M53

DRAFT

ALTAMONT PASS WIND RESOURCE AREA

STUDY PLAN FOR FUTURE MONITORING

PREPARED FOR:

Alameda County Community Development Agency
224 W Winton Avenue, Room 110
Hayward, CA 94544
Contact: Sandra Rivera
510.670.6526

PREPARED BY:

ICF International
640 K Street, Suite 400
Sacramento, CA 95818
Contact: Doug Leslie
916.231.9560

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Altamont Pass Wind Resource Area

M53—Draft Study Plan for Future Monitoring

Introduction

The Altamont Pass Wind Resource Ares (APWRA) is located in central California approximately 90 kilometers (km)(56 miles) east of San Francisco (Figure 1). There are approximately 5,400 wind turbines currently permitted within the APWRA, distributed over 150 square kilometers (km^2) (50,000 acres) of rolling hills and valleys dominated by annual grassland.

The APWRA supports a broad diversity of breeding, migrating, and wintering bird populations that regularly move through the wind turbine area (Orloff and Flannery 1996). Diurnal raptors (eagles and hawks), in particular, use the prevailing winds and updrafts for soaring and gliding during daily movement, foraging, and migration. Birds passing through the rotor plane of operating wind turbines are often killed. Multiple studies of the avian mortality rates in the APWRA indicate that golden eagles, red-tailed hawks, American kestrels, burrowing owls, barn owls and a diverse mix of other non-raptor species are killed each year by collisions with turbines (Howell and DiDonato 1991; Orloff and Flannery 1996; Howell 1997; Smallwood and Thelander 2004).

The current management goal for the APWRA is to significantly and substantially reduce the fatalities of birds resulting from collisions with wind turbines. The principal current management objective is to reduce the fatalities of four heavily affected raptor species (golden eagle, red-tailed hawk, American kestrel, and burrowing owl—collectively referred to as *target species*) by 50% through management actions including, but not limited to, seasonal shut-down of turbines; shutdown, removal, and/or relocation of high-risk turbines; and removal of derelict turbines.

The current program for monitoring avian fatality rates in the APWRA has been conducted continuously since its initiation in 2005. In April 2010, the Alameda County Community Development Agency asked the Avian Monitoring Team to examine ways to achieve greater efficiency in the monitoring program to reduce costs, thereby freeing up funding to support other avian mortality reduction research. This study plan is the result of this examination.

Goals

Current Program

The goals of the current monitoring program are to evaluate the effectiveness of the seasonal shutdowns of wind turbines and the relocation or removal of high-risk turbines in reducing the turbine-related mortality rates of the four target species.

However, data collected to date have demonstrated a high degree of inter-annual variability in turbine-related mortality rates, confounding attempts to evaluate the effectiveness of the various management actions in reducing fatalities. There is an inherent difficulty in assessing with any

