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Subcontractor Report

Ponnequin Wind Energy Project: Reference Site Avian Study

January 1, 1998 — December 31, 1998

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Foreword

Although the use of wind energy as an alternative electric generation source is now a viable choice, concern is still raised over the possible impacts of wind farms on birds. The concern includes two primary areas: the effect of bird mortality on their populations and possible litigation over killing even one bird protected by the Migratory Bird Treaty Act or the Endangered Species Act.

The activities of the avian research program at the National Renewable Energy Laboratory (NREL) focus on minimizing the effects of wind turbines on birds and bird populations. NREL, funded by the U.S. Department of Energy, conducts research that (1) contributes to the refinement of the methods developed to assess impacts on avian populations within wind farms, (2) seeks to understand how birds behave in and around wind turbines in different environments, (3) tries to identify how birds recognize wind turbines and develop recommendations for increasing the conspicuity of the turbines, and (4) seeks to develop recommendations for reducing impacts when they occur.

To date, several pre-construction-only studies and several post-construction-only studies have been conducted. However, only a few studies documenting pre- and post-construction avian wind-turbine interaction research are underway, including Buffalo Ridge, Minnesota; Foote Creek Rim, Wyoming; Searsburg, Vermont; and Ponnequin, Colorado.

This report summarizes the pre-construction avian research conducted on the reference sites at the Ponnequin Wind Resource Area in Weld County, Colorado. It also includes summaries of the research conducted on the project development site. Avian utilization and fatality surveys were simultaneously conducted at the project site with funding from the Public Service Company of Colorado (PSCO). Post-construction surveys are continuing with funding support from PSCO.

Preliminary information from the Department of Energy's Environmental Assessment of PSCO's proposed wind project site at the Ponnequin Wind Resource Area indicated that avian activity in and near the site was limited. Based on this preliminary information, it was believed the risk to birds from a wind project development would be minimal. When avian monitoring was begun, the original work funded by PSCO did not include reference sites. Including reference sites, or control sites if they are available, provides a basis for comparison to data collected within the development site. More importantly, data from reference sites, which are in theory sites that will not likely be built on, provides a basis for comparison to data collected after construction. It is more difficult to analyze data on a built site and draw conclusions on the cause of avian impacts, for example, without reference site data for comparison. Because NREL's avian research program aims to support research that is conducted using rigorous scientific methods, NREL offered to contribute funding to expand the monitoring to include reference sites.

NREL appreciated the opportunity to contribute to the collection of baseline data at the Ponnequin site. PSCO has opted to continue funding the monitoring of the site, post construction. The continued monitoring includes data collection at one of the reference sites.

The authors declined to conduct sample size and power analyses using the preliminary data presented herein. NREL believes that such analyses would have been useful in guiding future data collection, thus helping to refine subsequent field methods and analyses. NREL looks forward to reading the consultant's report documenting the continued monitoring and the analyses of the data collected at this wind site. It will be beneficial to learn whether the sample size and power from this study were in fact satisfactory to detect potential impacts to birds.

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Executive Summary

This report summarizes one year of pre-construction data collection for avian abundance, use, mortality, raptor nesting, and prey availability at the Ponnequin Wind Energy Project site and two nearby reference sites. The project owners have funded data collection on the area proposed for project development since June 1997. Data collection on the reference sites was funded by the National Renewable Energy Laboratory (NREL) for one year of study, January through December 1998. The project site is in Weld County, Colorado, just south of the Wyoming border. Reference sites are situated immediately to the west of the project site (Weld County) and 4.8 kilometers (km) (3 mi.) to the north of the project site (Laramie County, Wyoming). Data collection on the project and reference sites continues under the funding of the project owners.

Metrics and data collection methods established for the Ponnequin project site in June of 1997 were used for the reference sites so that methods would be identical. Avian survey methods included two main transects of more than 800 meters (m) at each site, with two 400-m perpendicular transects on three of the sites and one 400-m perpendicular transect on one site. Thirty-one avian surveys were completed on the reference site from January to December 1998. Prior to the start of construction on the project site, 29 surveys were completed on the project site from mid-September 1997 to mid-September 1998. Birds of all types and their behaviors were noted. Surveys of prey availability were conducted April through August 1998 along all four main transects. Carcass searches, with affiliated observer efficiency and carcass removal (scavenger) evaluations, were conducted.

The surveys revealed no endangered, threatened, or species of concern on the project or reference sites. Species composition and abundance patterns of songbirds and raptors on reference and project sites are presented, as are basic use patterns. Horned Lark and McCown's Longspur accounted for 85% of all songbirds observed on the project and reference sites. The Golden Eagle, Swainson's Hawk, and Ferruginous Hawk accounted for 75% of all raptors observed on both sites. Most raptors were observed at distances > 1 km from all transects. Few raptors were observed hunting along the main or perpendicular transects.

Potential prey species consisted primarily of thirteen-lined ground squirrels and northern pocket gophers. Abundance indices were determined for these species during their active period (April through August) for comparison with the post-construction study period. Surveys demonstrated that the abundance patterns varied along given transects.

Pre-construction carcass surveys revealed two avian (Horned Lark and Western Meadowlark) fatalities. Carcass search efficiency studies were conducted during August, with efficiency rates varying with the size of carcass: one-quarter of small songbird-sized carcasses, three-quarters of mid-sized (small ducks, rails, and small hawks) carcasses, and all large (large waterfowl, owls, and hawks) carcasses were detected. The efficiency rates of two field technicians were also measured. Carcass removal was rapid for small birds (1 to 3 days), but large carcasses were detectable for more than one to two months.

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Introduction

In June 1997, the first commercial wind energy project in the state of Colorado was permitted in Weld County near the Wyoming border. The issue of avian impacts was raised by several environmental agencies within whose jurisdiction the site was located. In addition, several conservation organizations and agencies voiced concern regarding the potential impacts of the project on birds in grassland environments, including those that nest on or near the site, those that migrate through the site, and those that winter on the site. The interest in avian impacts is based on experiences in the Altamont Pass Wind Resource Area of California, where hawk and eagle fatalities have been noted (Howell and DiDonato 1991; Orloff and Flannery 1992, 1996), and on lesser impacts on songbirds and waterbirds observed in Europe (Winkelman 1995). Because the fatalities in the Altamont Pass Wind Resource Area became public knowledge, there has been a tendency to make the generalization that wind turbines kill large numbers of birds although studies conducted at other wind plants in California (Anderson in press), Minnesota (Strickland in press), and Vermont (Kerlinger in press) have not demonstrated the same results. Thus, generalizations about the impacts of turbines on birds are problematic.

Studies were initiated at the Ponnequin project site in June 1997, using modifications of standard methodologies for determining avian use and potential impacts of the development. The studies are being funded by Public Service Company of Colorado (PSCO) and are ongoing. The methodologies established for the Ponnequin project site in June 1997, included an on-site before and after (BA) design in addition to an impact gradient (IG) design. The BA design examines bird presence and use before and after a site is developed. The IG design measures impact along transects or gradients moving away from the potential perturbation. A similar design was employed in a study of wind turbines in Minnesota (Leddy et al. 1999). In addition, these methods are discussed in detail by Anderson et al. (1999).

In mid-1997, the National Renewable Energy Laboratory (NREL) expressed interest in having a BACI-type study (Before, After, Control, Impact; Stewart-Oaten 1986, Green 1979) done at the Ponnequin site. The two study areas were intended to serve as reference sites for the project site. To facilitate this, NREL funded data collection at two reference areas near the Ponnequin project site. Two reference areas were subsequently identified and the funding was approved in January 1998. The field methods adopted for the two reference areas were, by necessity, identical to those that had been employed at the Ponnequin project site for the previous seven months. This status report only summarizes the data collected during the time period funded by NREL.

Wind Project Description

The wind energy project at Ponnequin will consist of 21 750 kilowatt (kW) NEG MICON turbines situated on a 3/4 section (480 acres, 194 ha.) privately held by a local ranching family. Seven turbines were up and operating when the NREL data collection was completed, with the remaining 22 scheduled to be erected and operating by May 1999. The turbines are mounted on 50-m tubular towers, with the total height-to-blade tip at the 12 o'clock position reaching about 74 m (242 feet) above the ground. Because of this height, the Federal Aviation

Administration (FAA) has required lighting to provide for aircraft safety. The area in which the blades turn, also called the rotor swept area, is 48 m (157 feet) in diameter and extends downward to within 26 m (85 feet) of the ground at the six o'clock position.

Methods

Study Sites

Two study sites were established near the Ponnequin project site as reference data sets for the avian and other studies. Both are on the Terry Bison Ranch, one directly to the west of the wind project site in Weld County, CO., and the other about 4.8 kilometers north of the site in Laramie County, just over the Wyoming border (Figure 1). Hereafter the sites are referred to as the Terry South and Terry North sites, or collectively as the "reference" sites as opposed to the "project site." (The two transects on the project site are referred to as the Meteorological Tower and Northeast transects.) The reference sites were chosen during two visits; the Terry South location was selected in July 1997 by a group that that included Karin Sinclair of NREL, NREL consultants (Michael Morrison and Richard Anderson), Paul Kerlinger, and Dr. Ron Ryder, and the Terry North site was chosen in January 1998 by the three authors. The Terry North site was added in order to have a site that was not immediately adjacent to the project area and therefore, less subject to influence of development activities. Both sites were chosen based on their topographic, vegetative, habitat, and avian community similarity, as well as proximity to the Ponnequin Wind Energy site.

