Summary of the Pilot Study Proposed as Part of the CalWEA Field Program for Evaluating Survey Error

October 2010

Introduction

This document presents a summary of the pilot study portion of the entire experimental design proposed by CalWEA for evaluating survey error at the Altamont, with application to other sites in California and nationally. The full experimental design, including information on the overall study goals and objectives, can be found in a document entitled ***Improving Methods for Estimating Fatality of Birds and Bats at Wind Energy Facilities in California: Research Plan,*** which was submitted for distribution to the SRC and the project's CEC advisors on October 7, 2010.

We are looking forward to interacting with the SRC and the monitoring Team (MT) on the pilot study. The following statements clarify some issues that may not have been fully covered in the full design document:

1. A project field manager (PFM) will visit the site frequently (see below), however, these visits will be targeted, and generally limited to the known locations of marked birds and bats, with the purpose of verification and data collection (see below for data collection details).

2. The pilot study will effectively represent the first of 5 blocks of strings (each block comprising 6 strings). The pilot study data, if considered of high quality, will be included in the analysis data set.

3. Observations by the blind observers will take place at most 3 times during a 6 week period. Keeping with CEC guidelines, the observation interval during the pilot study will be approximately every two weeks (note: more detail on observation interval is discussed below). However, should the PFMs confirm that all birds and bats have been removed from the strings, the pilot study will be considered complete. Analysis of the pilot study data will be implemented prior to implementing the full experimental design.

Pilot Study Experimental Design

This section describes key issues associated with the proposed experimental design for the pilot study (and therefore the entire study). The narrative initially describes the design, and follows with information on key issues that affect the implementation of the design and that impact the logistics of the pilot study.

Broad Overview of Pilot Study Experimental Design

The pilot study consists of 6 strings (termed a block), which are simultaneously observed by both the Project Field Manager (PFM) and blind observers. The number of individual turbines in a

string in the APWRA can vary from three to as many as seventeen, but the majority of strings consist of approximately seven to eight turbines. Each string within a block will be observed for up to six weeks, or until no marked birds or bats remain on the string, whichever is first.

At the beginning of the observation period for each string, one of two PFMs will randomly place a fixed number of uniquely marked birds and bats at each of the six strings comprising the sampling block. In order to maximize sampling efficiency, both birds and bats will be placed at the same string. The objective is to both observe the removal of birds and bats as a result of scavenging, and to generate observations reflecting monitoring error.

A PFM will visit the strings daily for fourteen days and record the position and character (i.e., body parts) of all carcasses remaining at the string. After the initial fourteen day period, a PFM will also visit each string every other day for the remaining of the block study period. These observations will not represent complete transect searches, but will be focused searches with the objective of verification and data collection. The PFMs will visit each string either during the evening or early morning, depending on the number of daylight hours available.

Three separate independent observers (preferably MT personnel) will visit each string, at approximately two week intervals. The observers will be blind to the location of carcasses. An individual observer will visit a specific string only once during the block study period. Therefore, assuming that an individual observer can visit two strings per day, a minimum of three independent observers are needed for the project. The observers will walk the strings using a standardized protocol (below, which is effectively the protocol currently used by the MT). The observers will identify observed birds and bats as "study carcasses" based on the markings. At the site of each observed study carcass, the observers will record the ecological conditions within a two-foot area around the found carcass (details described below). Carcasses will not be removed by the observers. All observers will be given explicit instructions on survey techniques, including instructions to ignore any pre-search information on the existence of birds or bats on the string. And, the observers will be informed that some strings will have no marked bird or bat carcasses, therefore, surveys will be conducted without the pre-conception that marked carcasses should be on the ground. In addition, the observers will be informed that the string may not have marked carcasses due to the presence of control strings. Strings will be selected such that the level of effort among observers is similar (i.e., the number of turbines and geographic area of the string is consistent).

Below is a representation of the pilot study planned for this study. The number of birds or bats per string was chosen as a representative of the expected daily maximum true mortality at wind facilities in the Altamont, and possibly across California. Examination of the APWRA Scientific Review Committee (SRC) current avian monitoring study indicates that the total number of birds (of any species) found during any one survey on any string ranges from zero to eleven, with some surveys resulting in observations of five to nine birds. We realize that during average string surveys at the Altamont, few if any birds are generally observed. However, in order to test the hypothesis associated with the relationship between survey error and bird density, the experiments need to begin with a representative high value, which is considered to be fifteen bird carcasses.