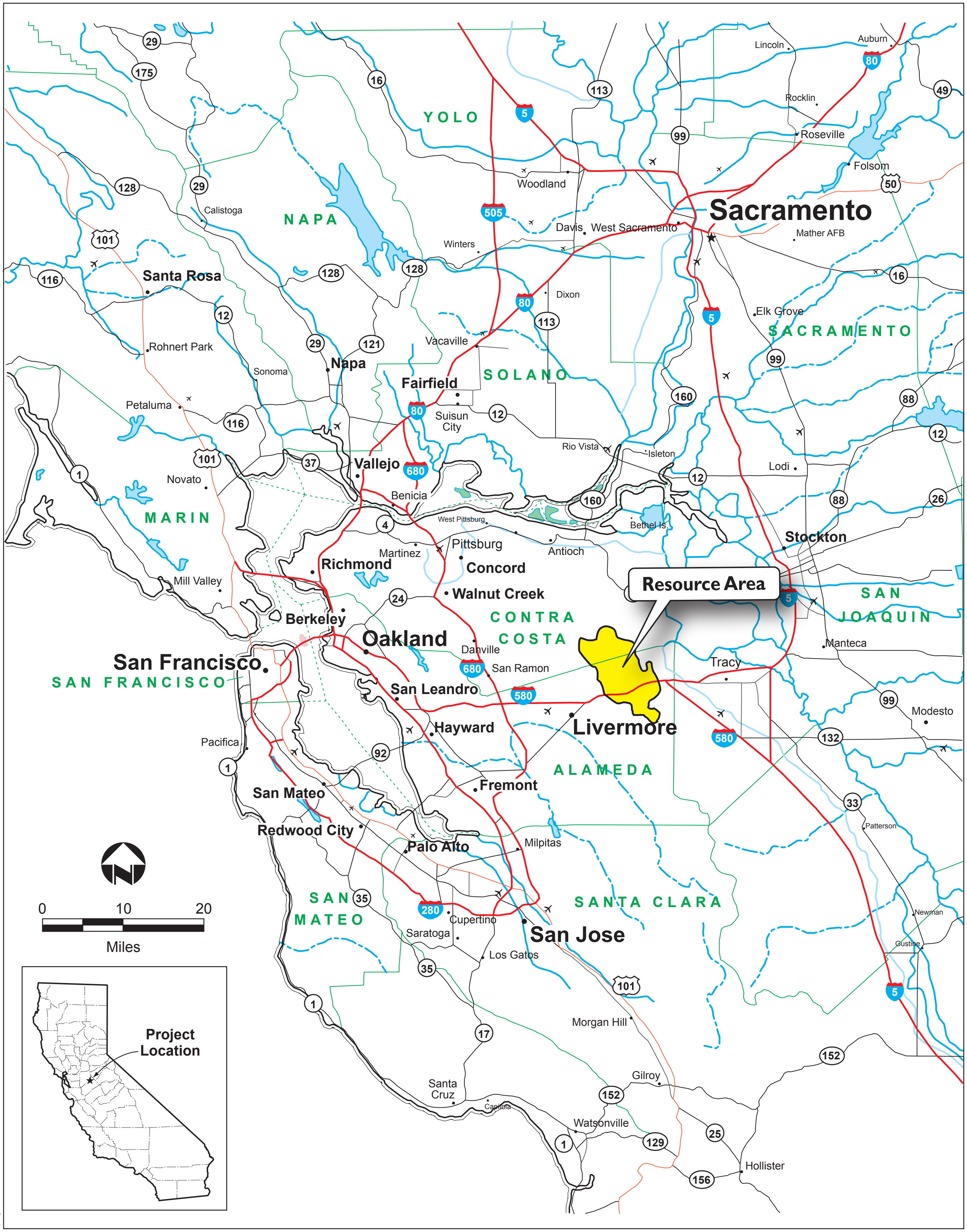

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Figure 1
Location of the Altamont Pass Wind Resource Area

precision the "treatment effect" of the relocation or removal of high-risk turbines (i.e., accurately tracking the timing and status of these turbines through time); consequently, meaningful and rigorous evaluation of the effectiveness of these management actions is extremely difficult, except through observed changes in annual mortality rates.

An additional goal of the monitoring program has been to collect information on bird use and behavior to refine the interpretation of observed changes in annual avian mortality rates and to inform the process of repowering (replacing smaller, old-generation turbines with fewer and larger new-generation turbines).

2011 Program

The primary goal of the APWRA avian fatality monitoring study has been simplified. It now consists of producing reliable estimates of annual mortality rates to assess trends in avian mortality over time as various measures are implemented to reduce avian fatality.

An additional goal is to continue to collect information on bird use to refine the interpretation of annual avian mortality rates and to inform the repowering process.

Mortality Sampling Design

Current Program

The current monitoring study (2005–2009) includes approximately 2,500 turbines in 62 strings, out of the approximately 5,000 turbines in approximately 104 strings operating AWPRA-wide. The current study detected 1,084 raptor fatalities (Table 1).

Table 1. APWRA-Wide Installed Capacity and Raptor Fatalities

Turbine Type	Number of Turbines	Number of Strings	Installed Capacity (kw)[a]	Raptor Fatalities[b]
Very Small				
Enertech (40 kW)	137	14	5,480	61
Micon (65 kW)	218	28	14,170	70
Nordtank (65 kW)	305	53	19,825	23
Windmatic (65 kW)	25	5	1,625	13
Small				
Vestas V-17, V-19 (95 kW)	199	19	18,905	48
Kenetech 56-100 (100 kW)	2,797	320	279,700	565
Polenko (100 kW)	12	2	1,200	4
Bonus S (100 kW)	499	115	51,015	208
Medium				
WEG (250 kW)	20	3	5,000	8
Howden (335 kW)	79	20	26,490	23
KVS 33 (400 kW)	41	9	16,400	16
Vestas V-47 (660 kW)	31	13	20,460	45

[a] Capacity in 2010.
[b] Fatalities detected 2005–2009.

The APWRA was divided into four geographic strata (northeast, northwest, southeast, and southwest) to facilitate the implementation of a Before/After/Control/Impact experimental design. All turbine strings were then grouped into sampling blocks containing approximately 10–60 turbines in 1–7 strings on the basis of turbine size and type and proximity of strings to each other. Blocks were then selected for sampling based on the following scheme.

- **Very small turbines** (40–65 kilowatt [kW])—complete census.
- **Small turbines** (100–150 kW)—random sample in the north and south geographic strata. This category constitutes the largest number of turbines: primarily Kenetech 56-100 turbines on lattice towers, but also Danwin 110 kW turbines, Vestas V-17 and V-19 turbines, and Bonus 120 kW and 150 kW turbines.
- **Medium turbines** (>250 kW)—complete census. This category comprises the WEG 250 kW, KVS-33 400 kW, Vestas V-47, and Howden 330 kW turbines.