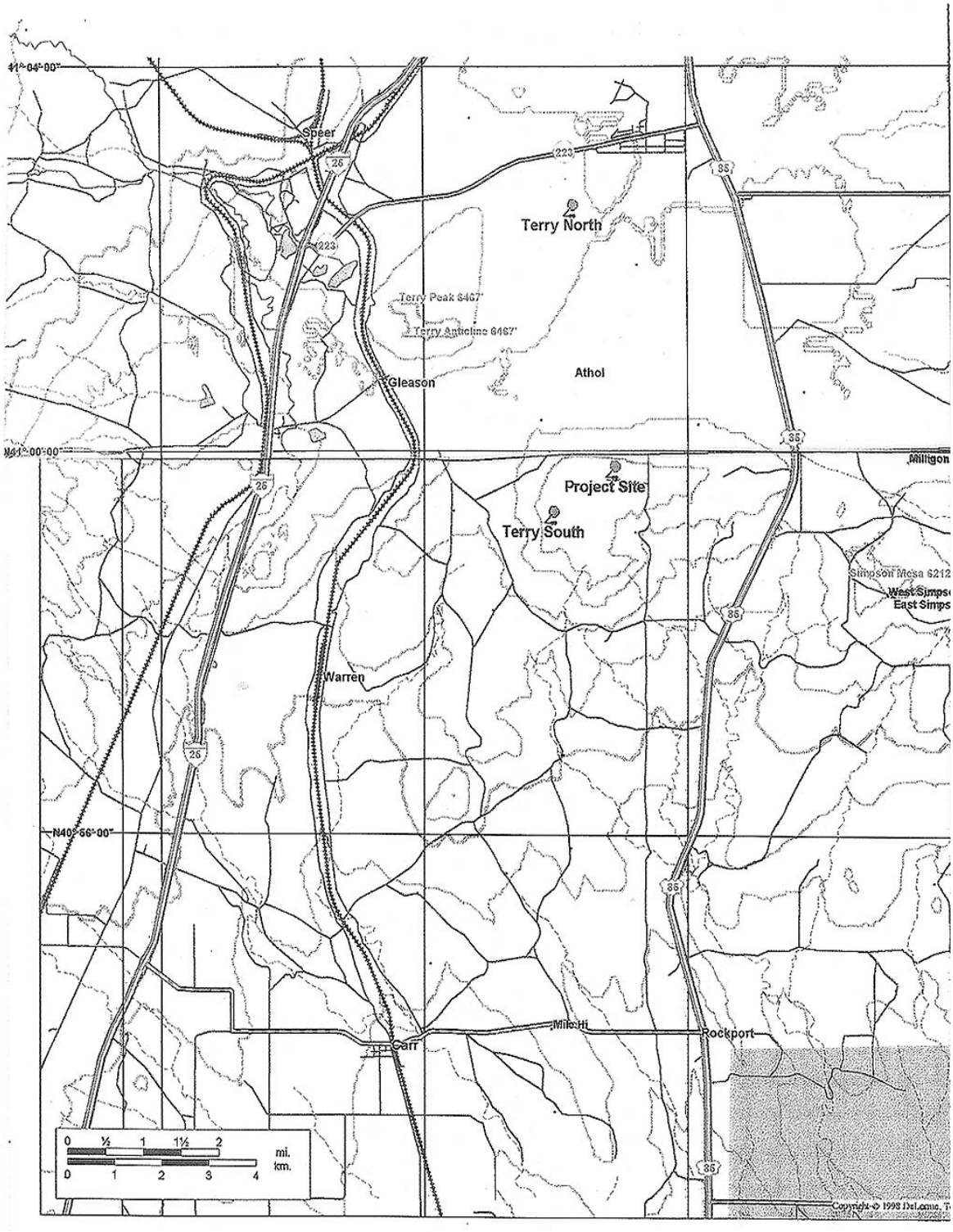
Both reference sites are situated in level to gently rolling, short-mid grass prairie, which is similar to the terrain at the Ponnequin Wind Energy Project site. The sites are floristically and topographically similar to the Roman property, on which the project is located. Visits during June 1997 by the three authors - and July 1997 by Dr. Ron Ryder - revealed a similar breeding songbird community. Raptor use also appeared similar, based on casual observations made during 1997 project site survey visits. The Roman property is used for cattle grazing and the Terry Ranch is used almost exclusively for bison grazing.

Avian Sampling

Avian sampling was conducted by Dr. Ron Ryder at each reference site along a main transect of 840 m and along two 400 x 100 m transects that were perpendicular to the main transect (see Figure 2). The main transect at each site was divided into 7, 120 m segments, a distance that corresponds roughly to the spacing distance between the turbines as originally specified in the project design and the dimensions of two avian sampling transects established on the Ponnequin project site. Observations along these transects were conducted one time per month during November through February, twice per month during March, April, September, and October, and four times per month during May through August.

We conducted 31avian surveys on the NREL reference sites and 29 surveys on the Ponnequin project site (see Table 1). These surveys provided a year of pre-construction data to eventually be used for comparison with data collected after construction of the wind plant is completed.

Figure 1. Map of Ponnequin project site and Terry North and South reference sites.



A site visit includes the observer walking the main transects slowly, recording all birds observed within 10 m of the main transect, and noting their behavior. A 10-m-wide corridor along the main transect is equivalent to the area where turbines will be erected on the project site; and birds present in this zone may be at risk. We were interested in how many birds used this specific area as well as how they used the project area. Prior to walking the transects, the observer made a 360 degree scan for at least five minutes to determine if raptors or other birds were in the area at the beginning of the survey. During the surveys, species identification, number of individuals, and general behaviors such as perching activity (directly on the ground, on fence posts and electrical poles, or other structures), and flight patterns (including altitude, territorial displays, and crossing of the transect) were noted. "Behavior" in this study is synonymous with "use" of the area. All of this information was noted on a data form for each of the 120-m segments (A1-2, A2-3, etc.) of the transect in which the observations were made. In addition to the initial 360 degree survey, at roughly the one- and two-thirds points along the main transects, all raptors (and other non-songbirds) were observed for at least five minutes. The area around these points were scanned in all directions. Noted for each observation were species, numbers of birds, location where they were seen, and behavior. About 90 minutes are required for the field observer to complete an entire transect.

The perpendicular transects were chosen to sample along a gradient going away from the main transect. Impacts may be detected along such gradients if use by or abundance of birds or other animals changes as distance from the main transect increases. The perpendicular transects extended 200 m on both sides of the main transect and were 100 m in width. These transects were divided into sixteen 50 x 50 m rectangles, eight on each side of the main transect. For analysis, the data were pooled into eight 50 x 100 m rectangles, four on each side of the main transects. These areas were surveyed via slowly walking a route that traversed the center of each area. All birds and their behaviors were recorded for each of the 50 x 100 m areas including species, number, and behavior (flight, perched on ground or other substrate, altitude of flight path, and territorial displays). Altitude for these birds and those on the main transects was estimated by eye and classified as 0, 1, 2, 3, 4, 5, …10, 20 meters, and for birds observed >20 meters altitude was estimated to the nearest 10 m. The 10-and 20-m categories were used for birds involved in territorial flight displays with all Horned Lark aerial territorial displays being categorized as 20 m and all McCown's Longspur and Lark Bunting territorial displays being categorized as 10 m above the ground. The reason for this is that the altitude of territorial displays varies greatly during a single bout and among bouts. By using the 10 and 20 m categories, we used a number that was close to the maximum heights to which these birds normally climb during territorial displays.

Raptors seen off site or outside of the surveys were noted as incidental observations. For the data summaries in this report, incidental observations of raptors were pooled with observations made during the surveys. By including all observations, we have added a conservative measure to future assessment of risk on the site.

Although not used in this report, the overall study design will incorporate the basic elements of both BACI and IG methodologies. The BACI methodology permits before-and-after and on-and off-site impact comparisons for a project. The reference sites allow the researcher to compare observations on the project site in different years, thereby controlling for regional or

Figure 2. Schematic diagram of main and perpendicular transects used for sampling birds and mammalian prey on the Ponnequin project site and two NREL reference sites. Main transects are 840 m in length and perpendicular transects are 400 x 100 m.

