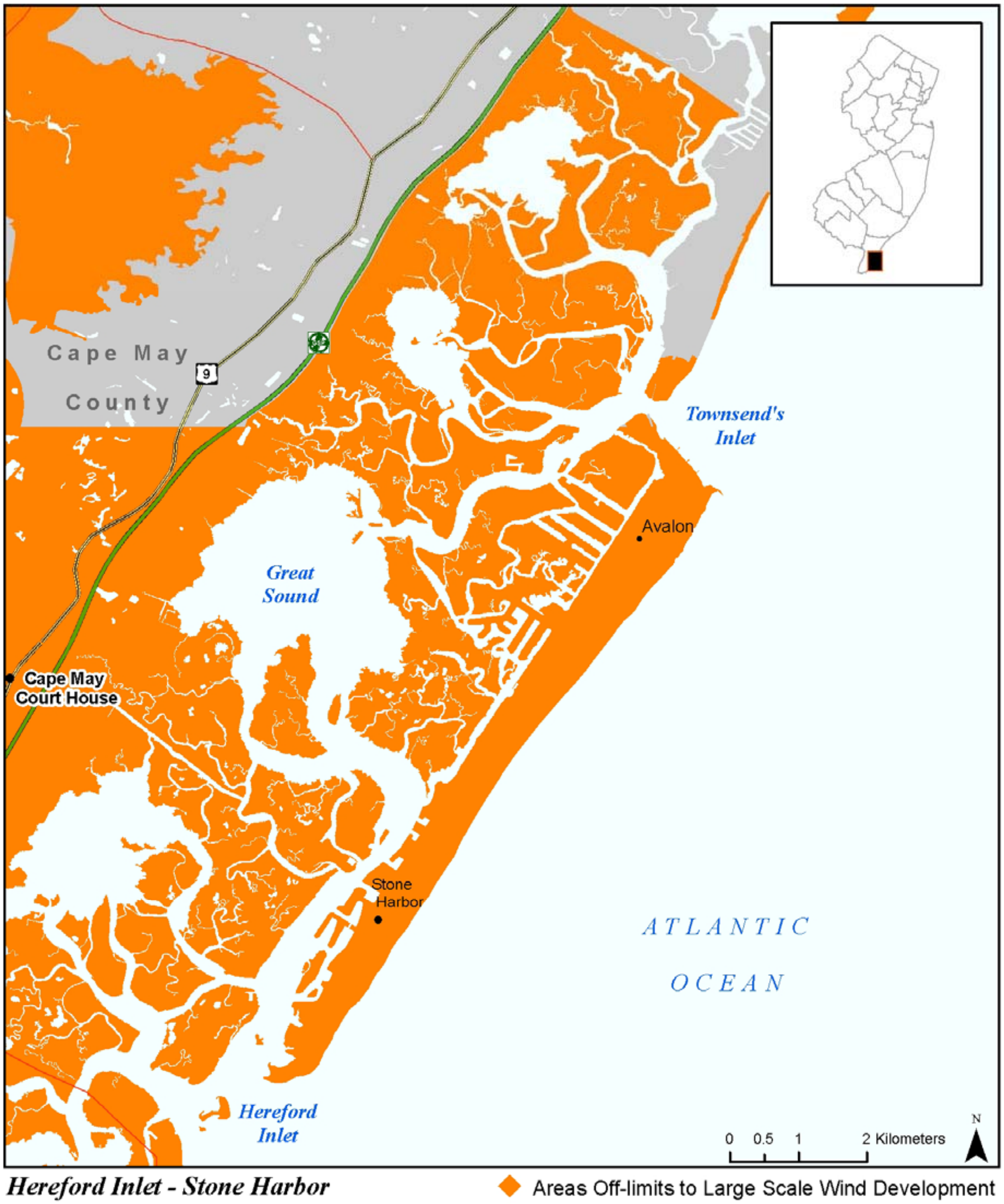


Figure 2. *Map of Hereford Inlet and the back-bay areas west of Stone Harbor.*

Justification: This area includes the most dense and largest concentration of nesting Ospreys in the state (Clark 2004, Clark 2008, NJDEP Biotics Database). In addition to this area's Osprey concentration, the area includes a Peregrine Falcon nest active since 2001. The shallow waters provide excellent foraging habitat for Ospreys in close proximity to their nests. Ospreys in such concentration within a nesting area, and their behavior of hovering while foraging, make them particularly vulnerable to direct (collision) and indirect (exclusion) effects of turbine development. After one year of monitoring, Mizrahi et al. (2008) reported two Ospreys and one Peregrine Falcon killed by the array of five wind turbines near Atlantic City. Raptors have been one of the groups most vulnerable to collision with turbines and power lines (Barrios and Rodriguez 2004, Driscoll et al. 2004, Smallwood and Thelander 2008).

2) *Little Egg, Brigantine Inlets, and Mullica River Region:*

Mapping Method: LU/LC polygons were selected to approximate the boundaries of federally-owned Holgate and Little Beach (part of Forsythe National Wildlife Refuge), and state-owned North Brigantine Natural Area and Great Bay Boulevard Wildlife Management Area. A small number of the northeastern-most islands of the Absecon Wildlife Management Area were also selected. In addition, polygons were digitized to capture all known Osprey nests, Bald Eagle foraging and wintering areas, Northern Harrier nests, and Peregrine Falcon nests in this region. These polygons were used to select LU/LC polygons containing suitable habitat for these species. All selected LU/LC polygons were dissolved to create the region (***Figure 3***).

Justification: The complex that consists of portions of Forsythe National Wildlife Refuge (particularly Holgate, Little Beach and the “wildlife drive” of the Refuge), North Brigantine Natural Area and Great Bay Boulevard Wildlife Management Area represents the least developed portion of the entire New Jersey coast. There is no development on the smaller marsh islands, Holgate, Little Beach or North Brigantine, representing unparalleled refuge and habitat for wildlife along the coast in the state. Forsythe National Wildlife Refuge is part of the Western Hemisphere Shorebird Reserve Network and is designated a Wetlands of International Importance by the Ramsar Convention. Little Beach and Holgate also have federal designation as a Wilderness Area (http://www.whsrn.org/, http://www.ramsar.org/key_sitelist.htm). Virtually all of the area has been deemed as Important Bird and Birding Areas by New Jersey Audubon Society as well as a globally significant Important Bird Area by National Audubon (http://www.njaudubon.org/Conservation/IBBA/, http://www.audubon.org/bird/IBA/). Most of the area has also been designated a Natural Heritage Priority Site by NJDEP (http://www.nj.gov/dep/gis/digidownload/images/statewide/prisites.gif). Tens of thousands of wintering waterfowl use this area, and about a third of the state's nesting pairs of Piping Plovers have consistently been located in the mapped region (http://www.njaudubon.org/Tools2.Net/IBBA/SiteDetails.aspx?sk=3155, Pover 2008). Large numbers of Ospreys nest here and the habitat provides excellent stopover habitat for migrating shorebirds and songbirds. This region also contains concentrations of wintering and foraging Bald Eagles and Osprey nests that co-occur with critical habitats for Northern Harrier, Peregrine Falcon and migratory shorebird stopover habitats.

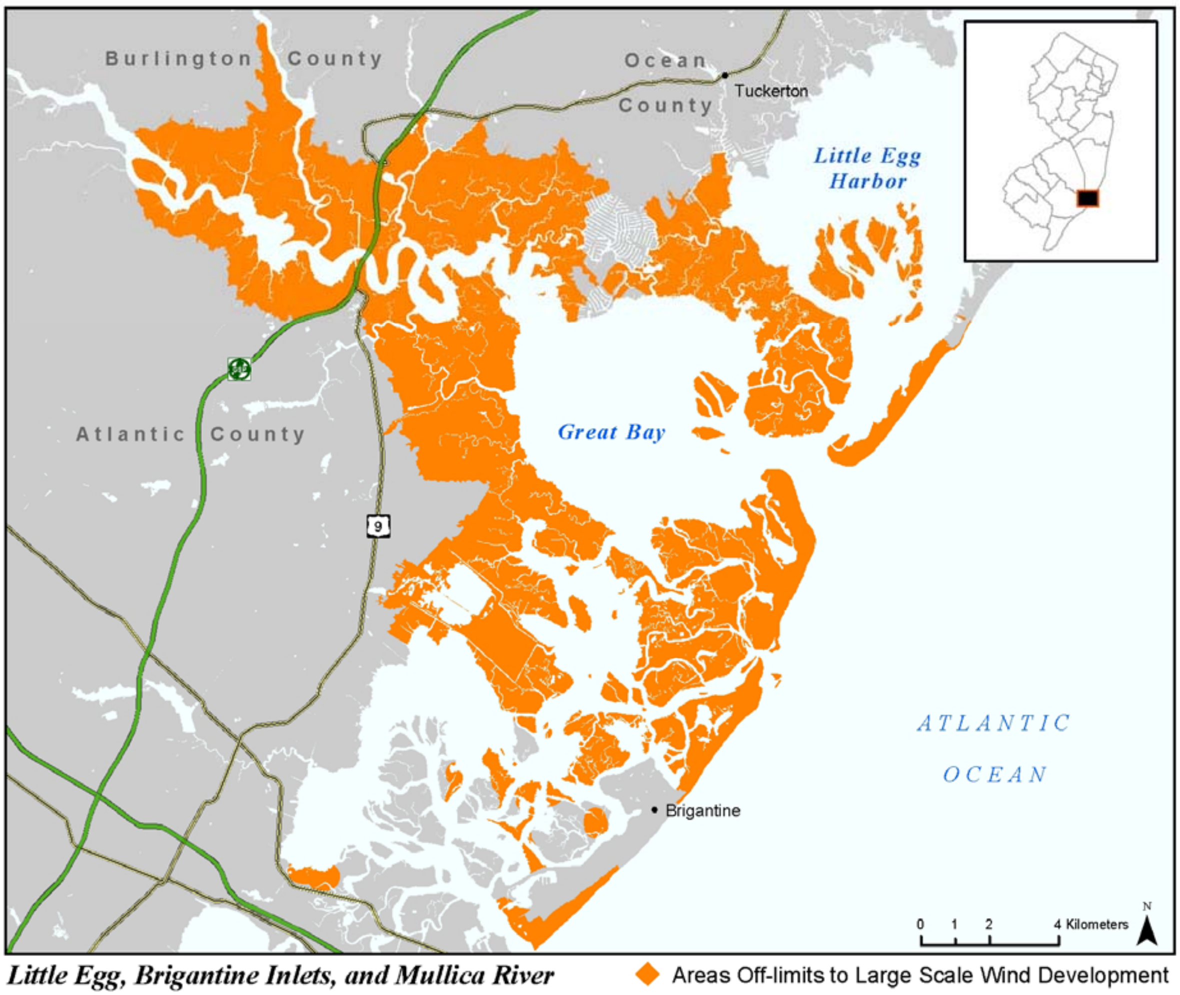


Figure 3. *Map of Little Egg, Brigantine Inlets, and Mullica River Region.*

3) Sedge Island and Island Beach State Park:

Mapping Method: LU/LC polygons were selected to approximate Island Beach State Park and most of the Sedge Island Wildlife Management Area (WMA). Where necessary, additional LU/LC polygons were selected to capture all known Osprey nests in the Sedge Island WMA and the southern shore of Island Beach State Park. All selected LU/LC polygons were dissolved to create the region (***Figure 4***).