Block Number	Control String Included	Starting number of birds per string (except control)	Starting number of Bats per string (except control)	Total Number of Birds	Total Number of Bats
Pilot Study	No	15	12	90	72

Pilot Study Details

The pilot study will be used to address key issues affecting the study procedures and will allow the PFMs to test and refine methods for carcass placement, daily tracking of carcasses, refine data collected by the PFMs, transportation issues, and other practical matters. The pilot study will replicate all procedures planned for the full study and will use the same types of bats and birds planned for the full study. Information obtained from the pilot study will be used to refine the full study activities and logistics. Specific issues of interest include the following:

1) Expected length of time birds and bats remain un-scavenged.
2) Time needed by the PFM to place carcasses, count remaining carcasses, take measurements, and record information.
3) Determination of the searcher speed or searcher time per some unit of distance to monitoring strings.
4) Coordination among the blind observers and PFMs.
5) Number of strings that can be simultaneously evaluated.
6) Estimation of observation intervals over the course of six weeks.
7) Estimation of observation intervals to ensure that both young and older carcasses are observed.
8) Estimation of the total effort for the current design; and evaluation of any needed changes based on the cost estimates.
9) Evaluation of carcass placement approaches (random, clustered, etc.).
10) Evaluation of best time of day for the PFMs to check each string.

The pilot study will include a full block (six strings). The pilot information will be evaluated for data quality. If the information from the pilot study is deemed of sufficient quality, the information will be used in the full data analysis. The pilot study block is considered part of the total five block project (leaving four remaining blocks). The pilot study will be run for the entire six week period. After the pilot study data have been compiled, the project will stop, and will continue only after a full evaluation and interpretation of the lessons learned from the pilot information. This break is anticipated to last approximately one week.

Process for Marking, Distributing, and Observing Carcasses

The PFMs are responsible for marking and distributing all birds and bats employed during pilot study.

Study birds' appendages will be marked with unique tape color, and flight feathers will be clipped. Bats' appendages will be taped. Trial bird identifiers can be written on the taped appendages but after scavenging actions, tape can easily be removed by scavengers. Careful tracking of carcass positions and the detection of cut flight feathers with be the most reliable ways of identifying carcasses as trial birds. In some cases, particularly over time at a specific string, whole bird carcasses may be torn into various body parts.

Tracking the position of trial carcasses will involve recording the distance and bearing to the closest turbine, as well as using a GPS with sub-meter accuracy. As the carcasses age, they may fragment due to scavenging actions and weather conditions (e.g. wind, sun and rain). When the PFMs check the study carcasses on a daily basis, he or she will continue to update the position of the carcasses as well as carcass condition. The PFMs will be able to identify trial birds and bats used in the study based on species-specific characteristics and initial marking procedures. The PFMs will attempt to track and record individual body parts throughout the six week observation period for a specific block. If all carcasses are removed on an individual string before six weeks, the PFMs will stop observations on that specific string.

The placement of whole bird and bat carcasses on a specific string will begin the observation period (day zero). Three observations periods are planned for each string within a block. The timing of the observations within the six-week period is critical. The objective is to distribute the observations over the six week observation interval so that a varying number of carcasses are on the plot at the time of observation. The actual number of birds and bats on the plot will be known to the PFMs, but unknown to the blind observers. The rate at which carcasses will be removed from the strings is unknown, and the generation of removal curves under varying condition is one of the objectives of this study. *During the pilot study phase of this project, timing of the observation days will be evaluated.* As the study progresses, changes in the timing of the observation days within the six week observation window may occur in order to maximize the variability in carcasses on the ground at the time of observation.

Figure 1 illustrates the issue with the carcass placement date and subsequent observations. For any given string, the actual shape of the removal curve is unknown, and evaluating the degree of variance in the curve shape (or statistical parameters of the underlying distribution from which the curve is derived) is one of the goals of the project. Finding appropriate placement dates prior to knowing the removal curve such that a range of carcass density is studied is part of the initial pilot study, and the interval between subsequent observation days may change over time.

At the Altamont, most strings are located on ridge lines. The search area for each string will extend 50 meters out from individual turbines comprising the string, on all sides. During each survey, mortality search transects will be walked within the string search area during which the searcher scans the ground for bird and bat carcasses and/or parts of carcasses such as feathers and bones. The distance between transects within each search area will average seven meters depending on the terrain, height of the vegetation, and the height of the individual searcher. When evidence of a

fatality is found, the location of the find will be marked with flagging, and the searcher will then continue to search the remaining area. After completing the search, the observer will return to each flagged location to record data on all the finds. Recorded data is explained below.