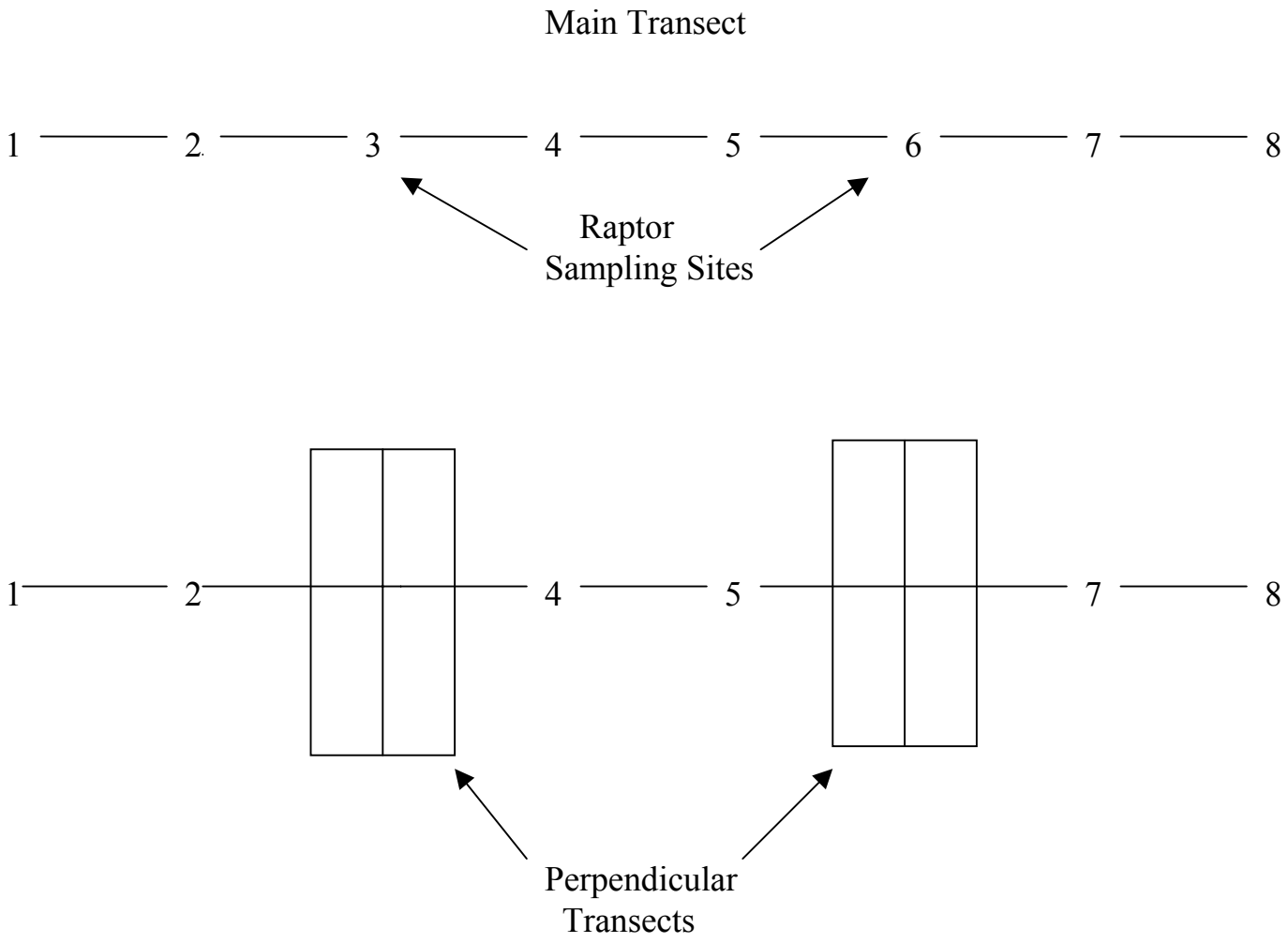


Table 1. List of dates of avian surveys included in this report

	NREL Reference Sites (31 surveys)	Ponnequin Project Sites (29 surveys)
Winter	January 5, 1998	November 18, 1997
	January 30, 1998	December 15, 1997
	February 27, 1998	January 16, 1998
	March 13, 1998	February 13, 1998
	November 25, 1998	March 6, 1998
	December 18, 1998	
Spring	March 27, 1998	March 20, 1998
(12 surveys)	April 10, 1998	April 3, 1998
	April 24, 1998	April 17, 1998
	May 2, 1998	May 1, 1998
	May 7, 1998	May 6, 1998
	May 15/16, 1998	May 15, 1998
	May 23, 1998	May 22, 1998
	May 30. 1998	May 29, 1998
	June 7, 1998	June 4, 1998
	June 13, 1998	June 12, 1998
	June 19, 1998	June 20, 1998
	June 26, 1998	June 27, 1998
Summer	July 4, 1998	July 3, 1998
(10 surveys)	July 11, 1998	July 10, 1998
	July 18, 1998	July 17, 1998
	July 24, 1998	July 25, 1998
	August 1, 1998	July 31, 1998
	August 8, 1998	August 7, 1998
	August 16, 1998	August 15, 1998
	August 22, 1998	August 21, 1998
	August 29, 1998	August 28, 1998
	September 11, 1998	September 4, 1998
Fall	September 25, 1998	September 26, 1997
	October 9, 1998	October 15, 1997
	October 23, 1998	

yearly changes in bird communities that can occur. The IG methodology is similar in that it allows comparisons, usually over shorter distances for species with small home ranges.

Observations on the reference sites were conducted for one year, from the first week of January 1998 until mid-December 1998. Project funding and construction of turbines precluded sampling at times that corresponded exactly with the reference sites. The project site data set used for the comparisons provided herein consisted of contemporaneous observations from January through mid-September 1998. Because of the commencement of construction (on the site but not specifically on the project site transects) in the fall of 1998, data collected from the project site from mid-September through December 1997 were paired with data collected on the reference sites during mid-September through December 1998.

Out of necessity, the "analyses" used in this report are simple, descriptive statistics and graphs that summarize the one year of pre-construction data funded by NREL on the two reference sites.

Aerial Surveys for Nesting Raptors

In April 1997 and June 1998 a square-shaped area 432.6 km^2 (169 mi^2) was surveyed via fixed-wing aircraft flying at an altitude of 31-150 m (100-500 feet) above ground level (AGL). The center of the area surveyed was the Ponnequin Wind Energy Station; the two NREL reference sites were slightly off-center of the surveyed square. The goal was to identify all active and inactive raptor nesting sites within the survey area. Each nest was mapped within the area using a global positioning satellite receiver (GPS). Presence of raptors on the nest or in the nearby area (via flushing from the nest) was usually the means for confirming that a nest was active.

Songbird Behavior/Use. Songbird behavior during main transect surveys was divided into the following categories: perched on the ground (including foraging, alert, and on nest, etc.) either along the main transects (imaginary line of turbine string) or not along the main transects, flying without crossing a main transect, crossing of main transects, and territorial displays. In addition to behavior, height of flight above the ground was also recorded. Birds on the ground were recorded as having a height of 0 m. The same type of information was gathered for birds observed while surveying the perpendicular transects.

Prey Activity/Abundance Index

Prey abundance is being evaluated because Orloff and Flannery (1992) are frequently cited as a source for the belief that excavation activities at wind plants (primarily roads) cause an increase in ground squirrel populations, thereby possibly attracting raptors. To assess raptor prey activity/abundance, counts of ground squirrel and pocket gopher burrow entrances were made on a monthly basis from April through August. This coincides with the period that these mammals are most active. During the cooler months of the year, these animals do not emerge on a regular basis and sometimes do not emerge for months at a time. Although counts of burrow entrances are not always highly correlated with absolute numbers of animals present, they are often a good

measure of the relative numbers of several fossorial mammals (Van Horne et al. 1997). Care was taken to determine whether the excavations were fresh or old as only fresh excavations were counted. The location of burrow entrances was noted and fresh digging signs were used to determine recent excavation activity. Burrow entrance counts are especially useful for determining new occupation of an area by a species that was previously absent.

Along the perpendicular transects, burrow entrance counts were made to provide an index of prey abundance and activity. Separate counts of burrowing activity of thirteen-lined ground squirrels and pocket gophers were made. Counts were made for each of the 50-m x 50-m areas in the perpendicular transects and were pooled into eight 50x100 m rectangles along each perpendicular transect.

Carcass Surveys

To establish a "control," or background avian mortality rate/level for the area, carcass surveys were conducted on a monthly basis from April to October along the perpendicular transects (on both project and reference perpendicular transects) on both the project and reference sites. The carcass searches along the perpendicular transects were done simultaneously with the prey availability surveys. During the collection of both data sets (prey availability and carcass searches), the observer looks at the ground. After reviewing the data on avian presence in the area and reviewing several months of data that were collected during carcass searches, we concluded that additional carcass searches were not warranted because there were so few carcasses.

In addition to the carcass surveys, tests were conducted of searcher efficiency and carcass removal. Starting in the first third of August 1998, carcasses of three size classes were placed randomly throughout the two reference transect areas and the Ponnequin turbine transects. Care was taken to not leave tracks in the short grass or soil (done on dry day) and to not leave any sign that a human had carried carcasses throughout the sites. The latter was accomplished via carrying carcasses in plastic bags until the moment they were tossed to the ground. Feathers left the birds as they were thrown in a fashion that is not dissimilar to that which occurs when a bird is struck by a turbine blade. The sizes corresponded to small, medium, and large birds. Road and window kills, including wild birds similar to those that might be found on site, were used. For the efficiency survey, two field technicians (Dr. Ron Ryder and Brett Petersen) were tested using a varying number of carcasses placed randomly throughout the two reference and two project transect areas. Searchers were not told how many carcasses were involved or where carcasses were located. For the carcass removal survey, the same carcasses were used. Each was checked for presence and condition on a daily basis for four days following placement, then again a month and slightly more than two months later. Additional notes were made in subsequent months as to presence and condition of these carcasses.

Results

Avian Surveys. At least 23 species of birds were identified at all sites, including some birds that were near, but not on the site. Eleven songbird and other small species were observed on the reference sites, along with 4 species of raptors, for a total of 15 species. Two Common Ravens that were observed from the reference site surveys were not included in the data summaries presented below for three reasons. First, they were about one kilometer off-site. Second, only two individuals were observed. Third, they do not fit into the functional categories we used for analyses (songbirds and raptors). These species are mentioned here so that there is a record of them being in the area of the project and reference sites.

We observed 16 species from the project sites, including nine small, mostly songbird species and seven raptor species (Northern Harrier, Swainson's Hawk, Rough-legged Hawk, Ferruginous Hawk, Golden Eagle, American Kestrel, and Prairie Falcon). In addition, one flock of about 25 Snow Geese was +observed flying 300 m above a main transect. Flocks of Canada Geese were observed well away from the transects (> 1 km), and a small flock (<10 birds) of shorebirds (species unknown) was seen flying about 300 m above a main transect. A flock of Sandhill Cranes was also observed several kilometers from the site. The observations of geese, shorebirds, and Sandhill Cranes were not included in the data summaries because they were rare on site; they amounted to a total of fewer than 10 observations (a very small sample size), and they were not flying within or near the rotor-swept area. They are mentioned here so that there is a record of them in this report. Three flocks of Lark Buntings and McCown's Longspurs, totaling 105 birds, were observed during what was most likely a migratory stopover or "touchdown." These individuals were not included in the summary of species composition because their presence was ephemeral. Individuals from these three flocks were included in the height analyses (use of the site) so that risk could be assessed from that perspective.

Several other species of birds were observed near the surveyed areas or before or after the official surveys. These included Red-tailed Hawk, Turkey Vulture, American White Pelican, Brewer's Blackbird, Grasshopper Sparrow, Greater Yellowlegs, Canyon Wren, Say's Phoebe, and some others. Individuals of some of these species may wander through the transect areas or fly over the sites, but their occurrence on the transects seems to be rare.

For this status report, data from the reference and Ponnequin project sites have been divided into raptors and songbirds for presentation purposes. The former includes all falconiforms, whereas the latter includes passeriforms and a few other small birds.

Songbird Abundance. Almost 2,800 songbirds and related small species were recorded on the four transects (see Table 2). Horned Larks and McCown's Longspurs were about equal in number and were the most common species on the four transects, accounting for nearly 85% of all individuals observed. Horned Larks were somewhat more numerous on the Terry South site than on the Terry North site. The reverse was true for McCown's Longspur on these sites. Lark Buntings were variable among sites, ranging from 0% of the birds observed on the Terry North site to nearly 13% of the birds seen on the Ponnequin Northeast site. Meadowlarks represented <6% of the totals on the four sites.

Seasonal abundance was greatest in spring and summer, with few birds present on site in late fall, winter, and early spring (Figures 3 and 4). During about one-half of the year, few individuals are present and the number of species is reduced. In winter, Horned Larks predominated, with a few other species being represented by one or a few individuals.

Songbird Behavior/Use. Height of songbirds observed along the main and perpendicular transects ranged from ground level to about 20 m above the ground (see Figures 5, 6, and 7). In fall and winter, <5% of all birds from all four study areas reached or flew above 20 m above the ground. During these seasons virtually all of the birds flew or perched at heights of < 3 m above the ground. In spring and summer, about 60%-70% of all songbirds seen on the main transects were below 3 m above the ground, and 12% to 25% flew at 10 to 20 m above the ground.

Raptors. We recorded 76 sightings of raptors during the course of 60 surveys (see Table 3). This is slightly more than one raptor per visit on the sites. The Terry North site had about four times more raptor observations than the Terry South site (see Table 4).