Justification: Island Beach State Park is 9.6-miles (15.4 km) long and contains 3,000 acres (1,214 ha) of almost entirely undeveloped barrier island (Boyle 2004). On its southern end, marsh islands in Barnegat Bay that are part of Sedge Islands Wildlife Management Area solidify the status of this area as one of the most pristine locations left in New Jersey. One of the densest nesting colonies of Ospreys in the state is located in Sedge Islands WMA and southern tip of Island Beach State Park, totaling about 30 pairs, with nests generally located <500 m apart (NJDEP Biotics Database). The area also supports one of the oldest Peregrine Falcon nests in the state, also in Sedge Islands WMA. Many species of shorebirds (including Black-bellied Plovers, Dunlin, Least Sandpipers, Willets and Piping Plover) use the barrier and marsh islands here for both migratory and breeding habitat. Wintering waterbirds (including loons, Northern Gannets, scoters and Long-tailed Ducks) are present in large numbers during the migratory season and many stay through the winter months. The vast expanse of maritime forest and scrub-shrub communities throughout the park serve as stopover, wintering and breeding habitat for large numbers of songbirds (http://www.njaudubon.org/Tools2.Net/IBBA/SiteDetails.aspx?sk=3162). In general, Atlantic coastal habitats are considered especially important to migrating land birds that may be carried to the coast (and over the ocean) as they migrate south in fall (McCann et al. 1993). The NJDEP designated Island Beach State Park as a Natural Heritage Priority Macrosite for its significant habitats and the New Jersey Audubon Society has designated Island Beach as an Important Bird and Birding Area because of its value to shorebirds and raptors (http://www.nj.gov/dep/gis/digidownload/images/statewide/prisites.gif http://www.njaudubon.org/Conservation/IBBA/,). Bat use is not well understood at this site, but it is likely that utilization of this area is high among bats traveling along the coastal corridor since we know they utilize similar habitats further south on their migration, such as Assateague National Seashore (Johnson and Gates 2008).

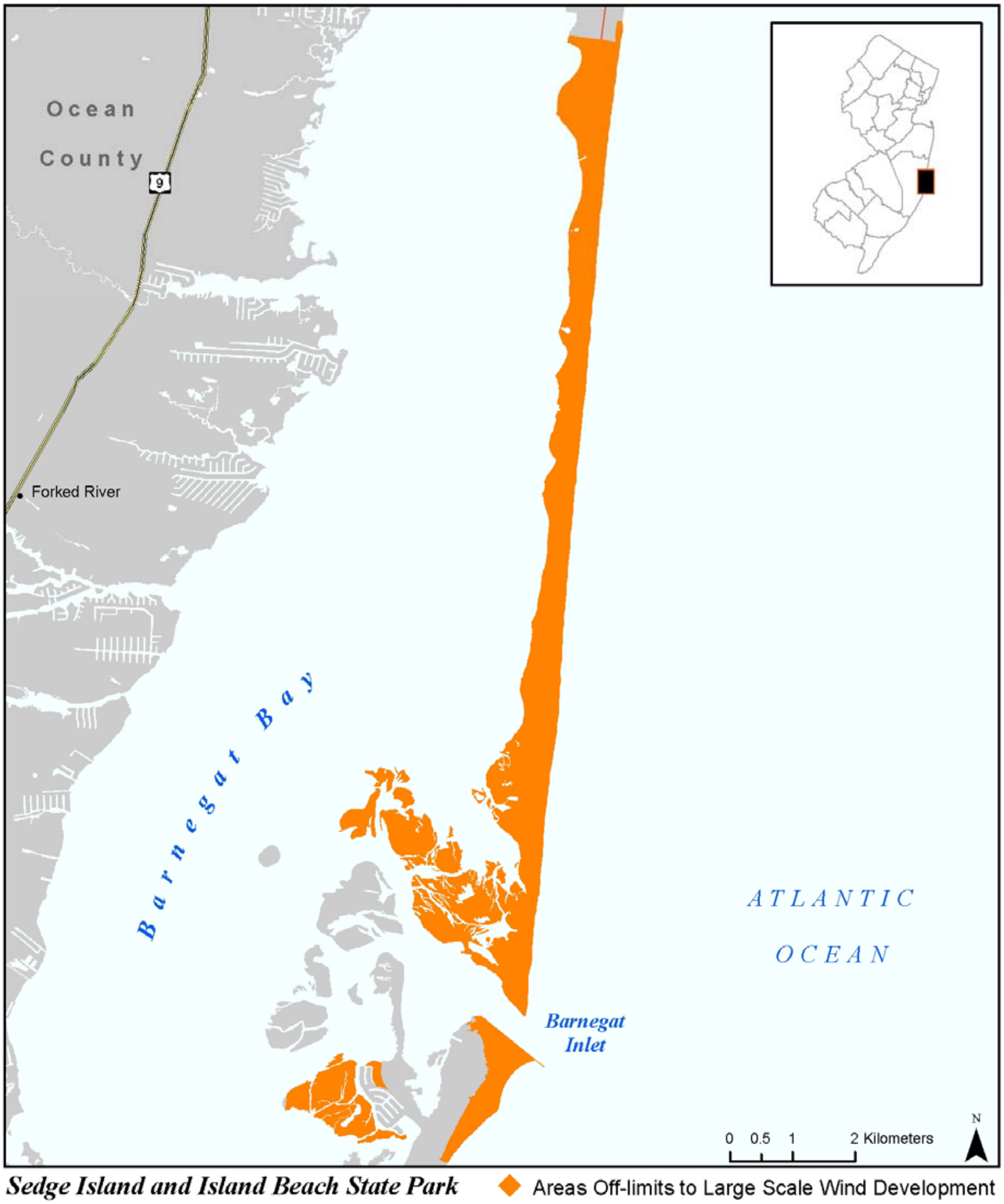


Figure 4. *Map of Sedge Island and Island Beach State Park.*

4) Gateway National Recreation Area - *Sandy Hook Unit:*

Mapping Method: LU/LC polygons were selected to approximate the boundaries of the Sandy Hook Unit of the Gateway National Recreation Area. Where necessary, additional LU/LC polygons were selected to capture all known Osprey nests on the Sandy Hook Unit. All selected LU/LC polygons were dissolved to create the region (***Figure 5***).

Figure 5. *Map of Gateway National Recreation Area – Sandy Hook Unit.*

Justification: The Sandy Hook Unit of the Gateway National Recreation Area is a major migration pathway and stopover for the birds and bats utilizing the Atlantic Coast Flyway. It is much less developed than other barrier islands along the coast and therefore provides a diversity of habitats that supports over 340 species of birds (http://www.njaudubon.org/centers/SHBO/). It contains the second largest remaining tract of maritime forest in the state and is known to provide stopover habitat for migrating songbirds and nesting habitat for breeders (http://www.njaudubon.org/Tools2.Net/IBBA/SiteDetails.aspx?sk=3151). The NJDEP designated Sandy Hook as a Natural Heritage Priority Site (http://www.nj.gov/dep/gis/digidownload/images/statewide/prisites.gif). The Sandy Hook Bird Observatory leads a spring raptor hawk watch to record the large number of raptors moving through the area at this time. New Jersey Audubon Society lists Sandy Hook as an Important Bird and Birding Area because of its significance as a Piping Plover (about a third of the state's breeding pairs nest at this site) and Least Tern nesting area, as well as its importance to wintering and migratory bird species (http://www.audubon.org/bird/IBA, Pover, 2008). Waterbirds (such as Greater Scaup and Atlantic Brant) can number in the tens of thousands in the park's cove in winter (Boyle 2004). Bat use is not well understood at this site, but it is likely that utilization of this area is high among bats traveling along the coastal corridor since they utilize similar habitats further south on their migration, such as Assateague National Seashore (Johnson and Gates 2008).

5) *Stow Creek and Mannington Meadows:*

Mapping Method: Polygons were digitized to capture all known Bald Eagle nesting, foraging and wintering areas. These polygons were used to select LU/LC polygons containing suitable habitat for eagles, including those polygons that linked nest locations with the most proximate open water foraging areas. All selected LU/LC polygons were dissolved to create these regions (***Figure 6***).

Justification: This region contains critical habitat for Bald Eagles and contains high concentrations of this species throughout the year (NJDEP Biotics Database 2009, Smith and Clark 2008). Annual Eagle Midwinter Survey data confirms high use of the area by eagles during the non-breeding season and the Department's Endangered and Nongame Species

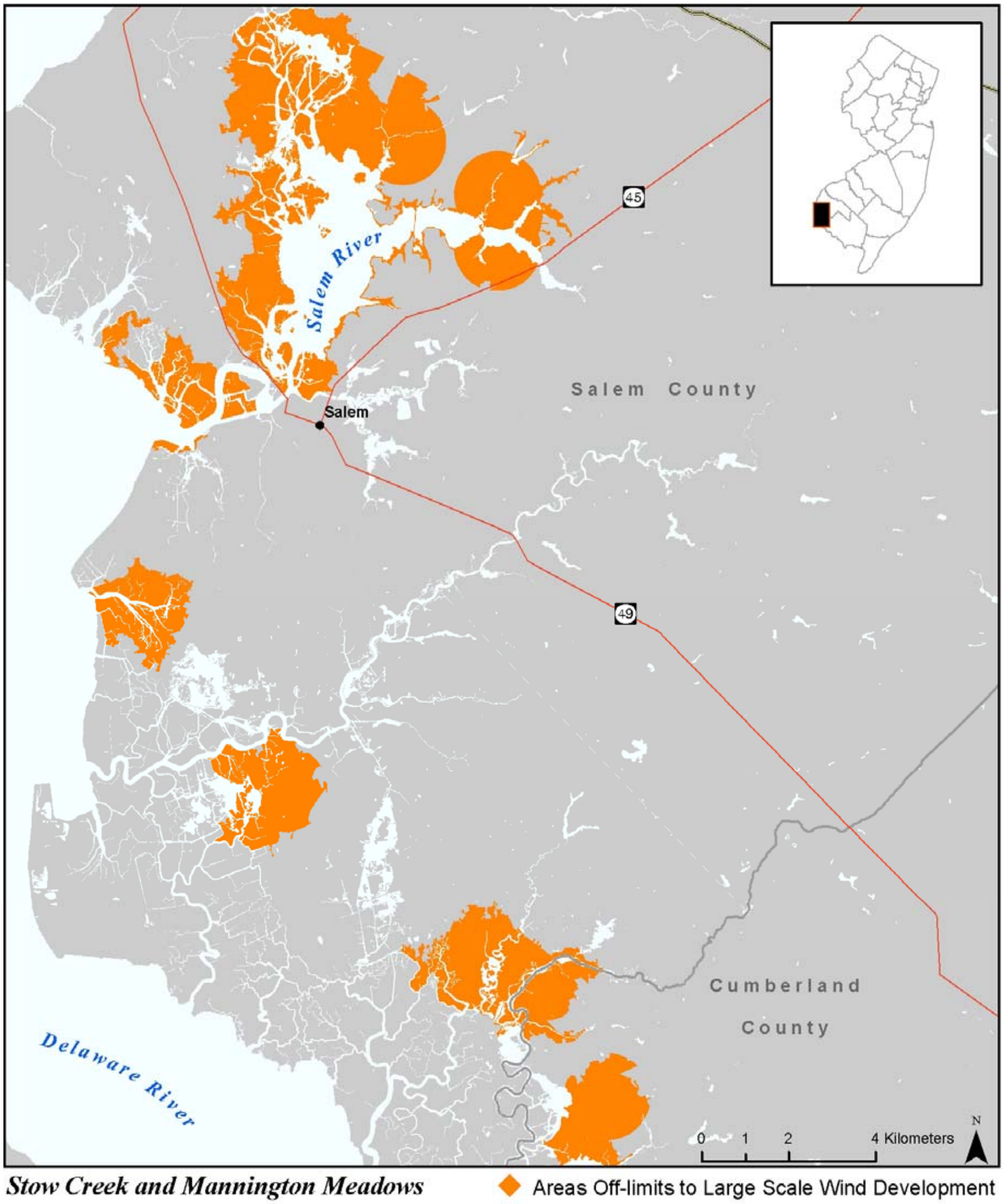


Figure 6. *Map of Stow Creek and Mannington Meadows*

Program has extensive data on nesting Bald Eagles in this part of the state (Smith and Clark 2008, NJDEP Biotics Database 2009). Turbine development within these defined regions would pose a high collision risk to Bald Eagles (USGS National Wildlife Health Center as cited in

Buehler 2000), and also create the potential to exclude eagles from habitats important to the state's population, or to degrade habitat for eagles by excluding waterfowl and other prey species (Goodale and Divoll 2009).