2011 Program

Due to the large number of widely distributed turbines in the APWRA it is possible to estimate annual fatality rates without a census of all the approximately 4,600 turbines that are currently deployed. We previously estimated the statistical power of various sampling rates for different turbine types in the APWRA, and found that reductions in sampling effort at widely distributed turbine types would not likely affect these estimates (M52). The required level of effort is partially a function of the number of turbines, their geographic distribution, and the leverage that different turbine types have on the overall estimator.

The WEG 250kw, Enertech, Howden, KVS 33, Polenko, and Windmatic turbines have been monitored as part of the baseline (1998–2002) and current study periods. During the current study, these turbine types constituted 7% of the turbines and 12% of the installed capacity of the APWRA, and they accounted for 12% of the turbine-related raptor fatalities detected. In general, these turbines are older generation turbines that are scheduled for repowering or removal. Changes in mortality rates associated with repowering will be addressed through the permitting and planning process on a project-by-project basis, and are not directly related to the long-term APWRA mortality monitoring program or this study design. We propose to remove these turbine groups from the monitoring design. The APWRA-wide annual mortality estimates would assume that the long-term per-kilowatt mortality rate would not change between now and repowering of those systems. As described below in *Data Analysis*, reductions of installed capacity between 2010 and repowering of those facilities would be accounted for in the calculation of expanded mortality rates.

The Diablo Winds site consists of the 31 V-47 turbines that have been monitored since 2005. These turbines are newer and larger than most of the APWRA units, and have been used as an out-group for comparing mortality rates in several recent analyses. Given the relative utility gleaned from monitoring these turbines and the relatively small cost of this effort, we propose a continuation of the census of these turbines.

The Bonus, Micon, Nordtank, and Vestas turbine types constitute 28% of the turbines and 23% of the installed capacity currently deployed in the APRWA. The Kenetech 56-100 turbines constitute 64% of the turbines and 61% of the currently installed capacity. The largest sources of bird and bat mortality are associated with these turbine types, which are widely distributed across the APWRA. We propose to monitor a representative subsample of these turbines using a spatially balanced randomized rolling-panel design (Stevens and Olsen 2003, 2004).

The subsampling approach for the most widely distributed turbines was designed using an analysis of variance and power in the data from the 2005–2009 APWRA monitoring program (M52). Based on those simulations, a sufficient portion of each turbine type will be monitored to limit the variance in the estimator to +/-10% of the estimate derived from a complete census. Table 2 shows the proposed level of monitoring effort. The design was built on the assumption that the search interval would not be decreased, and would remain similar and relatively constant within and across turbine types.

Table 2. Future Monitoring Effort by Turbine Type

Turbine Type	Installed Turbines	Percent of Turbines Monitored Annually	Turbines Monitored Annually	Capacity Monitored Annually (kw)
Bonus	499	33	165	16,835
Kenetech 56-100	2,797	25	699	69,925
Micon	218	66	144	9,352
Nordtank	305	66	201	13,085
V-47	31	100	31	20,460
Vestas	199	66	131	12,477
Total	4,018		1,372	142,134

The reduced level of effort would sample approximately 1,300 turbines annually, compared to the nearly 2,500 turbines that are monitored currently; however, the modified approach must generate a representative number of fatality detections. The representative sample must capture the sources of variability listed below.

- Spatial variability across the APWRA.
- Trends in fatalities through time at particular locations.
- Changes in fatality patterns that occur in both space and time.

To address spatial variability in mortality rates, we have gridded the APWRA into 13 panels that encompass the entire distribution of turbines (Figure 2). Each panel is assigned a Grid ID in the APWRA database. The relative monitoring effort will be distributed evenly across each panel so that approximately the same proportion of turbines is sampled in each area. However, the actual number of turbines will vary spatially relative to the distribution of installed capacity for the subsampled turbine types (Table 3). The Bonus turbines in panels A05, A06, and B05 will be censused because there are so few turbines in each of those panels.

Table 3. Total Number of Turbines by Grid ID and Turbine Type

Grid ID	Bonus	Kenetech 56-100	Micon	Nordtank	Vestas	Total
A04		249				249
A05	1	38		186		225
A06	15	42				57
B04		167				167
B05	10	528				538
B06	237	353			47	637
B07		163	167			330
C05		108				108
C06	76	476		35	152	739
C07	160	321		84		565
C08			51			51
D07		268				268
D08		84				84
Total	499	2,797	218	305	199	4,018

To address trends in fatality rates through time we will maintain fixed stations at some turbines/strings. These strings will include locations that were monitored during the baseline and/or current studies to allow for comparisons between the historic record and future monitoring results. However, some fixed stations will be new locations selected to spatially balance the monitoring effort across the APWRA. Approximately 50% of the strings monitored annually will be fixed stations that will be monitored every year until the monitoring requirements change.

