METHODS FOR CONDUCTING A FATALITY STUDY AT THE WINDMAR SITE IN GUAYNILLA, PUERTO RICO

Prepared for WindMar Renewable Energy
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Study Area. The study area will include all wind turbines and meteorology towers on the WindMar site. Presently, 25 wind turbines are protected to be constructed, with 12 on Punta Verraco, 4 on Cerro Toro, and 9 on Punta Ventana. There are two existing meteorology towers (both guyed) approximately 50 m and 60m in height. Each turbine will be approximately 116 m in height. A subset of turbines would be lit, most likely, with L-864 red strobes at the top of nacelle. The turbines will be located in clearings within the site's dry forest. Crushed limestone roads will connect the turbines, making access relatively easy.

Field Methods. Twenty-six complete rounds of searches of all 25 turbines and 2 meteorology towers (one search every two weeks) will be conducted each year for the first three years after the wind farm goes into operation. FWS has recommended that the initial search interval be one search per week. WindMar is willing to consider this, pending the results of the carcass removal study (see below). Given the semiarid nature of the environment, carcass deterioration is not expected to be accelerated.

The number of searches may eventually be decreased depending on results. Searchers will examine 12-13 turbines per day per researcher, facilitating that all turbines can be searched in no more than two days. Searches will be conducted when weather and other conditions permit. On occasion, maintenance work at a turbine may preclude conducting searches, such that those turbines will be searched after maintenance work is completed. The two meteorology towers will be searched following similar protocol as used for the turbines. The area beneath the meteorology towers will be searched to guy wire termination.

Searches will commence at or slightly after sunrise. The time required to search individual turbines will likely be approximately 30 minutes. Each turbine will be searched via slow walking of concentric circles outwards from the base of the turbine. Concentric rings will be located at 15 m intervals and turbines will be searched to a distance of 60 m from the base of the towers. Variation in search pattern may be necessary due to the dense, scrubby forest around the turbines, but an effort will be made to search these areas with equal intensity. If the searcher efficiency study demonstrates that 15 m intervals are too far apart, WindMar will decrease the intervals.

Regarding the search distance out to 60 m, this distance should prove to be adequate. In his broad experience with mortality studies, Dr. Kerlinger has found that after 40 m the number of carcasses decreases markedly. Should a different pattern, where carcasses are thrown farther, appear to be evident at the WindMar site, then WindMar will adapt the methodology to extend the search beyond 60 m.

Data will be recorded on two data sheets. Daily search information, including weather, date, turbines searched, and weather on the previous night, will be recorded on a Daily Data Sheet (Figure 1). Carcass information will be recorded on the Carcass Data Sheet (Figure 2). For each carcass, the following information will be recorded: species (when able to be determined), date/time, observer name, carcass identification number, turbine number, distance from turbine (m), cardinal direction from turbine, and condition of the carcass (scavenged, entire, partial, duration of time on ground, etc.). Each carcass will be collected and individually placed in a plastic, zip-lock bag. Carcasses will be deposited in a freezer maintained by WindMar. Any bat carcasses will be referred to Dr. Richard Thomas for identification.

<u>Estimation of Avian and Bat Fatalities.</u> Mortality estimates will be calculated seasonally for all birds and bats found at the WindMar site. The estimations of avian and bat fatalities will be calculated using the actual number of carcasses found during carcass searches, the detection probability defined as the estimated proportion of detectable carcasses found by observers during a single search, the mean carcass removal rate expressed as the number of days that a carcass remains under the turbine before being removed from the study area by scavengers, and the seasonal interval between searches in days.

To calculate the total number of fatalities, an estimator proposed in Shoenfeld (2004) will be used. This estimator gives equivalent results to the estimator provided in Erickson et al. (2003), but it is in a simpler form. The point estimates for the fatality rates will calculated seasonally by the formula:

$$m = \left(\frac{N * C}{k * t * p} \right) \left(\frac{e^{I/t} - 1 + p}{e^{I/t} - 1} \right),$$

where N is equal to the total number of turbines, C is the total number of carcasses detected for the period of study, I is the interval between searches (in days), t is the mean carcass removal time (in days), p is the detection probability, and k is the number of turbines sampled. This formula assumes correctness of the estimates for t and p, i.e., sampling error in those estimates is not considered. Fatality estimates for the entire period of study will be calculated by summing the seasonal estimates. Standard errors and associated confidence intervals will be calculated by parametric bootstrapping (Manly 1997). This method does account for sampling error in estimation of t and p.