6) Great Egg Harbor:

Mapping Method: Polygons were digitized to capture all known Osprey nests, Bald Eagle foraging and wintering areas, Northern Harrier nests, and Peregrine Falcon nests on the lower Tuckahoe, Middle and Great Egg Harbor rivers. These polygons were used to select LU/LC polygons containing suitable habitat for these species; the selected polygons were then dissolved to create the region **(*Figure 7*)**.

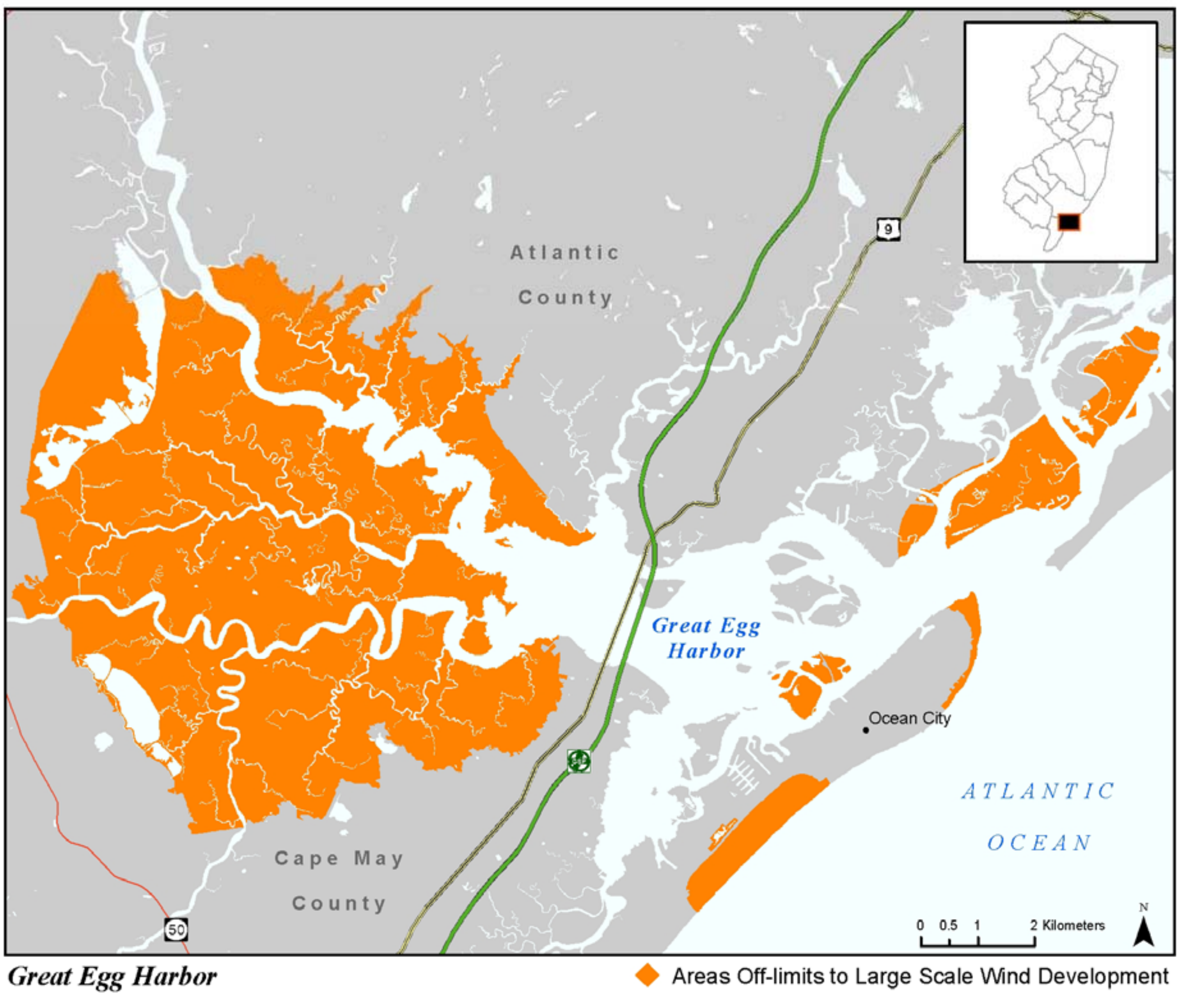


Figure 7. *Map of Great Egg Harbor.*

Justification: This region is a consistent wintering area for Bald Eagles and Northern Harriers (NJDEP Biotics Database 2009). The winter season can be a difficult period for survival, particularly of subadult raptors, which have higher mortality rates than adult raptors (Newton 1979, Buehler 2000). For eagles, the open waters of the Egg Harbor and Tuckahoe rivers are important for hunting fish and waterfowl throughout the year. The important habitat for harriers is the large salt marsh mosaic (high and low marsh, shrub). This region supports migrating eagles, harriers, and Ospreys in spring and fall, and nesting Ospreys, harriers and Peregrine Falcons, and foraging Bald Eagles in spring and summer. Like all raptors, they are highly vulnerable to impact injury and death associated with tall structures (Buehler 2000, White et al. 2002, Goodale and Divoll 2009). Due to the consistent use of this region by these raptors (and their prey species), turbine development would pose an unacceptably high risk to these species.

7) Palisades:

Mapping Method: A polygon was digitized to capture all known Peregrine Falcon nests that occur on the Palisades Interstate Park cliffs. These polygons were used to select LU/LC polygons containing suitable habitat for these species; the selected polygons were then dissolved to create the region (***Figure 8***).

Justification: Peregrine Falcons are vulnerable to direct impacts of turbines due to collision and documentation of such impacts has been recorded at one wind facility in New Jersey. In 2007, one Peregrine Falcon was killed by at five-turbine array near Atlantic City as a result of colliding with one of the turbines (Mizrahi et al. 2008). A peregrine's means of hunting included pursuing other birds in flight at high speed, throughout the airspace of 0-200 m (White et al. 2002). This puts them at high risk of collision and impact injuries with wires, poles, buildings and other structures, and is the main cause of injury and death for peregrine falcons (White et al. 2002). While Peregrine falcons nest on man-made structures in most of the coastal zone, as of 2003 they have reestablished nesting on historic habitat of the Palisades cliffs (Clark 2008). Between 2003 and 2009, peregrines have nested at multiple cliff sites in five territories in the NJ section, Palisades Interstate Park (Clark 2008). Maintaining and enhancing Peregrine

Falcon nesting within this natural habitat is one of the goals for this species' population recovery (Clark 2008).

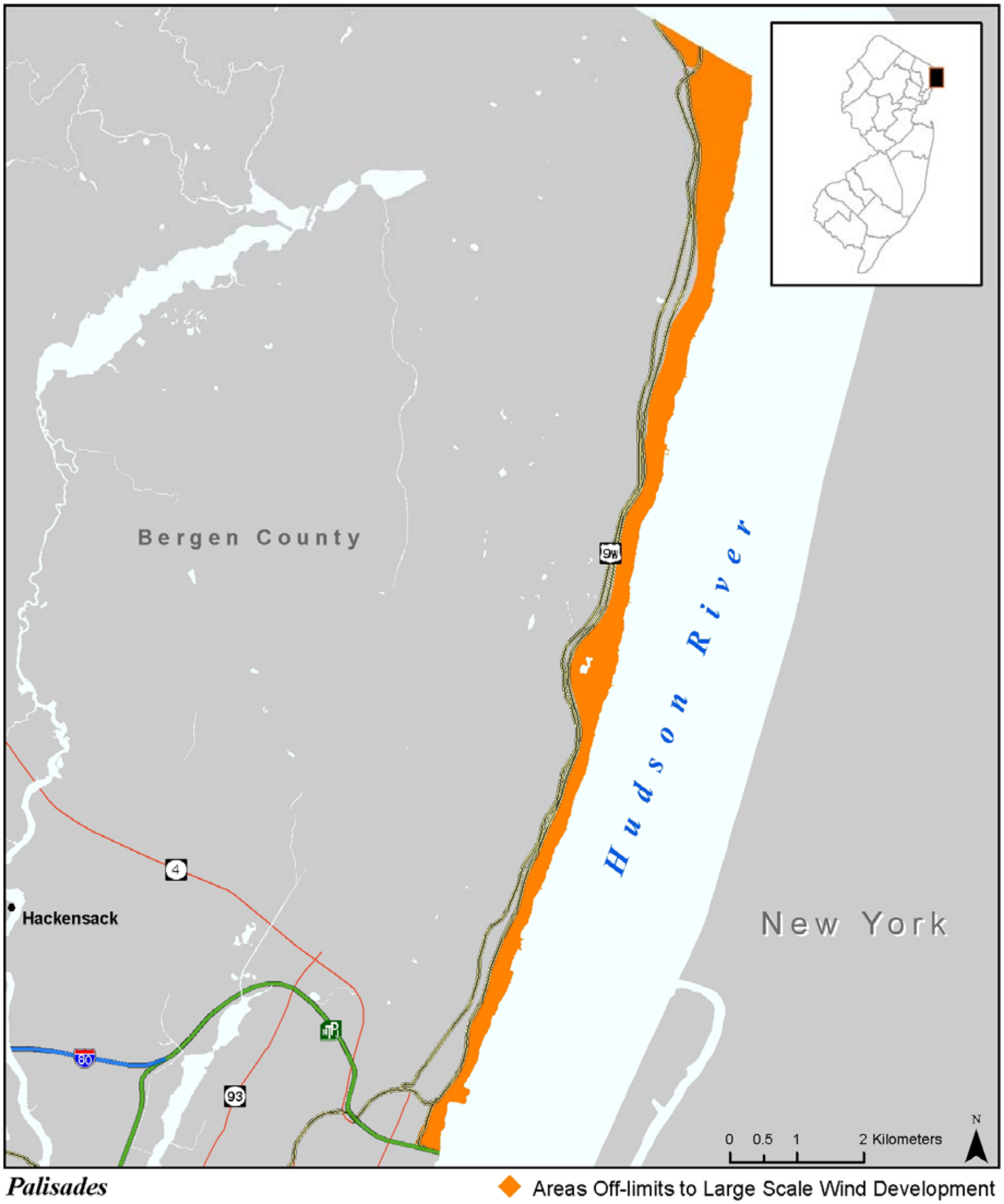
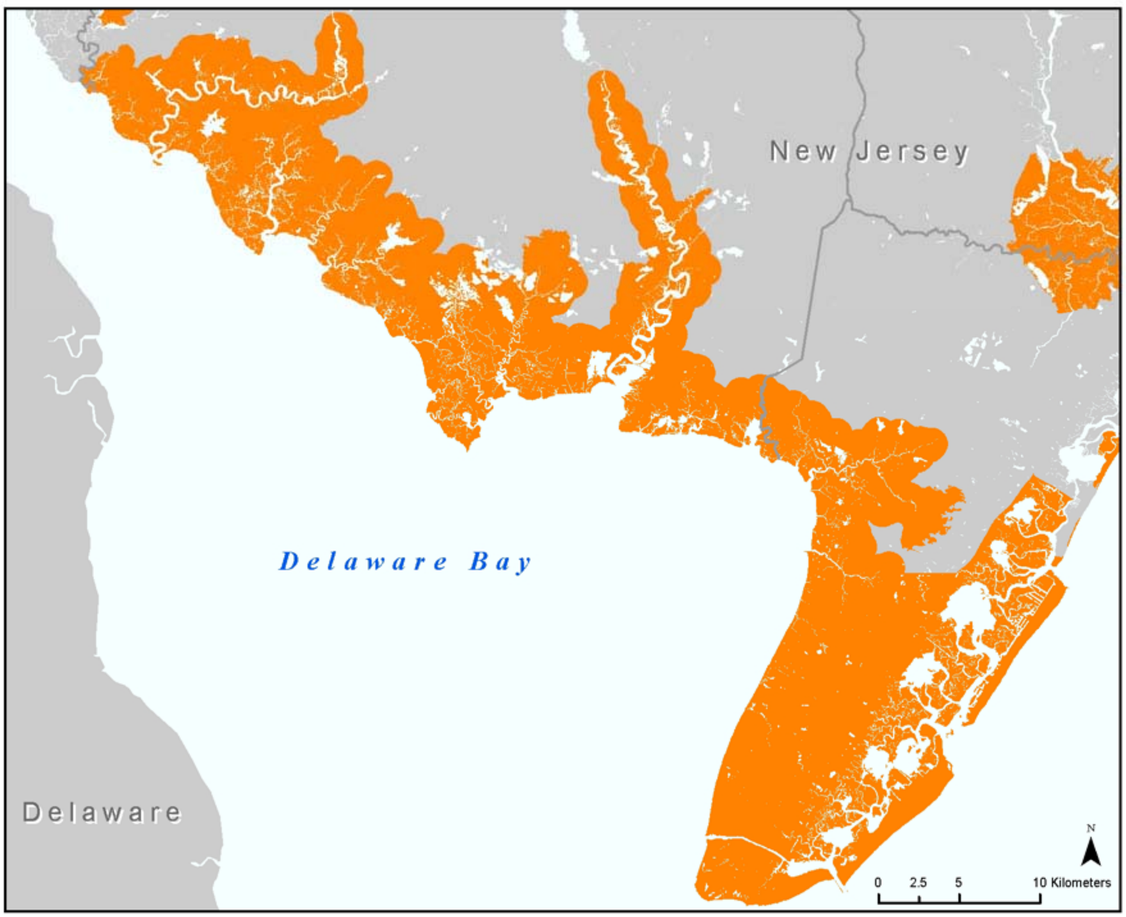