Seven species of raptors were observed during surveys on the reference and project sites, including four on the Reference sites and seven on the Project sites (see Table 3). In addition, two other species of raptors were observed on or near the sites during non-survey visits (Table 4). Three species, Golden Eagle, Ferruginous Hawk, and Swainson's Hawk, accounted for 75% of all raptors observed. These species accounted for all but one of the raptors observed on the reference sites. More than one-half of the raptor observations on both reference and project sites occurred during the summer season (see Figure 8). Fewest birds were observed from late autumn through early spring. Only about 10% of raptor observations occurred from November to March 15.

Abundance of raptors within the reference and project site transect boundary areas was low; and most raptors were observed over a wide geographic area around the actual transects. For example, only three Golden Eagles were observed within 0.5 km of the main transect and none was observed on the perpendicular transects. Only 21raptors (27.6% of all raptors observed during surveys) were within either 0.5 km of the main transect or within the boundaries of the perpendicular transects. Only three hawks were observed crossing the main transects (a Swainson's Hawk and a Northern Harrier on the Ponnequin Northeast transect and a Ferruginous Hawk on the Terry North transect). The heights of these birds above ground level were 10 m, 6 m, and 20 m, respectively.

Thus, of the 76 raptors observed during 60 surveys on four transects during a one-year period, 3 crossed the main transect (analogous to crossing a line of turbines) and none crossed at the height of the rotors.

Aerial Surveys for Nesting Raptors. Twenty-seven raptor nests were found during the 1997 survey. In 1998, only 16 active nests were located, although leaves on the trees may have obscured several nests that year. The numbers in Table 5 are smaller than those given in the previous sentences because species identity of some nests could not be determined. These nests were probably buteo nests (species unknown) and will not be considered in detail here because of the uncertainty of identification and occupation. The density of raptor nests in the 432.6 km^2 area was 0.62 nests per 10 km^2 in 1997 and a minimum of 0.37 nests per 10 km^2 in 1998.

Table 2. Summary of "songbird" (see Methods) species observed on the NREL reference sites during official surveys (January to December 1998) and Ponnequin Wind Energy Project site mid-September 1997 to mid-September 1998. (See text for explanation of survey time periods. Reference sites were surveyed 31 times and project sites 29 times within a 12-month period.)

Species	NREL Reference Sites		Ponnequin Project Sites		
	Terry North	Terry South	Northeast	Meteorological	Total (Percent)
Mourning Dove	0	0	2 - <1%	0	2 -<1%
Common Nighthawk	0	0	0	2 - <1%	2 -<1%
Hummingbird spp.	1- <1%	0	0	0	1 -<1%
Western Kingbird	0	1 - <1%	0	0	1 -<1%
N. Rough-winged Swallow	1 - <1%	0	0	0	1 -<1%
Cliff Swallow	3 - <1%	0	0	2 - <1%	5 -<1%
Barn Swallow	5 - 1.1%	3 - <1%	13 - 1.2%	21 - 3.5%	42 - 1.5%
Horned Lark	161 - 34.0%	319 - 48.4%	426 - 41.1%	276 - 45.5	1182 - 42.6%
Brewer's Sparrow	0	2 - <1%	0	0	2 - <1%
Vesper Sparrow	0	1 - <1%	0	1 - <1%	2 - <1%
Lark Bunting	0	68 - 10.3%	134 - 12.9%	46 - 7.6%	248 - 8.9%
McCown's Longspur	298 - 62.9%	226 - 34.3%	417 - 40.2%	231 - 38.1%	1172 - 42.2%
Western Meadowlark	5 - 1.1%	39 - 5.9%	45 - 4.3%	27 - 4.5%	116 - 4.2%
Totals	474	659	1,037	606	2,776

Figure 3. Seasonal abundance of songbirds along main transects of Ponnequin project and NREL reference sites. Metric is the number of birds seen per segment of transect (120 – m segments).

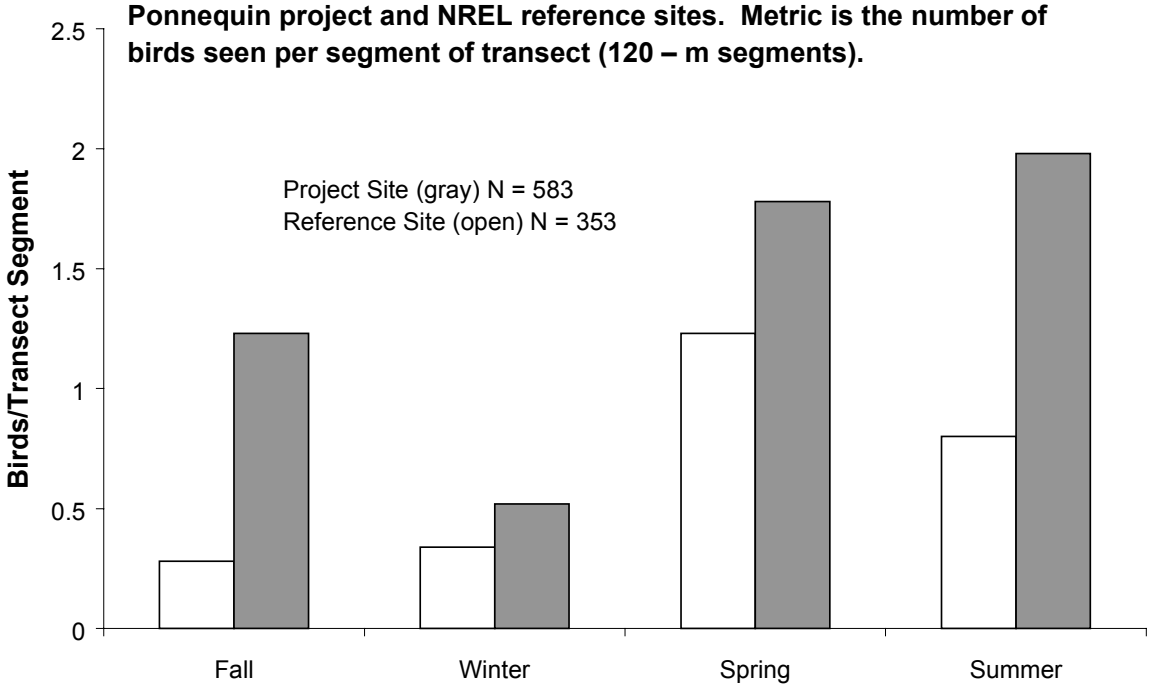


Figure 4. Seasonal abundance of songbirds along perpendicular transects located on Ponnequin project and NREL reference sites. Metric is the number of birds seen per hectare

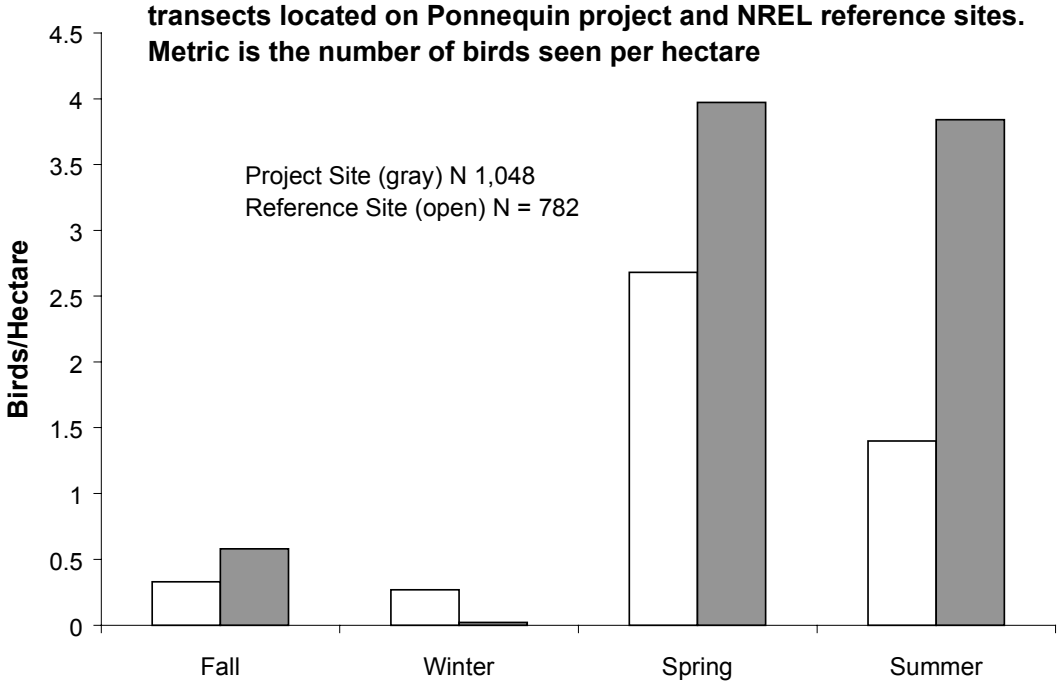


Figure 5. Height of songbirds observed on main transects on Ponnequin project and NREL reference sites during spring and summer.

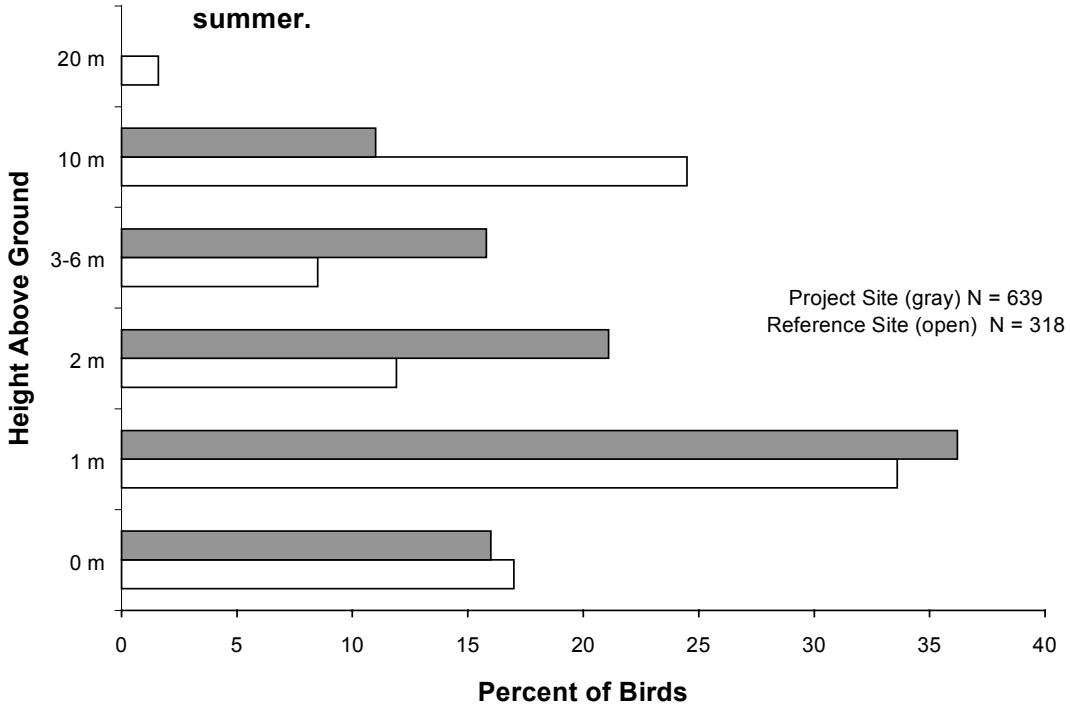


Figure 6. Height of songbirds observed on perpendicular transects on Ponnequin project and NREL reference sites during spring and summer.