An additional issue that will be studied, and is affected by the timing of observations, is the effect of carcass age on observer error. Carcass age is expected to influence scavenger removal rates, but may also affect observer detection probability. As an un-scavenged carcass ages it becomes may become less attractive to scavengers, reducing the chance for scavenging actions that may either remove the carcass completely or fragment the carcass, spreading signs of the carcass over the plot. Also as a carcass ages, if it is not removed, the chance that it will be fragmented by scavenging actions increases, possibly affecting the probability of observer detection. Once a carcass is scavenged and not removed, it may slowly degrade from abiotic mechanisms (wind and rain). This can reduce observer detection probability and can eventually remove all significant signs of the carcass. So, in general as a carcass ages, removal rates may decrease and then eventually increase slowly as the carcass degrades. Observer detection probability may initially increase as a carcass ages and fragments, but as the carcass ages further and degrades, observer detection probability may also decrease.

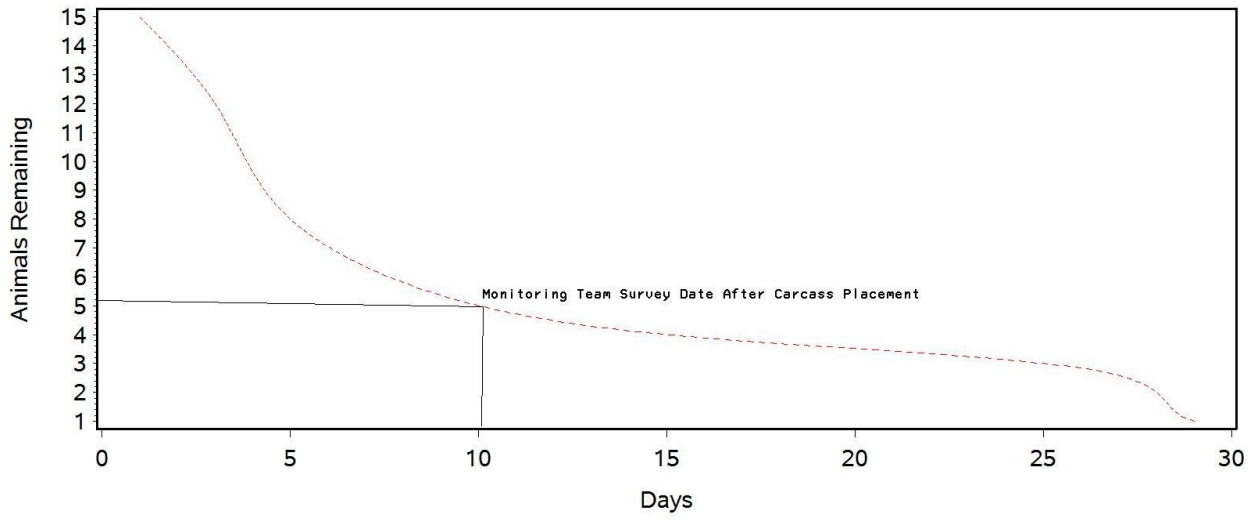

Figure 1. Hypothetical Representation of Carcass Removal over Six Weeks

Therefore, under the direction of the PFMs, the timing of observations within the six week interval of the pilot study will consider carcass age. Timing will be adjusted to ensure that both fresh and older carcasses remain on the string for possible observation. The observers will not remove carcasses as they are detected, therefore, the impact of carcass age on the shape of the carcasses removal curves can be evaluated during the data analysis phase of the project.

Species Selection

Carcass size is a key variable that influences both the observer detection probability and scavenger removal rate. This study will focus on smaller animals. The cowbird (*Molothurus ater*) and bat (species to be determined) are the current species of choice. To date, approximately one thousand cowbirds and three hundred bats have been located and are being shipped to the NextERA facility located at the Altamont. If carcasses representing local species become available, for example the American kestrel or red tailed hawk they will be incorporated into the pilot study activities. Generally, any species that is considered small (or moderately small) can be used in the pilot study (and other trials). Local species of interest, although preferred, are not available in the numbers required for this project. However, mixing species from the same size class is acceptable.