Figure 8. *Map of the Palisades.*

8) Cape May Peninsula and Delaware Bay Shore:

Mapping Method: This region encompasses the most southerly 20 kilometers of the Cape May Peninsula ("the lower 20K") and the habitats along the Delaware Bayshore. The mapped areas described below were combined and dissolved to create the region (***Figure 9***).

The lower 20K extends from the southern tip of the peninsula to an area roughly three kilometers north of Cape May Court House. All LU/LC polygons within this area were selected, with the exception of LU/LC polygons with TYPE02 coded as "WATER." Those LU/LC polygons that extended beyond the northern boundary line of the lower 20K, were clipped by the boundary. All selected LU/LC polygons were dissolved into contiguous areas.



Cape May Peninsula and Delaware Bay Shore   ◆ Areas Off-limits to Large Scale Wind Development

Figure 9. *Map of Cape May Peninsula and Delaware Bay Shore.*

The mapped portion of the Delaware Bayshore extends from the northern boundary of the lower 20K, northwest along the bayshore, to approximately five kilometers beyond the Cohansey River, and inland from the shoreline of the bay to the CAFRA boundary. Within this area, the following coastal wetlands (LU02: 6100) were selected from the NJDEP 2002 LU/LC: "SALINE MARSH (LOW MARSH)" (LU02: 6111), "SALINE MARSH (HIGH MARSH)" (LU02: 6112), "FRESHWATER TIDAL MARSHES" (LU02: 6120), "VEGETATED DUNE COMMUNITIES" (LU02: 6130), and "PHRAGMITES DOMINATE COASTAL WETLANDS" (LU02: 6141). These coastal wetlands were buffered by one kilometer and dissolved into contiguous areas. Areas outside of a wetland buffer, that were both completely surrounded by the buffered area and less than 50 acres in size, were identified and dissolved into the surrounding buffered area. All LU/LC polygons within a buffered area were selected, with the exception of LU/LC polygons with TYPE02 coded as "WATER". Those LU/LC polygons that extended beyond the boundary of the buffered areas, were clipped by the boundary. Where necessary, additional LU/LC polygons were selected to capture all known Bald Eagle nests in this region. All selected LU/LC polygons were dissolved into contiguous areas.

Justification: In July 2009, the New Jersey Department of Environmental Protection drafted a white paper entitled, "Migratory Bird Use of Delaware Bay with Respect to Risks of Wind Energy Development." This document is in included in its entirety in Appendix II, and highlights the unique and irreplaceable resources that are found in and along the Cape May Peninsula and Delaware Bay. It is for the reasons described in Appendix II that the Department feels that wind turbine development is inappropriate in this area.

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APPENDIX I

NJDEP 2002 Land-use/Land Cover Descriptions

(For complete details on New Jersey 2002 LU/LC data consult the DEP's website: http://www.nj.gov/dep/gis/lulc02shp.html)

LU02	***TYPE02***	***LABEL02***
1110	URBAN	RESIDENTIAL, HIGH DENSITY OR MULTIPLE DWELLING
1130	URBAN	RESIDENTIAL, SINGLE UNIT, LOW DENSITY
1140	URBAN	RESIDENTIAL, RURAL, SINGLE UNIT
1150	URBAN	MIXED RESIDENTIAL
1200	URBAN	COMMERCIAL/SERVICES
1211	URBAN	MILITARY INSTALLATIONS
1214	URBAN	FORMER MILITARY, INDETERMINATE USE
1300	URBAN	INDUSTRIAL
1400	URBAN	TRANSPORTATION/COMMUNICATION/UTILITIES
1410	URBAN	MAJOR ROADWAY
1419	WATER	BRIDGE OVER WATER
1440	URBAN	AIRPORT FACILITIES
1461	WETLANDS	WETLAND RIGHTS-OF-WAY
1462	URBAN	UPLAND RIGHTS-OF-WAY DEVELOPED
1463	URBAN	UPLAND RIGHTS-OF-WAY UNDEVELOPED
1499	URBAN	STORMWATER BASIN
1500	URBAN	INDUSTRIAL/COMMERCIAL COMPLEXES
1600	URBAN	MIXED URBAN OR BUILT-UP LAND
1700	URBAN	OTHER URBAN OR BUILT-UP LAND
1710	URBAN	CEMETERY
1711	WETLANDS	CEMETERY ON WETLAND
1741	URBAN	PHRAGMITES DOMINATE URBAN AREA
1750	WETLANDS	MANAGED WETLAND IN MAINTAINED LAWN GREENSPACE
1800	URBAN	RECREATIONAL LAND
1804	URBAN	ATHLETIC FIELDS (SCHOOLS)
1810	URBAN	STADIUM THEATERS CULTURAL CENTERS AND ZOOS
1850	WETLANDS	MANAGED WETLAND IN BUILT-UP MAINTAINED REC AREA
2100	AGRICULTURE	CROPLAND AND PASTURELAND
2140	WETLANDS	AGRICULTURAL WETLANDS (MODIFIED)
2150	WETLANDS	FORMER AGRICULTURAL WETLAND (BECOMING SHRUBBY, NOT BUILT-UP)
2200	AGRICULTURE	ORCHARDS/VINEYARDS/NURSERIES/HORTICULTURAL AREAS
2300	AGRICULTURE	CONFINED FEEDING OPERATIONS
2400	AGRICULTURE	OTHER AGRICULTURE
4110	FOREST	DECIDUOUS FOREST (10-50% CROWN CLOSURE)
4120	FOREST	DECIDUOUS FOREST (>50% CROWN CLOSURE)
4210	FOREST	CONIFEROUS FOREST (10-50% CROWN CLOSURE)
4220	FOREST	CONIFEROUS FOREST (>50% CROWN CLOSURE)
4230	FOREST	PLANTATION
4311	FOREST	MIXED FOREST (>50% CONIFEROUS WITH 10-50% CROWN CLOSURE)
4312	FOREST	MIXED FOREST (>50% CONIFEROUS WITH >50% CROWN CLOSURE)

LU02	***TYPE02***	***LABEL02***
4321	FOREST	MIXED FOREST (>50% DECIDUOUS WITH 10-50% CROWN CLOSURE)
4322	FOREST	MIXED FOREST (>50% DECIDUOUS WITH >50% CROWN CLOSURE)
4410	FOREST	OLD FIELD (< 25% BRUSH COVERED)
4411	FOREST	PHRAGMITES DOMINATE OLD FIELD
4420	FOREST	DECIDUOUS BRUSH/SHRUBLAND
4430	FOREST	CONIFEROUS BRUSH/SHRUBLAND
4440	FOREST	MIXED DECIDUOUS/CONIFEROUS BRUSH/SHRUBLAND
4500	FOREST	SEVERE BURNED UPLAND VEGETATION
5100	WATER	STREAMS AND CANALS
5200	WATER	NATURAL LAKES
5300	WATER	ARTIFICIAL LAKES
5410	WATER	TIDAL RIVERS, INLAND BAYS, AND OTHER TIDAL WATERS
5411	WATER	OPEN TIDAL BAYS
5420	WATER	DREDGED LAGOON
5430	WATER	ATLANTIC OCEAN
6111	WETLANDS	SALINE MARSH (LOW MARSH)
6112	WETLANDS	SALINE MARSH (HIGH MARSH)
6120	WETLANDS	FRESHWATER TIDAL MARSHES
6130	WETLANDS	VEGETATED DUNE COMMUNITIES
6141	WETLANDS	PHRAGMITES DOMINATE COASTAL WETLANDS
6210	WETLANDS	DECIDUOUS WOODED WETLANDS
6220	WETLANDS	CONIFEROUS WOODED WETLANDS
6221	WETLANDS	ATLANTIC WHITE CEDAR WETLANDS
6231	WETLANDS	DECIDUOUS SCRUB/SHRUB WETLANDS
6232	WETLANDS	CONIFEROUS SCRUB/SHRUB WETLANDS
6233	WETLANDS	MIXED SCRUB/SHRUB WETLANDS (DECIDUOUS DOM.)
6234	WETLANDS	MIXED SCRUB/SHRUB WETLANDS (CONIFEROUS DOM.)
6240	WETLANDS	HERBACEOUS WETLANDS
6241	WETLANDS	PHRAGMITES DOMINATE INTERIOR WETLANDS
6251	WETLANDS	MIXED WOODED WETLANDS (DECIDUOUS DOM.)
6252	WETLANDS	MIXED WOODED WETLANDS (CONIFEROUS DOM.)
6500	WETLANDS	SEVERE BURNED WETLANDS
7100	BARREN LAND	BEACHES
7200	BARREN LAND	BARE EXPOSED ROCK, ROCK SLIDES, ETC.
7300	BARREN LAND	EXTRACTIVE MINING
7400	BARREN LAND	ALTERED LANDS
7430	WETLANDS	DISTURBED WETLANDS (MODIFIED)
7500	BARREN LAND	TRANSITIONAL AREAS
7600	BARREN LAND	UNDIFFERENTIATED BARREN LANDS

APPENDIX II

Migratory Bird Use of Delaware Bay with Respect to Risks of Wind Energy Development

New Jersey Department of Environmental Protection

Division of Fish and Wildlife
July 2009

Report edited by: Dave Jenkins and Kathleen Clark
Contributors: Kathleen Clark, Christine Kisiel, Amanda Dey, Dave Golden, Ted Nichols, Paul Castelli

Abstract: The Delaware Bay and its wetlands support a diverse and abundant assemblage of migratory birds such that the region is internationally recognized for its natural resources. Delaware Bay is a major spring shorebird stopover in the Western Hemisphere, one of only four estuaries in North America where over one million shorebirds concentrate during migration. In Delaware Bay, spring migrating shorebirds spend several weeks replenishing fat reserves needed to continue migration to Arctic breeding grounds. Of particular importance are red knots, which are a candidate species for federal listing under the Endangered Species Act. Over 80% of the Atlantic Flyway population of red knots stages on Delaware Bay during spring migration. Delaware Bay also supports more than 500,000 waterfowl consisting of over 20 species, including an average of 35,000 American black ducks. During the fall and winter, southern New Jersey contains the largest concentration of black ducks on earth; approximately 35% of New Jersey's black ducks are found along Delaware Bay. In the open waters of the Bay, 200,000 to 400,000 sea ducks have been observed in winter, including the highest concentration of black scoters on the Atlantic coast. Thousands of songbirds and raptors migrating in fall become concentrated along the Delaware Bay coast in New Jersey since the open water of the Bay creates a barrier to migration. As a result, these migrating birds "stack up" along the Bayshore and subsequently move up and down the Bayshore seeking a favorable spot for crossing. The temporal and spatial use patterns of these bird groups are such that large numbers of birds reside in, and travel through, Delaware Bayshore marshes and open waters in low altitude flight. The birds of Delaware Bay include groups that are vulnerable to collision with structures like wind turbines. The mosaic of Delaware Bay waters, wetlands and forests supports the largest concentration of bald eagles in New Jersey in both breeding and wintering seasons, and represents the most vital region to the eagle's recovery in the state.