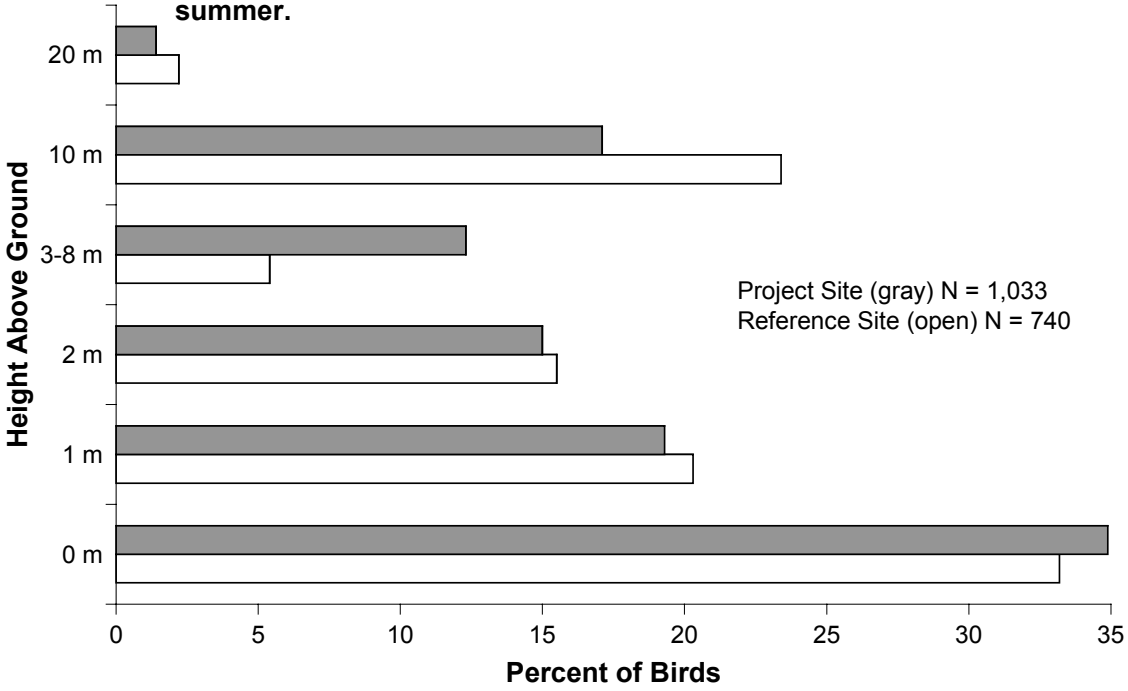


Figure 7. Height of songbirds observed on main and perpendicular transects on Ponnequin project and NREL reference sites during fall and winter.

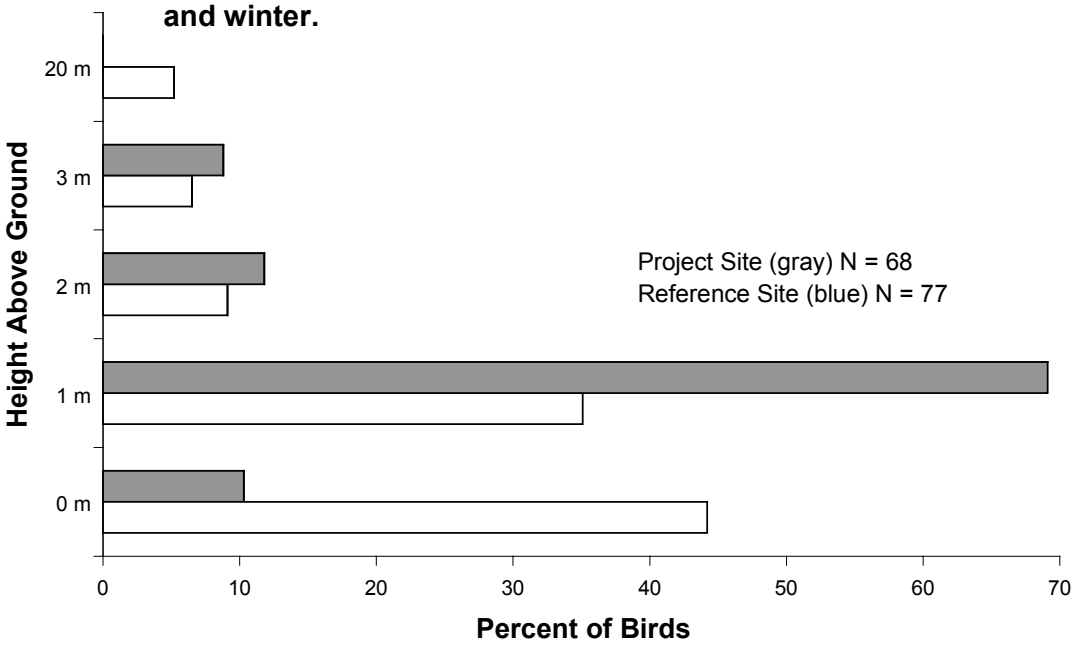


Table 3. Comparison of raptor species composition at NREL reference sites and Ponnequin project sites. Percentages given are the percent of all individuals observed during official surveys and within the study areas. The number of birds per survey is the number of individuals divided by the number of surveys (31 at the reference sites, 29 at the project sites) conducted during the one year study period (see Methods).

	NREL Reference Sites	Ponnequin Project Sites	Total
Northern Harrier		2 - 5.9% - 0.07/survey	26.3%
Swainson's Hawk	12 - 28.5% - 0.39/survey	8 - 23.5% - 0.28/survey	20 - 26.3%
Rough-legged Hawk		3 - 8.8% - 0.10/survey	3 - 3.9%
Hawk	15 - 35.7% - 0.48/survey	1 - 2.9% - 0.03/survey	16 - 21.0%
Unidentified Buteo		7 - 20.5% - 0.24/survey	7 - 9.2%
Golden Eagle	14 - 33.3% - 0.45/survey	7 - 20.5% - 0.24/survey	21 - 27.6%
American Kestrel		1 - 2.9% - 0.03/survey	1 - 1.3%
Prairie Falcon	1 - 2.4% - 0.03/survey	5 - 14.7% - 0.17/survey	6 - 7.9%
Total	42 - 1.35/survey	34 - 1.17/survey	76 - 1.27/survey

Table 4. Summary of raptor sightings (including incidental sightings) at NREL Reference sites and Ponnequin Project sites. "P" (meaning present) indicates that the species was seen, but not on the site or during official surveys. Number in parentheses indicates number of sightings of observations of birds seen within 0.5 km of the transect, birds crossing the main transects (only three birds – see text), and/or birds within the perpendicular transect boundaries. The difference between the two numbers is the number of observations of the species that were not within 0.5 km of a main transect or within the boundaries of the perpendicular transects.

* Indicates one individual of each of these species (total of three individuals) crossed the main transect during a survey (Swainson's Hawk at 10 m above ground, Ferruginous Hawk at 20 m, and Northern Harrier at 6 m).

	NREL Reference Sites		Ponnequin Project Sites	
	Terry North	Terry South	Northeast	Meteorological
Turkey Vulture	P	P	P	P
Northern Harrier*	P	P	2 (2)	P
Red-tailed Hawk	P	P	P	P
Swainson's Hawk*	10 (2)	2 (1)	7 (3)	1 (1)
Rough-legged Hawk	0	0	3 (1)	0
Ferruginous Hawk*	11 (4)	4	1	0
Unidentified Buteo	0	0	7	0
Golden Eagle	12	2 (2)	4	3 (1)
American Kestrel	0	0	0	1 (2)
Prairie Falcon	1	P	2	3 (2)
Total	34 (6)	8 (3)	26 (6)	8 (6)

Ferruginous Hawk nests were most numerous with a total of seven nest sites found in both years, followed by Golden Eagles and Red-tailed Hawks with six-and-four nest sites found, respectively. The closest raptor nest was that of a Swainson's Hawk (see Table 5) slightly more than one kilometer from the turbine site in a grove of trees in a ravine to the southeast of the Roman property. One other Swainson's Hawk nest was within 5 km of the turbine site, as was one Red-tailed Hawk (see Table 5). The closest Golden Eagle nest was 6.8 km.

Prey Activity/Abundance. Several species of mammals were observed that could be used as prey by raptors. Cottontail rabbits and jackrabbits were rarely seen on or adjacent to the sites during more than 60 site visits. On several dozen occasions, the primary field biologist (Dr. Ryder) arrived before dawn, yet observed few of these species. We judged them to be ancillary prey species for raptors in the area. Pocket gophers and thirteen-lined ground squirrels appear to be the most numerous prey on the "reference" and "project" sites. There is a strong seasonal component to abundance of these species because ground squirrels and pocket gophers are

Figure 8. Seasonal distribution of raptor sightings on Ponnequin project and NREL reference sites.