Field Measurements and Data Collection

The following information will be collected by the PFMs during each observation during the pilot study of a specific string:

a) String number
b) Block number
c) Date
d) Temperature
e) Precipitation amount since last observation (inches)
f) Total number of birds/bats on the plot
g) Position of bird/bats or significant parts of birds/bats (distance and bearing from closest turbine and GPS location)
h) Number of birds/bats that show sign of vertebrate scavenging (i.e., torn apart)
i) Number of birds/bats with no visible sign detected (i.e., dragged outside of search area, blown away, removed completely, etc.)
j) Description of remaining carcasses and carcass parts
k) Vegetation type (genus and species), vegetation height (mm), and vegetation color.
l) Visibility class (see discussion below).
m) Topography

Items (j), (k), (l), and (m) above will be recorded for each individual carcass on the ground. Grass height measurements will be taken using a metric ruler. If multiple carcasses are found within a uniform vegetation type and height, then a single measurement will be taken for all individuals in the group. Topography metrics will include whether carcasses are placed (1) on top of a ridge line, (2) on the side of a ridge, (3) on flat ground, (4) on a ridge saddle, or (5) in a ridge depression.

In addition to the above, the PFMs will assign, to the degree possible, a visibility class indicator for (a) the entire string, and (b) each carcass location. Visibility class is a metric for characterizing the types of ecological variation that influences survey error rates at wind developments. Visibility obviously impacts all aspects of the survey error rate components (both human and ecological), and is a surrogate metric for site-specific variability that can be used within a formal experimental design framework. The Pennsylvania Game Commission (PGC)

established four visibility classifications, recommending[1] that survey error rates be estimated for each:

- Class 1 (easy): Bare ground 90% or greater; all ground cover sparse and 6 inches or less in height (i.e. gravel pad or dirt road).
- Class 2 (moderate): Bare ground 25%-89%; all ground cover 6 inches or less in height and mostly sparse.
- Class 3 (difficult): Bare ground 25% or less; 25% or less of ground cover over 12 inches in height.
- Class 4 (very difficult): Little or no bare ground; more than 25% of ground cover over 12 inches in height.

The following information will be collected by the observers when marked carcasses are found at an individual string:

a) String number
b) Block number
c) Date
d) Observer name (or ID)
e) Total number of birds/bats observed
f) Number of birds/bats observed outside of search area
g) GPS location
h) Distance and bearing to closest turbine (including turbine ID or number)

Using the distance and bearing measurements, the PFM will, subsequent to the observers visit, correlate the found carcasses with the detailed information collected by the PFM.

All recorded data will be transferred to an Excel file by the PFM. The field sheets and Excel file will be transferred to the Principal Investigators, who will conduct an independent review of the Excel file to ensure that no transcription errors have occurred.

Field Study Personnel

The PFMs will have full responsibility for the day-to-day activities required by the field study. The primary PFM is Brian Karas, a part-time employee of EcoStat, Inc. He will be assisted by Loan Tran, a part-time employee of EcoStat, Inc.

Interactions with Ongoing Altamont SRC Study

The CalWEA study can interact with the on-going SRC study in the several ways. The Altamont MT can:

1) Act as blind observers for one or more strings, thus providing additional evidence that can be used to evaluate observer error. The MT may wish to double sample selected

[1] Pennsylvania Game Commission (PGC). 2007. Pennsylvania Game Commission wind energy voluntary agreement. Pennsylvania Game Commission, Harrisburg, Pennsylvania.

strings as part of the standard monitoring protocols. If the timing of those observations can be coordinated with the concept of an approximate 2-week sampling interval, the data from the MT sampling could be included in the data set.

2) Provide fresh carcasses representing local species of interest, including the American kestrel and red tailed hawk.
3) Provide coordination support for the selection of strings and blocks.
4) Provide additional support by characterizing ecological characteristics of the strings such as measuring grass height, type of vegetation, etc.
5) Provide support with site transportation, field supplies and equipment.

Appendix I: Mortality Estimation Equations

The following discussion provides information on some of the equations that will be evaluated during the entire study, including data gathered during the pilot study.

Various equations have been proposed for estimating the true mortality at a wind facility based on observational data collected during a monitoring survey. The experiments described in this document will provide information that can be used to better parameterize the existing equations, or lead to new models and equations for estimating the true site-specific mortality.