Because of the exceptional aggregations of birds found here, Delaware Bay has received international recognition by a number of organizations. It is recognized as a Western Hemisphere Shorebird Reserve Network site of international importance. It is a Wetland of International Importance under the Ramsar Convention on Wetlands of International Importance (an international treaty for the conservation and sustainable utilization of wetlands). BirdLife International and Audubon recognize Delaware Bay as an Important Bird Area of global significance. As such, New Jersey and Delaware have regional, national and international

responsibilities to protect birds and their habitats in Delaware Bay. Guidance on the siting of wind turbines specifically advises avoiding areas of high concentrations of birds and bats, such as migratory staging areas. Delaware Bay exemplifies such a bird staging and migration area in which wind turbines should not be permissible.

Introduction

The Cape May peninsula and the Delaware Estuary waters and wetlands support a diverse and abundant assemblage of wildlife, and are collectively considered one of New Jersey's, and the country's, most valuable natural resources. This report summarizes the information on significant migratory bird populations of Delaware Bay, and how the patterns of habitat use by these birds suggest that wind energy development carries particularly high risks to those populations. There are four general categories of significant migratory bird populations addressed: spring migratory shorebirds, fall migratory raptors and passerines, migrating and wintering waterfowl, and resident and wintering bald eagles.

Aggregates of more than 500,000 shorebirds use the estuary each year during spring migration (Myers et al. 1987, Clark et al. 1993). These shorebirds make daily cross-bay flights at altitudes below 150 m to exploit available foraging and roosting habitats. Each May-June, a large percentage of the Western Hemisphere's population of red knots is present along the bay, along with significant numbers of five other species. In winter, hundreds of thousands of waterfowl reside in Delaware Bay. Of particular importance is one of the largest concentrations of American black ducks on earth, for which the Delaware Bayshore marshes provide critical stopover habitat during both spring and fall migrations as well as throughout the winter. The Cape May region is home to one of the most significant raptor and songbird migrations in the world. These migrants become concentrated along the New Jersey coast of Delaware Bay and in the southern portion of Cape May peninsula. The open water of Delaware Bay creates a temporary barrier to many migrating birds, causing many to stop, rest and feed on the peninsula, and to move along the Delaware Bayshore wetlands looking for better crossing points. Delaware Bayshore marshes, fields and forests also host a growing population of bald eagles that congregate around open waters in winter, taking advantage of the convergence of migrating and wintering waterfowl and fish. The Bayshore has been the epicenter of bald eagle recovery for New Jersey, and continues to support the core of the nesting and wintering populations.

The diversity and abundance of wildlife using the Delaware Estuary has led to national and international recognition of these areas. Delaware Bay has received international recognition as a Western Hemisphere Shorebird Reserve Network site, a Wetland of International Importance under the Ramsar Convention, and an Important Bird Area of global significance. Similarly, Cape May peninsula is considered by many authorities as one of the top birding destinations in the world. As such, New Jersey and Delaware have regional and national responsibilities to protect birds and their habitats in Delaware Bay.

Stopover, defined

Cape May peninsula and Delaware Bayshore is a well-recognized, vital stopover site for migrating birds, including waterfowl, shorebirds, raptors, woodcocks and neotropical migrants (Allen and Peterson 1936, Stone 1965, Krohn et al. 1977, Wiedner and Kerlinger 1990, Wiedner et al. 1992, Herpetological Associates, Inc. 1993, McCann et al. 1993, Niles 1996, Sutton and Sutton 2006). A migratory stopover is "an area with the combination of resources (i.e., food, cover, and water) and environmental conditions (temperature, precipitation, presence and absence of predators and competitors) that promotes occupancy by individuals of a given species in migratory passage" (Morrision et al. 1992). During migration stopovers, it is essential for birds to replenish fat reserves, rest, and locate cover from predators and harsh weather conditions (Biebach et al. 1986, Barlein 1987, Greenberg 1987, Moore and Kerlinger 1987, Winker et al. 1992, Moore et al. 1993, Niles et al. 1996, Moore and Aborn 2000). The ability of migrants to fulfill these requirements affects success throughout migration and at wintering grounds, and influences productivity during the breeding season (Moore and Kerlinger 1987, Myers et al. 1987, Moore et al. 1993).

A description of the significant birds and their habitats in the Delaware Estuary

1. Migratory Shorebirds

Delaware Bay is a major migration stopover, unique because of the occurrence of the Western Hemisphere's single-largest horseshoe crab (*Limulus polyphemus*) population. Horseshoe crab spawning and shorebird migration coincides in spring (Botton et al.1994), and abundant horseshoe crab eggs attract up to one million shorebirds including 80% of the Western Hemisphere's population of red knots (*Calidris canutus rufa*) and large numbers of six other species (ruddy turnstone [*Arenaria interpres*], sanderling [*Calidris alba*], semipalmated sandpiper [*Calidris pusilla*], dunlin [*Calidris alpina*], short-billed dowitcher [*Limnodromus griseus*]) (Clark et al. 1993, Niles et al. 2008). Horseshoe crab eggs provide rapid weight gains of >80% in less than 14 days (Gillings et al. 2009). Spring migration is time-constrained, and Delaware Bay is the last critical stop for shorebirds before lifting off to frozen Arctic breeding grounds (Niles et al. 2008). Fat reserves obtained on Delaware Bay are critical for adult survival (Baker et al. 2004) and successful reproduction.

The abundance and distribution of migrant shorebirds on Delaware Bay have been documented by weekly aerial surveys during May and early June, from 1986 to 2009 (Clark et al. 1993, New Jersey Division of Fish and Wildlife [NJDFW] unpublished data). Up to 500,000 migrant shorebirds annually use beaches, sandy creek mouths and some sod banks that stretch almost continually along the Delaware Bay shore -- from Town Bank north to the Cohansey River, and from Woodland Beach south to Cape Henlopen in Delaware (Clark et al. 1993, Niles et al. 2008). NJDFW biologists have also counted shorebird using marshes and mudflats, and estimated that marshes support more than twice the number of shorebirds counted on Bayshore beaches (Burger et al. 1997).

A review of published papers, unpublished NJ Division of Fish and Wildlife reports, and data from various studies (including radio telemetry, resightings of marked individuals, aerial and ground surveys) shows that large numbers of shorebirds use Bayshore beaches as their main foraging areas (sandy beach is preferred spawning habitat for horseshoe crabs); shorebirds make multiple day and night-time flights to use these beaches and roost on a tidal schedule.

To find optimal food resources, radio-tagged red knots make frequent daytime flights among foraging beaches in both New Jersey and Delaware. Red knots make frequent nighttime flights directly from roost sites on the Atlantic coast to Bayshore foraging areas on falling tides (Sitters 2001, 2003, 2005). Day and nighttime flights from New Jersey roosts to New Jersey and Delaware Bayshore beaches are made directly over land and Bay waters (Figure 1), and birds make frequent flights across Delaware Bay (Sitters 2005).

Spatial and Temporal Patterns of Use

Shorebird movements between foraging and roost habitats are integrally linked to tidal cycles. Birds make frequent flights between habitats to take advantage of food resources on falling tides, roost areas on rising tides, to avoid human disturbance, and to escape predators (Burger and Olla 1984, Clark et al. 1993, Meyer 1999, Niles et al. 2008).

Researchers in Delaware Bay have been banding and color-marking red knots since 1996, and have used alpha-numeric codes (readable from a distance) since 2004 (NJDFW reports at http://www.njfishandwildlife.com/ensp/shorebird_info.htm). Resightings of individually-marked red knots have been made each spring since 2004. This large data set has not been extensively analyzed to develop baywide movement patterns for red knots, ruddy turnstones and sanderlings. However, in May 2007, at least 14% of marked red knots resighted (481 of 3,429), 6% of marked ruddy turnstones (103 of 1,767), and 7% of marked sanderlings resighted (80 of 1,085) made cross-bay flights (NJDFW and DEDFW unpubl. data). An examination of a sample of seven individually-marked red knots in 2007 showed that movement distances for knots that made cross-bay flights ranged from 24 km to 138 km in an observation period of 2-10 days (Table 1).

Table 1. Movement distances of a sample of individually-marked red knots (n=7) that made cross-bay movements in May 2007. A complete analysis of all marked individuals resighted within season (2004–2009) is not yet available (A. Dey, NJDFW, unpubl. data).

Bird ID	Obs. Period 2007 (No. Days)	No. Obs.	No. Del. Bay Crossings	Total Distance (km) Between Obs. Locations
Fo(AES)	May 24-25 (2)	2	1	23.79
Fr(XC)	May 17-27 (11)	3	2	57.37
Fl(5N)	May 26-31 (6)	3	1	70.27
Fl(AEU)	May 17-27 (11)	4	2	70.78
Fl(7A)	May 16-21 (6)	4	2	82.52
Fl(28)	May 14-21 (8)	5	2	104.27
Fl(AJE)	May 17-26 (10)	5	4	138.57

A more detailed picture of individual red knot movements is derived from radio-telemetry studies (Meyer 1999; Sitters 2001, 2003, 2005) and direct counts of red knots during daytime aerial (Clark et al. 1993, NJDFW unpubl. data) and Stone Harbor roost counts (Sitters 2001, 2003, 2005). In each of 2001, 2003, 2004, and 2005, between 50 and 65 red knots were tagged with radio transmitters and tracked using aerial and ground tracking and stationary radio receivers (NJDFW and DEDFW unpubl. data). These data represent a minimum characterization of movements typically made by red knots on Delaware Bay, since birds are more mobile than we can detect with conventional radio telemetry.

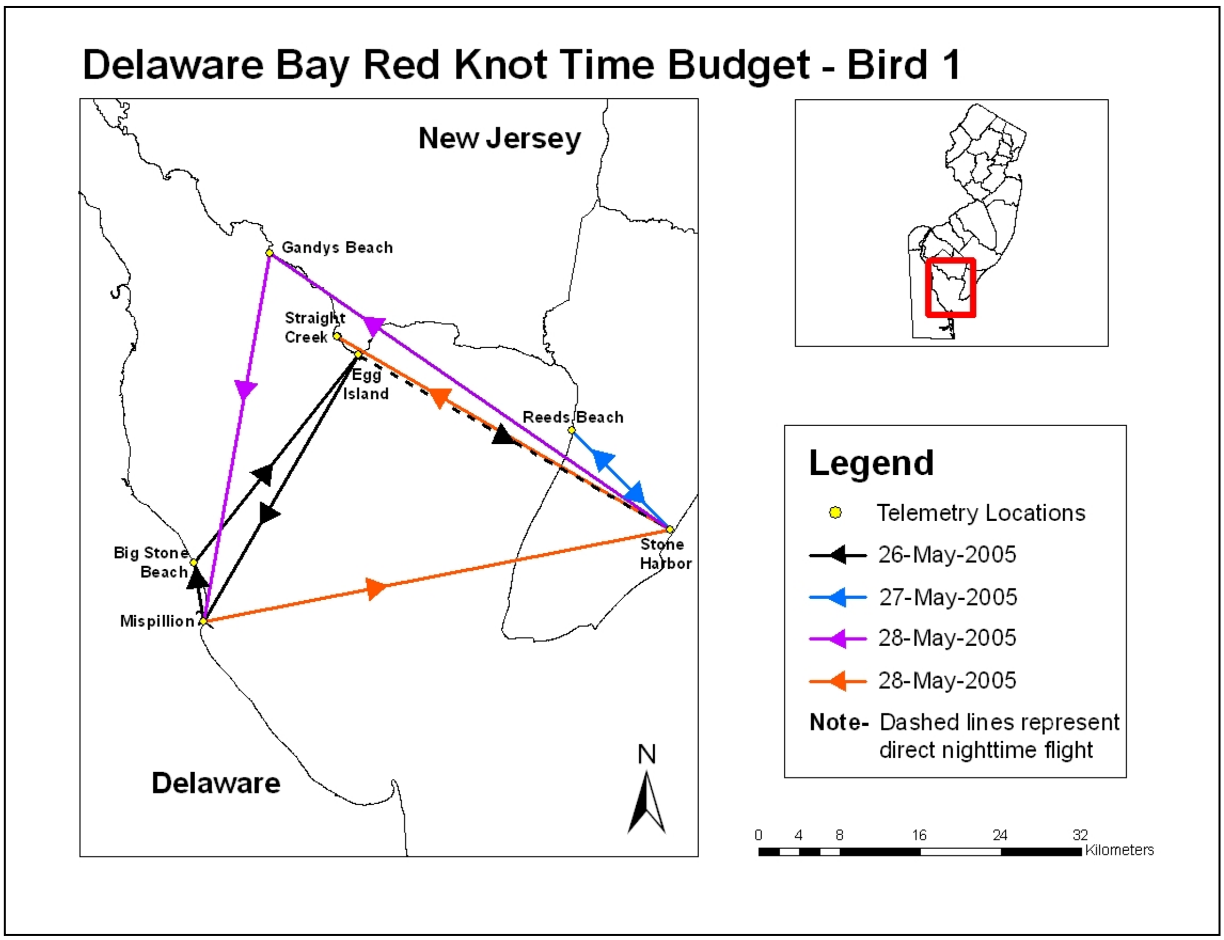
An examination of telemetry data shows the following general movement patterns of radio-tagged red knots (Sitters 2001, 2003, 2005):