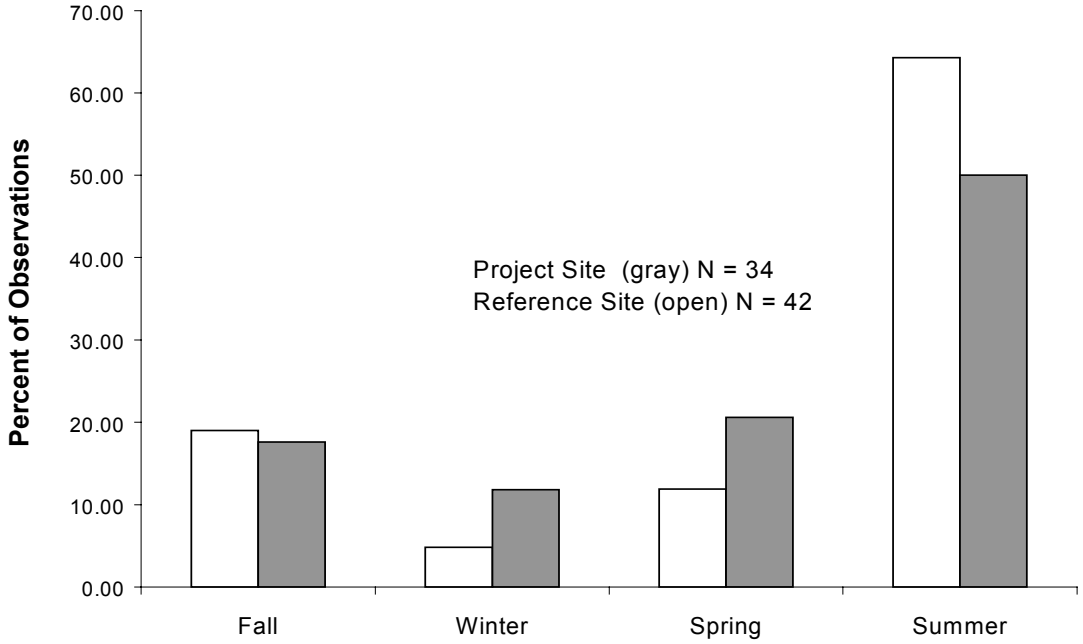


Table 5. Aerial raptor nesting surveys conducted by Dr. Archie Reeve in the 432.6 square km^2 (169 mi^2) area surrounding the Ponnequin Wind Energy Project site and NREL reference study sites. Numbers with question marks represent known nesting sites that could not be seen adequately or were inactive in 1998.

Number of Active-Occupied Nests Observed

Species	1997	1998	Distance to Closest and Second Closest Nest in Kilometers
Red-tailed Hawk	4	0 (4?)	4.7 - 9.0
Swainson's Hawk	1 (2)	0 (3?)	1.1 - 3.8
Ferruginous Hawk	4 (3?)	3 (4?)	6.5 - 8.9
Golden Eagle	5 (1?)	2 (2?)	6.8 - 7.7
Prairie Falcon	1	0 (1?)	6.7
Great Horned Owl	1	0 (1?)	11.1

August), the numbers of excavations varied among visits and among sites. Ground squirrel abundance ranged from slightly fewer than 5 burrow entrances to more than 15 excavations (see Figure 9A-9D) per hectare.

Pocket gopher burrow entrances were also variable, with large counts of sign noted on some sites and smaller counts only a short distance away (see Figure 10A-10D). Even within a transect area, there were few signs of pocket gopher activity. Extremely small numbers of ground squirrel and pocket gopher sign's were observed on the 17 April survey, with much larger numbers of excavations being counted in the subsequent month. This suggests these animals became active in late April. These animals were largely absent on one of the Terry North perpendicular transects during the entire 1998 survey period.

Carcass Searches

Carcass searches were conducted on the perpendicular transects on a monthly basis from April to October and incidentally during all site visits. Two songbird carcasses were located during the study: a probable Horned Lark and a Western Meadowlark. The Horned Lark had been dead for a long time. Two other dead birds were located during the course of site visits but not during carcass searches. One was likely impaled on a fence off the transects and the other, a McCown's Longspur, was a young bird newly out of the nest. The latter was found within the study area, but not found during an official survey visit. The other was not on a study site.

Observer Efficiency. Tests of observer efficiency were conducted in mid-August 1998 with two field observers being tested (Ron Ryder and Brett Petersen). Carcasses put out for the trials are listed in Table 6. Searchers found similar numbers of birds (see Table 7). Small birds, the size of warblers, blackbirds, finches/sparrows, and small woodpeckers were most difficult to locate with about one-quarter being located. Mid-sized birds the size of mid-sized owls (Long-eared Owl, small ducks, rails, kestrels, etc.) were easier to find. Both observers found about three-quarters of the mid-sized birds that were placed out (see Table 7). All of the large birds (large owls, large raptors, large ducks, Sage Grouse, and some others) were found.

Carcass Removal/Scavenging. Removal of the smallest carcasses was via carrion beetles that buried songbirds, in some cases, within 24 to 48 hours (see Table 8). Some songbirds were visible on the ground for several days. Mid-sized and large carcasses were also scavenged by beetles, but the beetles could not bury them. Instead, the carcasses were "eaten out" leaving the skeleton and feathers, which were obvious to observers for one to more than two months, in many cases. A few large carcasses disappeared completely within a week or two, although some of the largest carcasses (e.g., Ferruginous Hawk, Great Horned Owl and Rough-legged Hawk) were obvious for more than two months after they were placed out and even some medium and small carcasses were present after a month (see Figure 11).

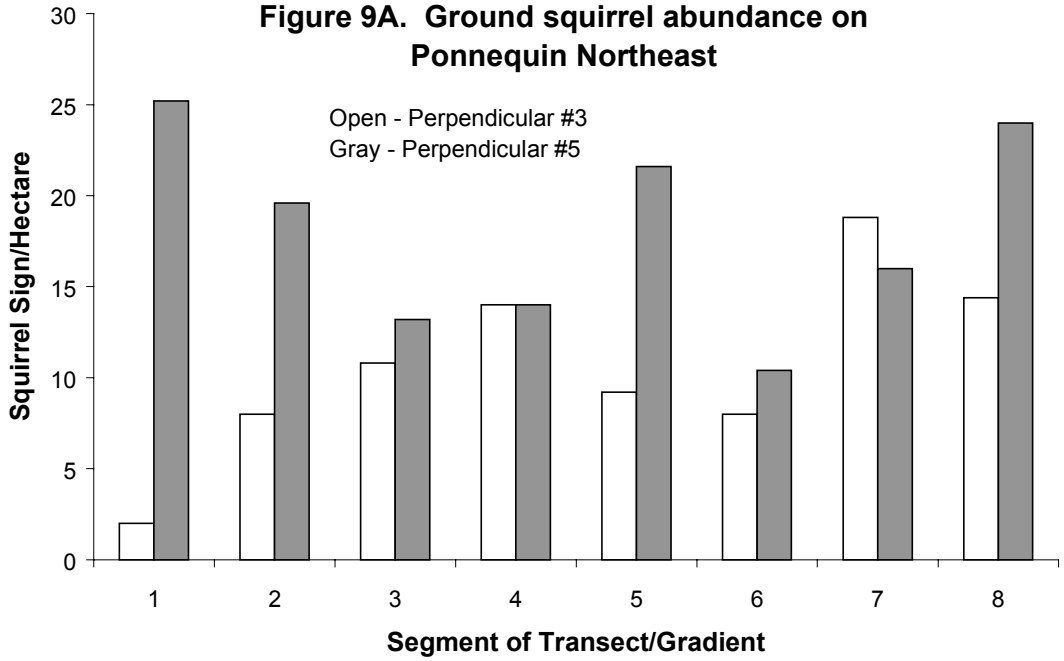


Figure 9A. Ground squirrel abundance on Ponnequin Northeast
Open - Perpendicular #3
Gray - Perpendicular #5
Squirrel Sign/Hectare
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
Segment of Transect/Gradient

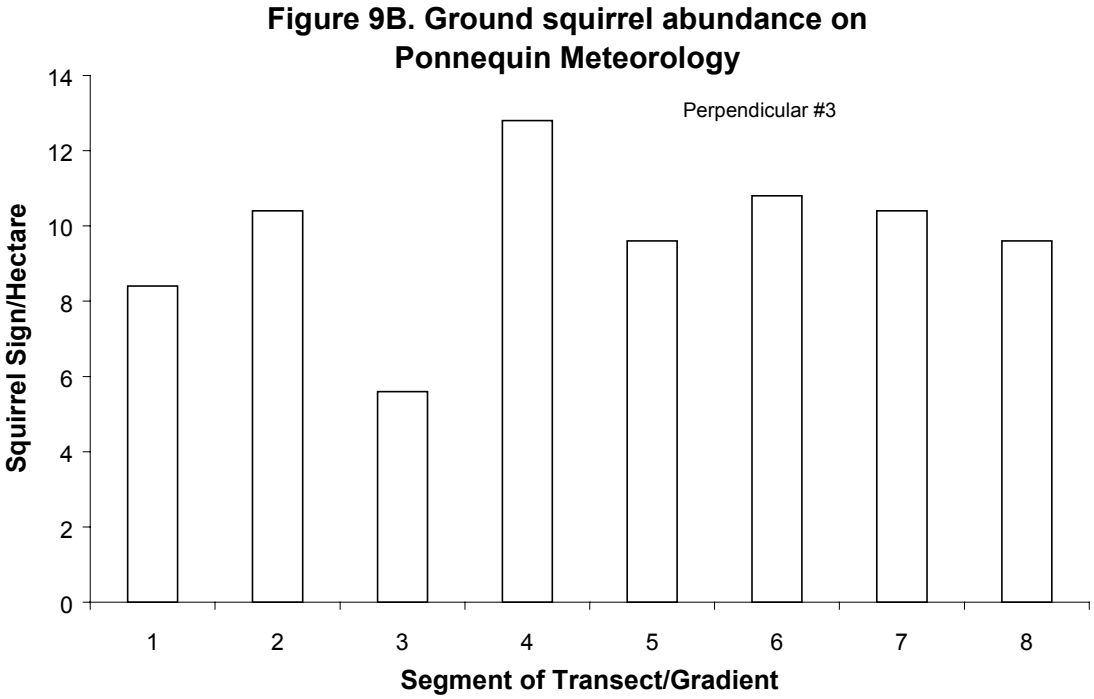


Figure 9B. Ground squirrel abundance on Ponnequin Meteorology
Perpendicular #3
Squirrel Sign/Hectare
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
Segment of Transect/Gradient