The equations found in the literature take various mathematical forms, but require (to varying degrees) similar types of data: number of observed birds (or carcasses, partial carcasses e.g. feathers, etc.) at a specific time and location, interval since the last survey at the location, a measure of searcher efficiency, an estimate of the carcass removal rate, or an estimate of the scavenger efficiency as a function of time. Therefore, at a minimum the experimental design must collect these data, or information leading to the calculation of these variables, in order to test and evaluate the various equations.

Below is a listing of the equations this project will evaluate, followed by a list of comments concerning the limitations of these existing equations, including the procedures used to parameterize the equations using field trials of generally short duration. If additional equations are found, we will include them in our analysis.

Schoenfeld[2] (and as cited in Erickson et al.[3]) provides a review of several equation forms, including the following which are evaluated using simulation:

1)

$$m_{ij} = \frac{I_{ij} C_{ij}}{t_{ij} p_{ij}}$$

2)

$$m_{ij} = \frac{I_{ij} C_{ij}}{t_{ij} p_{ij}} \left(\frac{e^{I_{ij}/t_{ij}} - 1 + p_{ij}}{e^{I_{ij}/t_{ij}} - 1} \right)$$

The CEC *Guidelines* Appendix F[4] presents an alternative form that was proposed by Dr. Ken Pollock of North Carolina State University:[5]

3)

[2] Schoenfeld, P. 2004. Suggestions Regarding Avian Mortality Extrapolation, unpublished report to West Virginia Highlands Conservancy, Davis, WV.
[3] Erickson, W. P., J. Jeffrey, K. Kronner, and K. Bay. 2004. Stateline Wind Project Wildlife Monitoring Annual Report, Results for the Period July 2001 B December 2003, report submitted to FPL Energy, the Oregon Office of Energy, and the Stateline Technical Advisory Committee.
[4] http://www.energy.ca.gov/windguidelines/index.html
[5] Dick Anderson, personal communication.

$$m_{ij} = \frac{C_{ij}}{s_{ij} p_{ij}}$$

Smallwood[6] modifies equation 3 to adjust for scavenging over time, which is used in the Altamont 2008 Monitoring Report:[7]

4)

$$m_{ij} = \frac{C_{ij}}{s^{*}_{ij} p_{ij}}$$

Huso[8, 9] used simulation to evaluate the following equation:

5)

$$m_{ij} = \frac{C_{ij}}{s_{ij} p_{ij} e_{ij}}$$

Where:

m_{ij} = true number of dead birds at turbine i in interval j
C_{ij} = number of carcasses counted at turbine i at the end of interval j
p_{ij} = measure of searcher efficiency, representing the proportion of carcasses found by searchers during a survey as estimated by searcher detection trials
I_{ij} = length (days) of the search interval
t_{ij} = average number of days a carcass will persist unscavenged (usually considered the same for all turbines, but not all intervals)
s_{ij} = estimate of the carcass removal rate, as measured by the proportion of carcasses remaining since the last search
s^{*}_{ij} = carcass removal rate as a function of time
e_{ij} = effective interval = -log(0.01)* avg. removal time

Other available methods calculate the potential incremental increase due to various sources of bias (e.g., search, removal, habitat, and crippling bias), and use a linear additive model e.g., Gauthreaux[10]) to estimate true mortality.

The observer error and scavenging terms in the above equations are typically estimated from independent field trials of a fixed length. The trials can be conducted prior to wind project

[6] Smallwood, K. S. 2007. Estimating wind turbine-caused mortality. Journal of Wildlife Management, 71(8), pp. 2781-2801.
[7] http://www.altamontsrc.org/alt_doc/m21_2008_altamont_bird_fatality_report.pdf
[8] Huso, M. P. 2010. An Estimator of Wildlife Fatality From Observed Carcasses. Environmetrics. Published online in Wiley InterScience (www.interscience.wiley.com).
[9] http://www.nationalwind.org/pdf/HusoManuela.pdf
[10] Gauthreaux, S. A. 1995. Suggested Practices for Monitoring Bird Populations, Movements, and Mortality in Wind Resource Areas. Proceedings of National Avian-Wind Power Planning Meeting, Denver, CO, 1994.

operation, or during the course of operations. Each of the above equations has both advantages and disadvantages with respect to simulating the process of finding birds at wind turbine sites. While some of the equations have been evaluated using computer simulation, none of the equations have been rigorously tested for precision and accuracy using experimentally designed and rigorous field studies.