- Radio-tagged red knots make frequent day- and nighttime flights between Atlantic coast roost and Bayshore foraging beaches, and among Bayshore foraging beaches.
- Red knots make direct, cross-bay flights between New Jersey and Delaware. At least 34% of radio-tagged red knots were detected making 1-7 cross-bay flights during the stopover period.
- The flight paths documented with telemetry indicate the entire red knot population, as well as other shorebird species using Delaware Bay, are in constant diurnal movement along all Bayshore beaches, directly over land and Bay waters, and over Cape May peninsula, throughout the duration of the May-June stopover period.
- Seventy to 80 percent of the red knot migrant population in Delaware Bay roost on Stone Harbor Point in Hereford Inlet, and 20%-30% roost on Egg Island (estimated from radio tracking data and direct counts; Sitters 2001, 2003, 2005). Radio-tagged red knots made direct flights from Delaware and northern Bayshore beaches of New Jersey to roosting areas at Stone Harbor Point (18-47 km away), and frequently left Stone Harbor Point on the falling tide at night to fly directly to foraging areas (18-47 km away). Elapsed time between departures and arrivals of tagged birds was sufficiently short to indicate that birds could have only made a direct flight over land and water to reach their destination.
- A number of day and nighttime flight paths were documented by radio telemetry (Sitters, 2001, 2003, 2005):
    1) Between Stone Harbor roost and northern Bayshore beaches in New Jersey
    2) Between Egg Island roost and northern Bayshore beaches in New Jersey
    3) Between Stone Harbor and Delaware beaches
    4) Between Egg Island/northern Bayshore and Delaware Beaches
    5) Between Egg Island and southern Bayshore beaches in New Jersey
    6) Between Egg Island and Stone Harbor roosts
- Observations of red knots departing from foraging areas (Reed's Beach) and arriving at the Stone Harbor roost reveal that these flights, generally made at dusk or night (~8:30 PM-9:30 PM), are low-altitude (i.e., <150 m) flights directly over Cape May peninsula (A. Dey, pers. obs., 2005-2009).

Red knots make frequent flights to seek out optimal food resources and roost sites. While many flights occur in daylight among foraging sites, red knots also actively fly and forage at night, making direct flights from roost sites to foraging areas on the falling tide (Sitters 2001, 2004, 2005). Two locations, Stone Harbor Point in Hereford Inlet and Egg Island Point, were consistently used as day and nighttime roosts by a major portion of the red knot migratory population each May (Sitters 2001, 2005). Direct flights to and from Stone Harbor Point were made during the day and at night to foraging sites that included Jenkins Sound (≤3 km west), Reed's Beach (13 km west), northern New Jersey Bayshore including Moore's Beach (23 km), Egg Island (35 km), Fortescue (45 km), Gandy's Beach (48 km), and directly across Delaware Bay to Mispillion Harbor (47 km southwest) (Sitters 2005). Direct flights to and from the Egg Island roost were made to foraging sites at Straight Creek (5 km), Fortescue (5 km), Moore's Beach (18 km), and to Stone Harbor (35 km; Sitters 2005).

There is no reason to suspect that the movement patterns of radio-tagged red knots are not representative of the red knot population on Delaware Bay. Therefore, it is likely that thousands of birds at any given time are making both diurnal and nocturnal flights across Delaware Bayshore marshes and Delaware Bay open waters to find adequate foraging and roosting opportunities.

Figure 1. Example of radio-tagged red knot that made multiple cross-bay movements and direct, nighttime flights in May 2005. Bird 1 was detected on 9 dates over a 14-day period (May 17-May 30, 2005), it used an average of 2.27 sites per day (range 1-5 sites used in a given day), and made 8 cross-bay movements during the observation period (2 in one day from Egg Island, NJ, to Mispillion, DE, back to Egg Island then to Stone Harbor to roost for a minimum of 90 km traveled in one day).



Vulnerability

The concentration of large numbers of shorebirds, coupled with high frequency of flights (day and night) across Delaware Bay wetlands and waters, increase the risk of impact from wind turbines. This is especially the case if fog or poor weather further reduces nighttime visibility. The patterns of shorebird movement across the wetlands, mudflats, and across the peninsula and open Bay waters make it unlikely that siting turbines in any portion of Delaware Bayshore lands or waters could be done without risk of high levels of mortality.

These elements of shorebird stopover in Delaware Bay increase risk of negative impacts from wind turbine development:

- The concentration of more than one million shorebirds in Delaware Bay each spring (May–early June).
- The patterns and frequency of shorebird movement among Bayshore beaches, marshes and roost areas, as well as across Delaware Bay open waters.
- Shorebirds' behavior of flying at night, moving among roosting and foraging areas on a tidal schedule.
- Shorebirds are mobile in both fair and poor weather conditions; poor conditions may reduce visibility and thus increase the risk of accidental impacts.
- Local shorebird flights are lower altitude (<150 m) flights typical of birds searching out good foraging areas, not high altitude flights characteristic of active long-distance migration.
- Compounding the risk to shorebird populations is the fact that a major portion (~80%) of the Hemisphere's *Calidris canutus rufa* red knot population (a candidate for federal listing) and major portions of five other shorebird species are present in Delaware Bay at the same time each May. Precipitous declines in red knots, related to over harvest of horseshoe crabs, have left this small population (estimated 18,000–27,000 individuals) extremely vulnerable to endangerment, or total loss, from any catastrophic events (e.g., oil spill in Delaware Bay, red tide, or loss of essential habitat). For small populations, additive losses may reduce the effective population size below a viable level, from which red knots may not recover (Shaffer 1981, Baker et al. 2004).

2. Migratory Raptors and Songbirds

Challenges faced by migrating birds intensify when a migrant is forced to confront an ecological barrier such as an inhospitable landscape, a mountain range, or a large water body (Alerstam 1981, Kerlinger 1989, Barrow et al. 2000, Berthold et al. 2003). Those challenges of migration include weather conditions, the risk of mortality from predation and other threats, the availability of resources at stopovers and bird body condition (Alerstam 1981, Kerlinger 1989, Alerstam and Lindstrom 1990, Moore and Aborn 2000, Schaub and Jenni 2001, Berthold et al. 2003). Habitats adjacent to ecological barriers have been recognized as critical stopovers for migrants that concentrate there prior to making the energetically demanding flight (Sprunt 1975, Moore et al. 1993, Barrow et al. 2000).

Migratory raptors at the Cape May stopover are faced with the challenge of making the energetically demanding, 18-km water crossing of Delaware Bay. Some raptor species readily make water crossings, including ospreys (*Pandion haliaetus*), merlins (*Falco columbarius*), northern harriers (*Circus cyaneus*) and peregrine falcons (*Falco peregrinus*; Kerlinger et al. 1985), but must use powered flight in the absence of thermals over water. Sharp-shinned hawks (*Accipiter striatus*), Coopers hawks (*Accipiter cooperii*), American kestrels (*Falco sparvarius*), northern goshawks (*Accipiter gentilus*), vultures and many species of Buteo hawks are reluctant to negotiate water crossings in adverse weather conditions (Allen and Peterson 1936, Kerlinger 1989). Many species fly back inland to use the resources of the peninsula and the Bayshore and wait for favorable weather to cross the Bay, or they follow the Bayshore coast north in search of a narrower crossing (Allen and Peterson 1936, Kerlinger 1989, Niles et al. 1996). In a seminal study of raptor migration at Cape May, 73% of sharp-shinned hawks arriving at Cape May Point between mid-September and mid-November were observed flying north along Delaware Bayshore, while just 27% made the water crossing near Cape May; sharp-shinned and other forest hawks flew north following the forested edge, while open-habitat hawks like American kestrels flew north across marshes and creeks (Allen and Peterson 1936). Most of the raptors and songbirds migrating through Cape May in fall are juveniles making their first migration, so they are inexperienced and more likely to be affected by local habitat changes and prey availability (Kerlinger 1989). Therefore they must forage during migration, and the peninsula and Bayshore provide the resources needed for these migrating raptors and songbirds to refuel (Niles et al. 1996).

The Cape May peninsula and Bayshore offers areas of concentrated resources for southbound migrants (Wiedner and Kerlinger 1990, Wiedner et al. 1992, McCann et al. 1993, Niles et al. 1996). The region is rich in prey for raptor species, including migrating passerines for sharp-shinned hawks, Cooper's hawks, northern harriers, northern goshawks, peregrine falcons; fish for ospreys; and insects for American kestrels. Migrants also find resting and roosting sites in shrub and forest habitats on the peninsula and along the Bayshore (McCann et al. 1993). The quality and quantity of these and other habitats within the region, however, are in decline due to increases in development. Between 1984 and 2001, residential development on the lower 20km of the peninsula increased by 23%. Between 1972 and 1995, development destroyed over 40% of forest, shrub-scrub and field habitats (Niles 1996).

Surveys conducted by Niles et al. (1996) on the peninsula during fall, 1984 and 1986, demonstrated that migratory raptors were associated with habitat throughout the Cape May stopover but concentrated near the southern tip of the peninsula. Surveys of the concentration area (i.e., the lower 10 km) showed that raptors were distributed throughout the concentration area, using a variety of habitats and avoiding developed land (Niles et al. 1996). In 2002, a follow-up study found a reduced concentration of raptors and an even distribution throughout the northern portions of the peninsula (Frank 2007). The loss of habitat in the lower peninsula has caused raptors to fly and forage (i.e., stop over) in a larger area of the peninsula than previously found (Frank 2007). These findings, and the continued habitat loss in the lower peninsula, have led to the recommendation that land-use protections in place for the lower 10 km be extended to the entire peninsula, and the lower 20 km at a minimum (Frank 2007). The changes observed in the peninsula emphasize the importance of maintaining good conditions in the stopover region: continued loss and degradation of habitat will ultimately reduce the carrying capacity of the stopover. Lower carrying capacity of the Cape May stopover (the peninsula and the Bayshore), will translate to reduced raptor and passerine populations that can survive migration (Myers et al. 1987, Moore 2000).