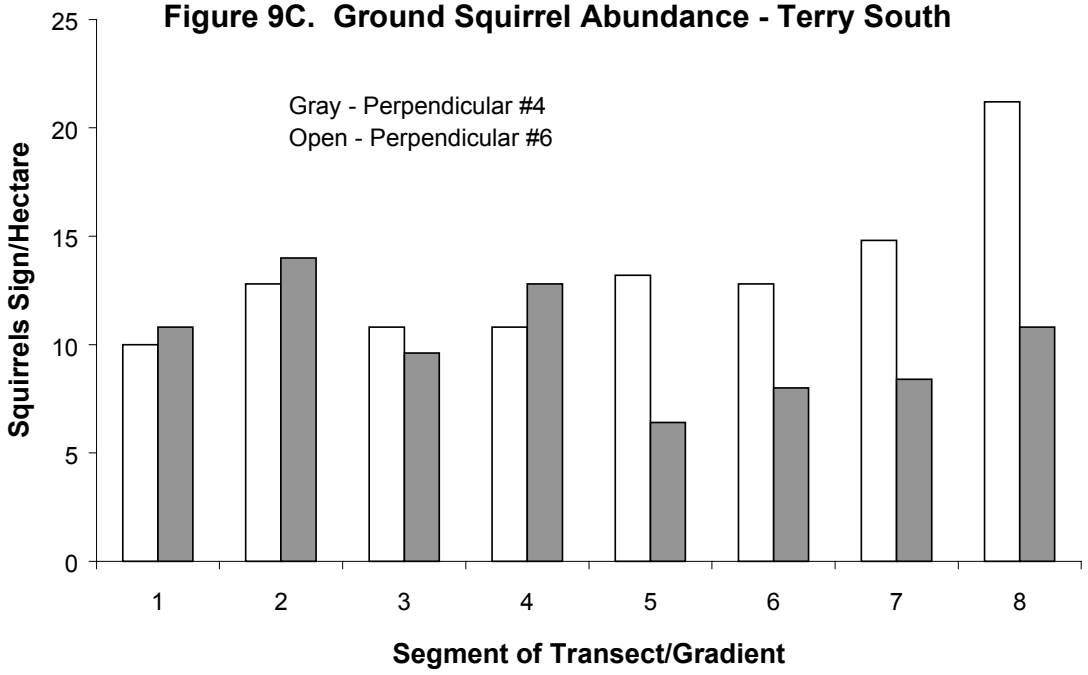


Figure 9C. Ground Squirrel Abundance - Terry South
Gray - Perpendicular #4
Open - Perpendicular #6
Squirrels Sign/Hectare
25
20
15
10
5
0
1
2
3
4
5
6
7
8
Segment of Transect/Gradient

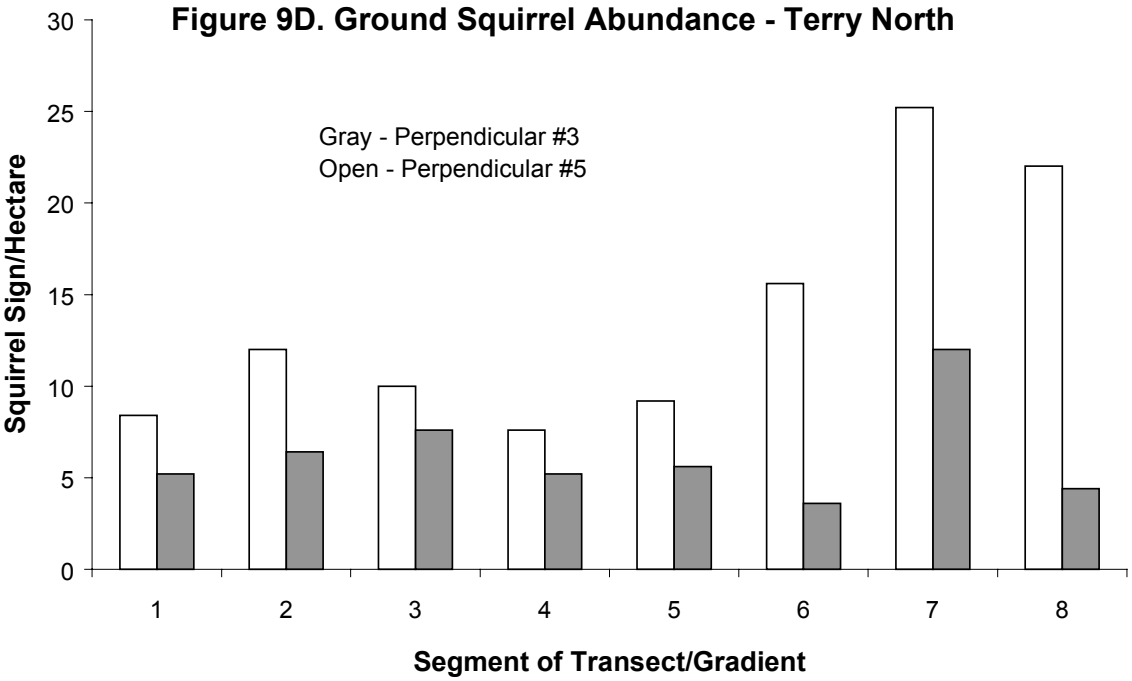


Figure 9D. Ground Squirrel Abundance - Terry North
Gray - Perpendicular #3
Open - Perpendicular #5
Squirrel Sign/Hectare
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
Segment of Transect/Gradient