Searcher Efficiency Study. The objective of a searcher efficiency study is to estimate the proportion of carcasses that a searcher is able to find from the total number of carcasses that may be present beneath a turbine. A detection probability will be calculated to estimate the total numbers of birds killed by the wind turbines when corrected for detection bias.

We will endeavor to collect 30 avian carcasses (we hope that FWS and DNER will be able to provide the bulk of the carcasses from road and window kills) for use in the carcass removal and efficiency study. Fifteen avian carcasses will be placed randomly beneath the wind turbines on one evening. The remaining 15 carcasses will be placed randomly on another evening, months later. The carcasses should represent songbirds and other small-medium birds. Large carcasses, such as those of pelicans will not likely disappear completely and observers rarely miss such large carcasses. Therefore, efficiency and scavenging studies of such large carcasses are not needed. While the species composition of these birds should correspond with species that migrate from North America, the study will do its best to collect these species, but it may have to use local birds of similar size. The numbers of carcasses placed at the turbines will range from 0 to 2 in an attempt to simulate patterns found at other wind farms. Direction and distance of placement will be randomly determined for each carcass prior to the carcass removal study. Carcasses will be tossed behind the back of the tester at each of these locations and will be left in the position in which they landed – an attempt to simulate carcass condition following collision with a wind turbine. Test birds will be discreetly marked with dental floss through the nares so that they could be identified as test birds upon recovery. Searchers will not be told that they were being tested; however, searchers will be aware of the test once the first test bird has been recovered. The direction and distance of each test bird found will be recorded. Test birds will not be removed from the study site in order to perform a carcass removal study.

The detection probability (p) will be defined as the estimated proportion of detectable carcasses ($n = 30$) found by observers. This probability will not be estimated by size of bird carcass due to the small sample size. We no not plan to use bat carcasses in the searcher efficiency study.

Carcass Removal Study. The objective of a carcass removal study is to determine the average length of time that an avian carcass remains under the turbine before being removed from the study area by scavengers. A carcass removal rate will be used to adjust for removal bias when estimating the total number of carcasses present.

Carcasses used in the searcher efficiency study will also be used in the carcass removal study. Randomly placed carcasses will be comprised of the species as listed under the section on searcher efficiency. Carcasses will be checked 1, 2, 3, and 4 days after being placed out, and then they will be checked weekly for the remainder of the season or until the carcass are removed or decomposed. Presence/absence for each

carcass will be recorded as well as body condition (lightly scavenged, heavily scavenged, etc).

The length of time that a carcass remains in the study area (t_i) will be calculated for each experimental carcass. Mean carcass removal time (t) will be calculated by summing t_i for each carcass and dividing the sum by n = 30. Large and small birds will not be differentiated in calculating the carcass removal rate. No bat carcasses will be used in the carcass removal study.

Technical Advisory Committee (TAC). A TAC, consisting of four stakeholders (one each from industry, environmental organizations, academia, and government agencies) will be established prior to initiation of the study in order to provide transparency and a degree of oversight for the post-construction study described in this methodology. At meetings, the committee will be apprised of research efforts and progress, problems encountered, news of fatality events, transparency of the process, and other matters relevant to the process. In addition, members of the TAC will be able to contact the research team via email and phone to ask questions about the research or other aspects of the process.

Figure 1. Data sheet used to record data collected for each field day.

Daily Data Sheet

Date	Start/End	Observer	Towers	Weather	# Carcasses

Figure 2. Data sheet used to record bird and bat fatality information for each carcass found.

Carcass Data Sheet

Date/Time	Carcass #	Observer	Sp/Age/Sex	Turbine #	Dir-Dist	Conditions/Notes