Migrating songbirds also funnel into Cape May peninsula, even though their migration strategy differs somewhat from raptors. Songbirds migrate at night using both the night sky and terrestrial landmarks (Able 2001). Many birds, especially inexperienced juvenile birds, get carried by northwest winds to the coastal barrier islands and beyond, and must make their way back to land in early morning hours (Wiedner et al. 1992). In a study of migrating songbirds in the mid-Atlantic region (New Jersey, Delaware, Maryland, Virginia), biologists documented the distribution of Neotropical migrant songbirds in coastal and interior areas on the Cape May and Delmarva peninsulas (McCann et al. 1993). Four distribution patterns emerged:

1) Migrant abundance and species richness were significantly greater near the coast (0–1.5 km) than in areas farther away from the coast (1.5–3 km).
2) Bay coastal zones (in New Jersey, 0-3 km from the Delaware Bayshore) have higher abundances of migrants than seaside coastal zones or peninsula interiors (10–23 km from the mean high tide line).
3) Migratory songbirds are more abundant on barrier islands than the coastal mainland.
4) Migrants are associated with particular habitats on a species-specific basis; i.e., migration stopover and breeding habitat affinities were similar for individual species.

This study (McCann et al. 1993) and others (cited below) made these conclusions about habitat for migrating birds:

1) Geographic factors override habitat factors; therefore, all native habitats in coastal areas are important (McCann et al. 1993).
2) Migrant songbirds will use all available habitat patches regardless of size, particularly where habitat is limited (Biebach 1995, Skagen et al. 1998). Isolated patches or “oases” serve both as critical stopover sites and migratory “stepping stones” (Skagen et al. 1998).
3) Large forest and scrub-shrub patches support greater numbers and diversity of migrant birds and also provide breeding habitat (McCann et al. 1993).
4) Migrant songbirds fall out along coastal areas and will remain there to rest, forage and shelter from predators until fat reserves and hydration are restored. This is particularly true for fat-depleted birds which stay for longer periods than fatter birds (Moore and Kerlinger, 1987), and inexperienced first-year birds where the benefits of rejecting even marginal habitat is outweighed by the energetic cost of finding more suitable sites (Moore et al. 1990, Kuenzi et al. 1991).
5) Migration is physically stressful, and migrant songbirds are highly vulnerable to predators, starvation, and adverse weather during migration (all cited authors).

<u>Spatial and temporal patterns of use</u>

Most raptors are actively hunting and migrating during daylight hours. Altitudes for foraging and local habitat use are below 100 m (Holthuijzen et al. 1985), while migrating flight is 100 m and above (Holthuijzen et al. 1985, Smith 1985, Kerlinger 1989). However, raptors within the Cape May stopover – on the peninsula and along the Bayshore – may be in various stages of migratory movement and stopping-over at any time from August to November. Their behaviors and habitat use range from migratory flight (generally >300 m) as they arrive, to low flight (generally <100 m) as they descend in altitude approaching Delaware Bay open water then move about the region actively searching for food and cover (*cf* Harmata et al. 2000, Mabee and Cooper 2004). Altitude of flight in the Cape May stopover is related to habitat type, wind speed and wind direction, and ranged from 43 m (buteos in forested habitat) to 153 m (buteos in field habitat) (Niles et al. 1996). The most numerous species, sharp-shinned hawk, was observed at mean altitudes of 52 m (field habitat) to 86 m (marsh habitat). Raptors that pause in the Cape May region before continuing migration may do so for days or weeks, and spend their days moving among and between habitats for hunting and resting (Niles 1996). As individual raptors gain weight and prepare to continue their migration, they may make repeat flights south along the peninsula, or (in adverse wind conditions) move north and west along the upland edge of Delaware Bayshore to a point that offers a shorter water crossing (Allen and Peterson 1936, Niles 1996, Sutton and Sutton 2007).

<u>Vulnerability</u>

The concentration of raptors that occurs in the Cape May stopover, along with the various patterns of flight (foraging and low level flight) as they funnel into and mill around the region, makes them vulnerable to collision with turbines placed within the same airspace (<100 m); two raptors (osprey and peregrine falcon) have been killed by an array of five turbines located in wetlands near Atlantic City after one year of monitoring (Mizrahi et al. 2008). The density of land birds (raptors and songbirds) concentrating in the region, and the fact that the majority are inexperienced, juvenile birds, increases the likelihood of collisions as birds make their way into and out of this migration stopover. Perhaps of equal importance is the likelihood of turbines causing migrating birds to avoid habitat, and therefore be subject to habitat loss that is additive to that occurring at a high rate on Cape May peninsula. The loss of habitat to development has already had a negative impact on migrating raptor habitat use on the peninsula, causing birds to move farther to find adequate foraging and roosting areas (Frank 2007).

Post-construction carcass surveys have shown that passerines are among the most likely avian groups to be impacted by collisions with wind turbines (Howe et al. 2002, Johnson et al. 2002, Schmidt et al. 2002, Kerns and Kerlinger 2004, Mizrahi et al. 2009). Although migrating songbirds often fly at higher altitudes than current turbine rotor blades can reach, they fly lower when crossing over bodies of water and this makes them more likely to be flying in the rotor swept area (Huppop et al. 2006). They also fly at lower altitudes when the conditions for migrating are poor (e.g., fog, low cloud ceiling, headwinds), and in areas where stopover habitat exists as they descend and ascend to take advantage of resting and foraging areas (Langston and Pullen 2003). Radar data of bird migration from the Cape May area recorded the presence of thousands of low-flying migrants (<100 m in altitude), confirming that migrants fly at lower altitudes in the Cape May stopover than might be expected during migration (Mizrahi et al. 2009)

3. Waterfowl

Delaware Bay is a significant region for wintering waterfowl, whose numbers exceed 500,000. It is also an important stopover for fall and spring migrants as well as a breeding ground for a significant portion of the New Jersey black duck population.

Wintering waterfowl have been documented by the Midwinter Waterfowl Survey (MWS), a standardized aerial survey conducted annually since the 1970's. The MWS covers the tidal marshes and waters within 3 km of the marsh. Biologists have documented over 150,000 ducks, geese and swans wintering along Delaware Bay each January (NJDEP DFW unpubl. data). That includes 35,000 black ducks (*Anus rubripes*), more than 6,000 mallards (*Anus platyrhychos*), and 20,000 Canada geese (*Brant canadensis*), all of which are species of regional priority under the New Jersey State Wildlife Action Plan (NJDEP 2008). During the fall and winter, southern New Jersey contains the largest concentration of black ducks on earth. Approximately 35% of New Jersey's black ducks are found along Delaware Bay (Nichols, unpubl. data; Castelli, pers. comm. 7/28/09). Significant numbers of greater snow geese (*Chen caerulescens*), green-winged teal (*Anus crecca*), and northern pintails (*Anus acuta*) are also counted along Delaware Bay.

The MWS, with its focus on tidal marshes and nearshore open waters, does not account well for open water species known as sea ducks (Nichols 1995). This group includes 15 species, among them black scoter (*Melanitta nigra*), surf scoter (*Melanitta perspicillata*), white-winged scoter (*Melanitta fusca*), greater scaup (*Aythya maila*), lesser scaup (*Aythya affinis*), canvasback (*Aythya valisineria*), buffleheads (*Bucephala albeola*), ruddy duck (*Oxyura jamaicensis*), and hooded merganser (*Lophodytes cucullatus*). Large numbers of these migratory waterfowl winter in Delaware Bay, and others pass through on the way to wintering areas further south or to spring breeding grounds in the north (Nichols 1995). The U.S. Fish and Wildlife Service conducted a targeted aerial survey of wintering waterfowl in 1999 in waters more than 3 km offshore, where biologists found an estimated 200,000-250,000 black and surf scoters in the mid-depth (5-8 meters) areas of lower Delaware Bay. During the winter of 2001-02, an aerial survey of offshore waters out to 20 km found that waterfowl (primarily scoters) were more prevalent on open waters of Delaware Bay than on shoals of the Atlantic Ocean in New Jersey (Forsell and Koneff 2002). More recently, Silverman et al. (2008) estimated over 400,000 sea ducks, primarily scoters, in Delaware Bay waters in February 2008. The number of black scoters in Delaware Bay was by far the highest of any survey region along the Atlantic Flyway (Silverman et al. 2008).

Numbers of Eastern Population (EP) tundra swans (*Cygnus columbianus*) have doubled since the 1960's (Serie et al. 2002). Satellite tracking data has shown that EP tundra swans make brief stopovers in Delaware Bay and Chesapeake Bay during migration (Petrie and Wilcox 2003). Swans are large-bodied birds that have a more difficult time making fast maneuvers to avoid structures than other birds do. Research has shown that they have a high "hit-wire index" (Rose and Baillie 1989) and are susceptible to collisions with other tall structures like power lines (Butler 1999). Swans, as well as other large species like wading birds, decrease and increase altitudes at a gradual rate when approaching or departing from areas like stopover habitat that is found in the Delaware Bay region.

Nearly 2.2 million waterfowl winter south of New Jersey (U.S. Fish and Wildlife Service's Migratory Bird Data Center 2009). Delaware Bay is an important migration stopover for these birds. Malecki et al. (2006) found Delaware Bay to be one of two key spring migration stopovers for Atlantic Flyway northern pintails. Nutrient reserves obtained during the winter and spring migration stopovers are critical to reproductive success. In addition, while most wintering black ducks migrate north to nest, Delaware Bay is a breeding ground for a significant portion of the resident New Jersey black duck population.

Spatial and temporal patterns of use

Biologists conducting the MWS have found that dabbling ducks (particularly black ducks) respond to hunting pressure by moving 2-5 km offshore into Delaware Bay waters to avoid hunting pressure on a daily basis (T. Nichols pers. comm. 7/24/09). They return to feed and roost in tidal marshes in the evenings after hunting has ceased. Altitude of these daily flights is less than 100 m, consistent with localized movements of ducks (van der Winden et al. 1999, Dirksen et al. 2000).

Winter use of salt marsh habitat by black ducks is strongly related to open vs. closed hunting seasons and the presence or absence of ice. Conroy et al. (1987) found that during the open hunting season, nocturnal use of salt marsh habitat was higher as birds flew to salt marshes from open-water areas of refuge on a daily basis, presumably to forage. Such localized flights at (or after) dusk are estimated to occur below 100 m in altitude (van der Winden et al. 1999, Dirksen et al. 2000). Extensive ice cover led to a local dispersal of black ducks throughout the salt marshes along the Atlantic and Delaware Bay, as well as some dispersal to more southerly locations throughout the flyway.

Cross-bay movements have been documented in greater snow geese using radio telemetry (Hill and Frederick 1997). The average daily movement distance for marked snow geese ranged 4–23 km between roosting sites and feeding sites, with the longer flights involving geese crossing Delaware Bay to feed in southern New Jersey Delaware Bay tidal marshes (Hill and Frederick 1997). With an average of nearly 100,000 snow geese on New Jersey Bayshore (NJDFW Mid-Winter Waterfowl Survey), and approximately the same number on the Delaware Bayshore (DEDFW Mid-Winter Waterfowl Survey at http://www.fw.delaware.gov/Hunting/Documents/Wfowl%20survey%20January%202009.pdf), there is the potential for many thousands of snow geese to make cross-bay flights daily in the winter concentration period.

Movements of sea ducks with respect to offshore wind farms in Denmark were studied by van der Winden et al. (2000). Foraging flights of sea ducks occurred most often at night. Movements were significantly different on moonless nights compared to moonlit nights. Sea ducks avoided flying through wind farm areas on moonless nights, thereby increasing flight distance and duration to reach feeding areas. Presumably, these increases lead to an increase in the demand for individual energy.

Vulnerability

One of the greatest potential impacts of wind turbines to waterfowl and seabirds in the Delaware Bay region is avoidance of habitat containing turbines and the "barrier effect" that would occur to these species during migration. Waterfowl and seabirds tend to avoid habitat containing turbines in their daily movements (e.g., in wintering and stopover areas), and tend to move away from turbines (as "barriers") during active migration (Goodale and Divoll 2009). While avoidance reduces their likelihood of collision, it also increases the energy expenditure for flight by forcing birds to fly farther to avoid turbines. Flight is the most energetically costly activity for birds. Increases in flight cause increases in daily energetic requirements, thereby reducing the overall carrying capacity of the habitat at the population level. At the individual level, birds must spent additional time foraging to accrue the energy lost by the increase in flight. Birds unable to accumulate adequate energy are more susceptible to predation as vigilance is sacrificed for increased foraging. This may lead to decreased survival and lower productivity as a result of being energetically stressed.