Figure 10A. Pocket gopher abundance on Ponnequin Northeast

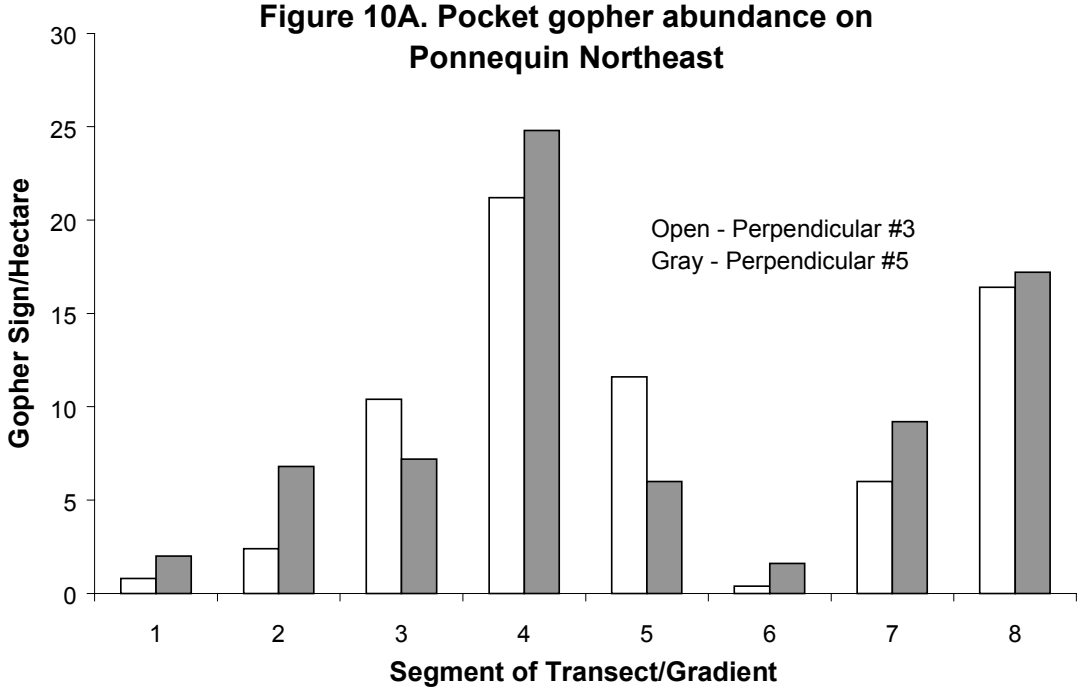


Figure 10B. Pocket gopher abundance on Ponnequin Meteorology

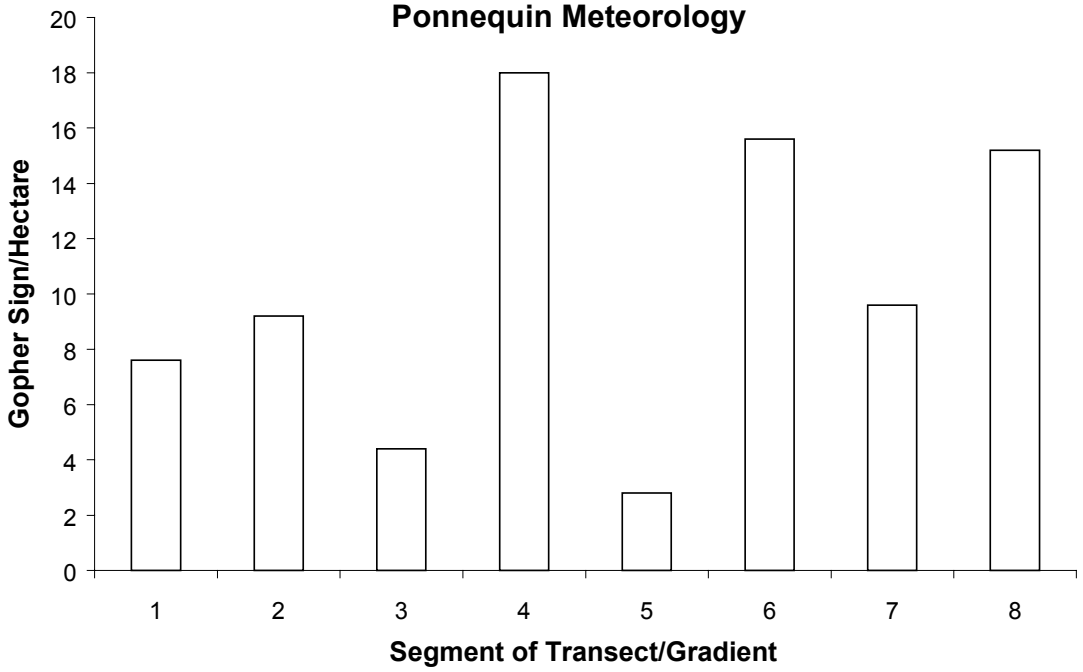


Figure 10C. Pocket gopher abundance on Terry Ranch South

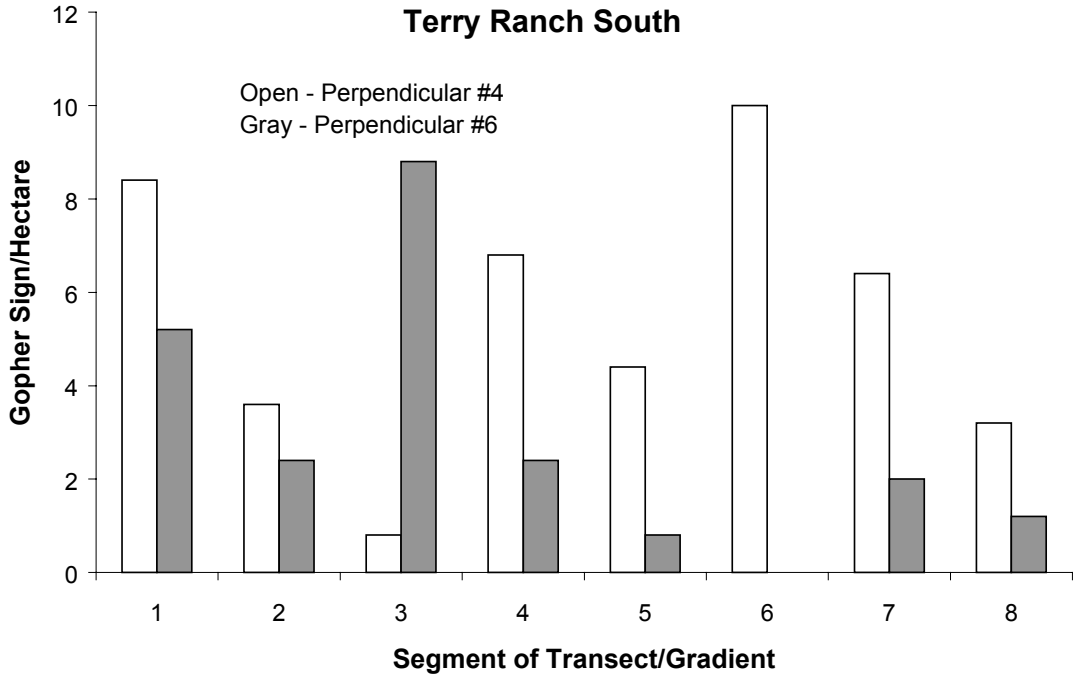


Figure 10D. Pocket gopher abundance on Terry Ranch North

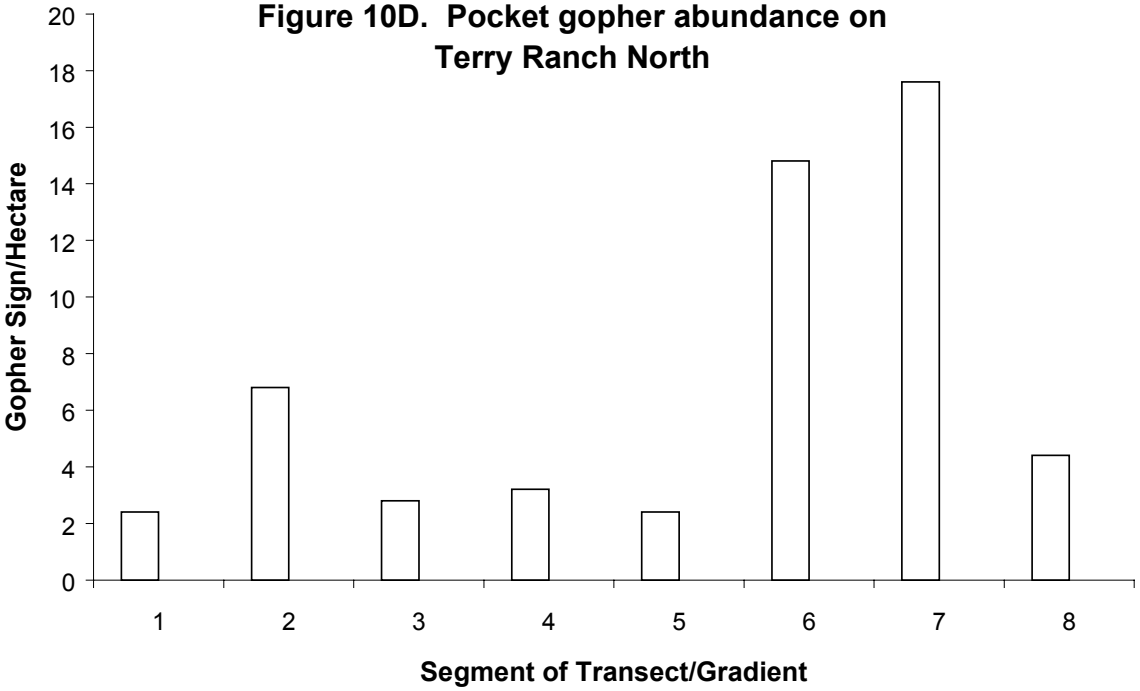


Table 6. List of species used for carcass removal and observer efficiency studies

(N = 39)

Species

Small – Sized
Virginia Rail
Eastern Screech Owl
Red-bellied Woodpecker
Williamson's Sapsucker
Cedar Waxwing
Eastern Kingbird
Hermit Thrush
Dark-eyed Junco
White-crowned Sparrow
American Goldfinch
Lark Bunting
McCown's Longspur
Western Meadowlark

Medium – Mid-Sized
Horned Grebe
Eared Grebe
Belted Kingfisher
American Kestrel
Cinnamon Teal
Blue-winged Teal

Large – Sized
American Coot
Common Moorhen
Ring-billed Gull
Mallard
American Wigeon
Rough-legged Hawk
Ferruginous Hawk
Great Horned Owl
Long-eared Owl
Sage Grouse

Table 7. Carcass detection efficiencies of two observers (Ron Ryder and Brett Petersen)

Size of Carcass	Observer #1 Present - Found	Observer #2 Present - Found	Totals Present - Found
Small	8 - 2 (25%)	8 - 1 (13%)	16 - 3 (19%)
Medium	8 - 6 (75%)	3 - 2 (67%)	11 - 8 (73%)
Large	8 - 8 (100%	4 - 4 (100%)	12 - 12 (100%)
	24 - 16 (67%)	15 - 7 (47%)	39 - 23 (59%)

Discussion

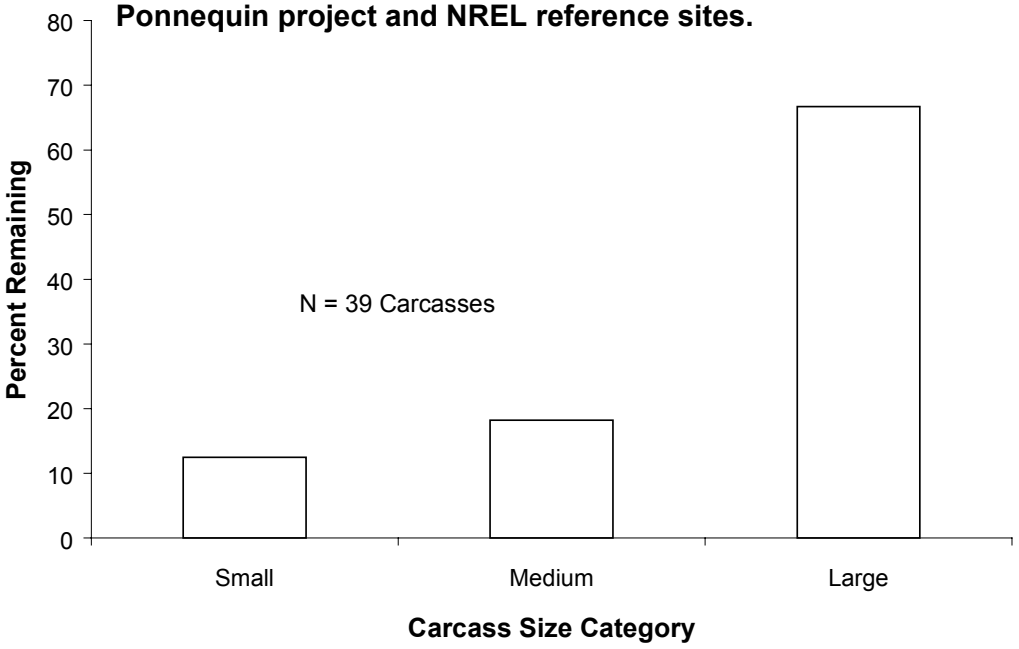
By terms of the contract, funding for the first 12 months of data collection on the reference sites was concluded by NREL effective December 10, 1998. To bring the larger study to completion, PSCO is sponsoring continued data collection by Curry & Kerlinger, L.L.C. at the reference and project sites for both the pre-and post-construction periods.

The data summarized in this status report will be incorporated with the data that has continued to be collected during the pre-and post-construction period and will be fully analyzed after studies are completed at the Ponnequin Wind Energy Project.

Table 8. Summary of carcass removal rates for carcasses of three size categories (small, medium, and large) at Ponnequin Wind Energy Facility and two reference sites. The mean days represent the mean for minimum duration carcasses remained visible as determined by successive surveys.

	Carcass Size			
	Small	Medium	Large	Total
Sample Size	16	11	12	39
Mean Days	11.9	18.6	40.8	
Range of Days	1-62	1-68	1-64	

Figure 11. Summary of carcass removal rates for small, medium, and large carcasses during the first month after placement on the Ponnequin project and NREL reference sites.



Since even the pre-construction data collection was not completed during the terms of this study, the authors feel that analyses of the data are premature and inappropriate in this document. Conducting such analyses based on a partial dataset of one phase of the larger project would not shed light on the design and implementation of the larger study, nor would it help the reader. Accordingly, assessments regarding the strengths and/or weaknesses of the greater project will have to await completion of that study.

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13. ABSTRACT *(Maximum 200 words)*
This report summarizes the results of surveys completed during the period January 1, 1998, through December 31, 1998, at the Ponnequin Wind Energy Project in Weld County, Colorado. The surveys were conducted at two reference sites, and Include a pre-construction avian abundance and use survey and raptor nesting, prey, and carcass surveys. The reference sites were situated immediately to the west of the project site in Weld County, Colorado, and 4.8 kilometers to the north of the site in Laramie County, Wyoming. The surveys were conducted along two 800-meter (m) main transects at each site with two 400-m (by 100-m) perpendicular transects. About 30 complete surveys were completed during the year, with a greater frequency of surveys in the late spring and early autumn. The surveys revealed mostly common species, with no endangered or threatened species on the sites. Small numbers of raptors were observed on or near the project and reference areas. During the winter, avian use and abundance was minimal. Prey species consisted primarily of thirteen-lined ground squirrels and northern pocket gophers. Two songbird carcasses were found. The results of these surveys, combined with data from several more months of surveys, will be compared to surveys conducted after construction of the wind farm.

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