Avoidance of suitable habitat during the wintering period results in an overall decrease in the amount of habitat available for survival in the difficult winter conditions. Reduced habitat for waterfowl species like the American black duck, which winter in large numbers in Delaware Bay, reduces the carrying capacity of Delaware Bay for waterfowl, leading to lower populations of those species (Goodale and Divoll, 2009, P. Castelli, pers. comm. 7/28/09). Various studies have shown that seabirds will travel distances of 100-3,000 m to avoid flying near turbines (Winkelman 1992, Christensen et al. 2004, Kahlert et al. 2004a). Other research has shown that scoters, an important winter inhabitant of Delaware Bay, avoid wind farms and the surrounding area (Langston and Pullen 2003, Christensen 2004, Kahlert et al. 2004b, Petersen et al. 2004). Furthermore, it appears that as more time passes, the abundance of these species decreases in the vicinity of wind farms. Although it was once speculated that habituation would occur over time, surveys have not borne this out (Stewart et al. 2007).

4. Bald Eagles

The bald eagle (*Haliaeetus leucocephalus*) population in New Jersey had declined to a single nest in Cumberland County by 1970, due to the severe and pervasive effects of DDT in their food chain (Smith and Clark 2008). Biologists in the NJDEP Division of Fish and Wildlife worked since 1980 to restore the population. Prior to the population crash as well as in recovery, the bald eagle population has been centered on the tidal rivers, marshes and forests of the Delaware Bay area. Records from 1970-1980 indicate eagles wintered in the Bayshore region even before the nesting population recovery began (NJDEP Biotics database). As eagles began to repopulate the state, nests became established in the Bayshore region: East Creek, Maurice River, Stow Creek, Cohansey River, Nantuxent Creek and Mannington Meadows, all by 1995. In 2009, with the statewide population at 82 pairs, the highest density of eagle nests continues to be found in the Bayshore region in Cumberland and Salem counties. Several nests have been established less than 2 km apart, which is an indication of the exceptional resources that exist in this region for bald eagles.

In addition to resident, nesting bald eagles, the region supports an annual concentration of eagles in winter, wherein eagles forage and roost. Concentration areas for foraging and roosting are recognized by the U.S. Fish and Wildlife Service (even after removal of the bald eagle from the federal Endangered Species List) because of the importance of these areas to the survival of large numbers of eagles, particularly sub-adult birds (Buehler 2000, USFWS 2007). Essential elements for eagles are reliable locations of open water and prey, with nearby forested areas that provide shelter from wind and weather for night roosting. These elements are found all along the Delaware Bayshore. Human activities near or within communal roost sites may prevent eagles from feeding or taking shelter, especially if there are not other undisturbed and productive feeding and roosting sites available (USFWS 2007). Activities that permanently alter communal roost sites and important foraging areas can altogether eliminate the elements that are essential for feeding and sheltering eagles (USFWS 2007). Thus, development that destroys habitat and interrupts the landscape, such as residential housing, roads and structures, poses the risk of eliminating bald eagle habitat that is essential to the survival of resident and wintering bald eagle populations.

Nesting bald eagles are year-round residents of their nest territories (NJDEP-DFW Bald Eagle Project reports at http://www.njfishandwildlife.com/ensp/raptor_info.htm#eagle), and therefore can be found in the Bayshore region in all seasons. The nesting season begins in December when eagles begin courtship activities and build or rebuild nests. The nesting season proceeds through incubation and hatching, and young eagles begin learning to fly in late June and throughout July. Young eagles remain in their nest areas for approximately two months after fledging as they learn to fly and hunt with their parents, frequenting ponds, creeks, rivers and marshes from Pond Creek (near Cape May) along the Bayshore and beyond the Cohansey River. Resightings of some eagles banded in New Jersey indicate many young eagles move south to Chesapeake Bay for the winter (B. Watts, College of William and Mary, Center for Conservation Biology, pers. comm.). However, there is also an influx of bald eagles in the Bayshore for the winter months. The Midwinter Eagle Survey has consistently recorded more wintering eagles in the Bayshore region than anywhere else in the state: 94 bald eagles were counted in the 2008 midwinter survey between Reed's Beach and the Cohansey River, with most of those observed in the Maurice River-Turkey Point area (Smith and Clark 2008). Wintering eagles move daily between foraging areas around open waters of the marshes, rivers and the Bay, to forested tracts with large trees that offer shelter from weather. Although eagles are capable of extensive soaring, gliding and flapping flight, they tend to use soaring and gliding for food searching and migration (Buehler 2000). In many cases hunting is done from a sedentary perch near water, particularly during winter when eagles need to conserve their energy (Buehler 2000). Bald eagles can be found perched and in low flight (<100 m) on Bayshore marshes in all daylight hours (Clark, pers. obs.) as they hunt fish, waterfowl, muskrat and other aquatic prey (Buehler 2000).

Vulnerability

Fifty-four golden eagles (*Aquila chrysaetos*) were killed by turbines in the Altamont Pass in California, 1998-2003, accounting for 10% of all raptors killed (Smallwood and Thelander 2008). While bald eagles differ somewhat in their flying and hunting behaviors, they are like golden eagles in overall size and dimensions. Eagles are large birds with relatively high wing loading (the ratio of body weight to wing area – how much "load" each unit area of wing must carry; Able 2001). They are less able to maneuver around obstructions compared to smaller, more agile birds. One of the leading causes of bald eagle mortality is impact injuries: of 1,428 bald eagles necropsied by the USGS National Wildlife Health Center, 1963-1984, 23% died from trauma, primarily impacts with wires and vehicles (as cited in Buehler 2000). Similarly, 24% of bald eagles in Maryland, 1988-2004, died of collision-type trauma, for those with a known cause of death (Driscoll et al. 2004). Bald eagles are also susceptible to collision with powerlines, causing injury and death due to impact or from electrocution (Buehler 2000, Driscoll et al. 2004).

Bald eagles use the open waters of Delaware Bay, creeks and rivers for foraging, and the Bayshore forests and woodlands for roosting (Paturzo and Clark 2003, NJ DEP Biotics database, July 2009). The U.S. Fish and Wildlife Service (USFWS 2007), in its Bald Eagle Management Guidelines, makes this specific recommendation: "Minimize potentially disruptive activities and development in the eagles' direct flight path between their nest and roost sites and important foraging areas."

Conclusions

Many guidance documents and literature reviews highlight the importance of careful consideration of potential locations for wind turbines, noting that appropriate siting of turbines is one of best ways to avoid unacceptable levels of impact to wildlife resources (Bright et al. 2008, Drewitt and Langston 2006, Everaert and Steinen 2006, Fox et al. 2006, Goodale and Divoll 2009, Huppop et al. 2006, Langston and Pullen 2003, U.S. Fish and Wildlife Service 2003). Appropriate siting includes avoiding areas where there are high concentrations of birds and bats, such as migratory stopover locations, as is the case in Delaware Bay (U.S. Fish and Wildlife Service 2003). The turbines at Altamont Pass in California and Navarra and Tarif in Spain stand as examples of the consequences of poorly sited wind farms (Langston and Pullan 2003). If consideration had been given to bird use at each site prior to their turbine construction, the high mortality of birds could have been reduced (through better design) or avoided (by not permitting turbines in these locations). The Delaware Bay region is known and internationally recognized for its importance to migratory and wintering birds. Placing turbines in this area would be a critical mistake, given what is known about bird use at this site and what can happen when turbines are placed in unsuitable locations.

There is precedent for prohibiting turbine development in an environmentally sensitive area with known high bird use. The wetlands of the Wadden Sea contain the largest stretch of unbroken mudflats in the world and are renowned for their high concentrations of birds. Like Delaware Bay, it is recognized as a Wetland of International Importance under the Ramsar Convention, and also recognized under the Bonn Convention on Migratory Species and the EC (European Commission) Bird and Habitat Directives. The Trilateral Wadden Sea Plan, completed in 1997, is an international agreement between the Netherlands, Germany and Denmark (who all share its shoreline) and it explicitly prohibits wind turbines in the Wadden Sea Conservation Area, which covers the vast majority of the Wadden Sea area (Merkel et al. 1997).

The shoreline, wetlands, upland edge and open waters of Delaware Bay, as well as the lower Cape May peninsula, comprise an internationally recognized, highly significant migratory bird stopover in spring, fall and winter. The region's habitats provide essential food and shelter resources that are unmatched in the state or the Atlantic Flyway. The Delaware Bay habitats are critical to the welfare of several hemispheric populations – a resource shared with Canada and South America. The States of New Jersey and Delaware have a high hemispheric responsibility in the Western Atlantic Flyway for populations of red knots and other bird species that use the Bay. The importance of the Bay to migratory birds is recognized nationally and internationally. Delaware Bay has recognition by the Ramsar Convention on Wetlands of International Importance, an international treaty for the conservation and sustainable utilization of wetlands. The Bay is recognized by BirdLife International and Audubon as an Important Bird Area of Global Significance, and has the highest level of significance in the Western Hemisphere Shorebird Reserve Network. Most recently, Delaware Bay conservation was specifically supported by the Atlantic Flyway Council, comprised of U.S. east coast states and Canadian provinces responsible for management and conservation of migratory waterbirds and land birds. Wind turbine development in this region would cause disruption to the migratory and wintering patterns of hundreds of thousands of shorebirds, raptors, songbirds and waterfowl, and would likely cause permanent harm to bird populations in New Jersey, Atlantic Flyway and Western Hemisphere.

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APPENDIX III

GIS Data Sources

New Jersey Department of Environmental Protection (NJDEP), Office of Information Resources Management (OIRM), Bureau of Geographic Information Systems (BGIS). 2006. *NJDEP 2002 Land use/Land cover Update for New Jersey (Final).*

Online Linkage: http://www.state.nj.us/dep/gis/lulc02cshp.html

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Online Linkage: Unpublished.

APPENDIX IV

Terms and Definitions

Biotics - Biodiversity data management software used by the Endangered and Nongame Species Program (ENSP). The successor to the Biological and Conservation Database, this data management software was developed by NatureServe and, within New Jersey, is maintained jointly by ENSP (animal data) and the Natural Heritage Program (plant and ecological community data).

feature label - A label assigned to each occurrence that describes the occurrence type (i.e. nest, colony, den, dead on road, etc.).

NatureServe - A non-profit conservation organization that provides scientific information and tools to help guide effective conservation action. NatureServe represents an international network of biological inventories (known as natural heritage programs or conservation data centers) operating in all 50 states, Canada, Latin America, and the Caribbean.

NJDEP Landuse/Landcover (LU/LC) - A geographic information system (GIS) dataset produced by visually interpreting color infrared aerial photography of New Jersey. Through this process, photo-interpreters examine each image, and based on their knowledge of photo signatures, classify the image into various land use/ land cover categories. The classifications are converted into a land use/land cover GIS digital file, with each delineated polygon representing a distinct land use/land cover type.

source feature - A location of a species occurrence represented by either a point, line, or polygon in the Biotics database.

Geographic Information Systems Terminology
from Environmental Systems Research Institute's Online GIS Dictionary
(http://support.esri.com/index.cfm?fa=knowledgebase.gisDictionary.gateway)

clip - A command that extracts features from one feature class that reside entirely within a boundary defined by features in another feature class.

dissolve - A geoprocessing command that removes boundaries between adjacent polygons that have the same value for a specified attribute.

feature class - In ArcGIS, a collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference. Feature classes can be stored in geodatabases, shapefiles, coverages, or other data formats. Feature classes allow homogeneous features to be grouped into a single unit for data storage purposes.

GIS - Acronym for geographic information system. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed.

heads-up digitizing - Manual digitization by tracing a mouse over features displayed on a computer monitor.