To address changes in fatality patterns that occur in both space and time we will rotate a portion of the sampling sites annually. Changes in spatiotemporal patterns in fatalities can result from biological variables such as changes in micro-scale bird use patterns, environmental variables such as micro-scale changes in wind patterns, or random processes. Fixed stations may miss short-lived fatality hotspots, or may randomly select for locations with high fatality rates. To account for these issues we will rotate 50% of the overall monitoring effort annually using the same spatially balanced

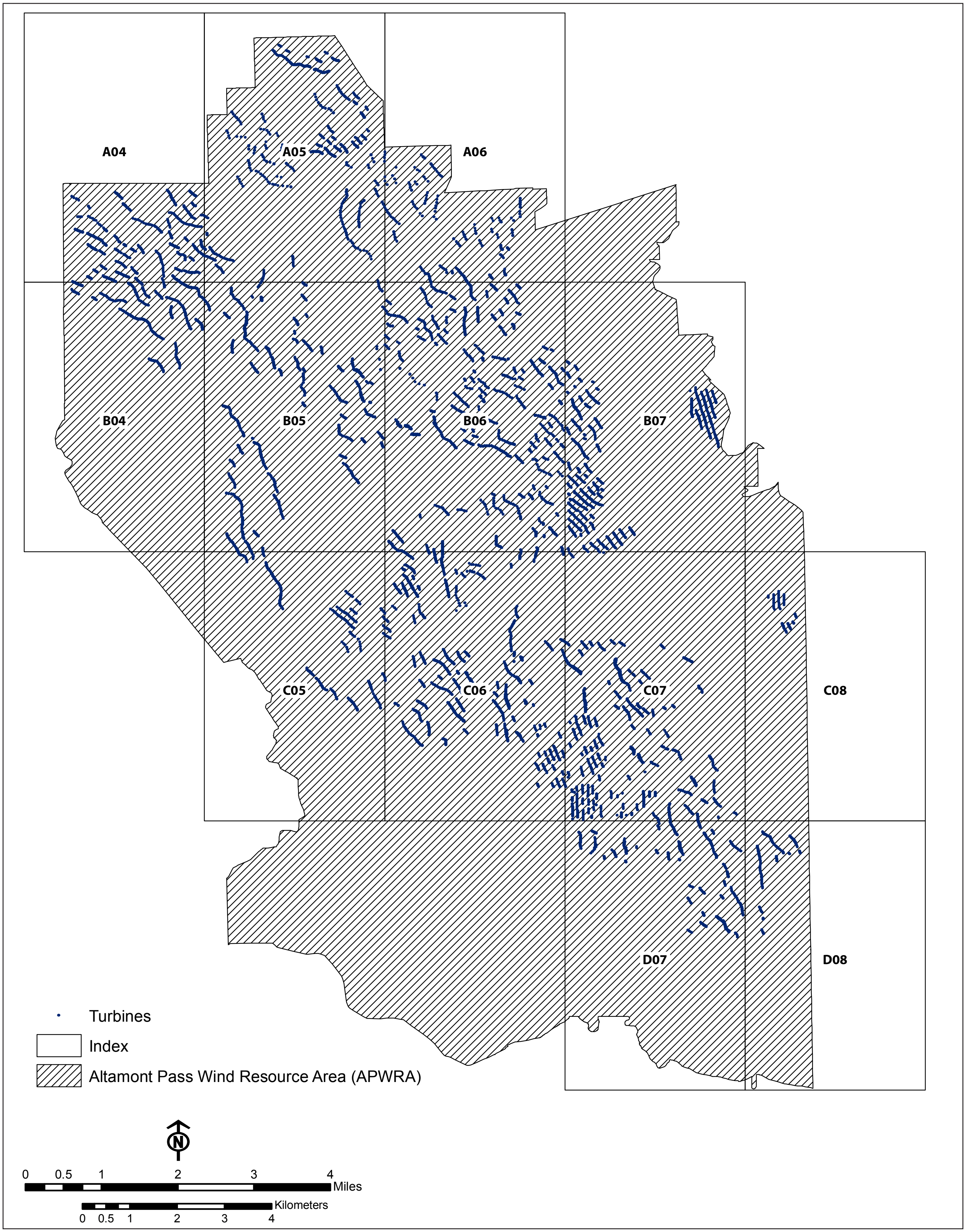

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Figure 2
ID Grids in the AWPRA

approach for both fixed and rotating stations. For the Bonus and Kenetech 56-100 turbines the rotating sites will be selected using a 3-year panel such that the same string is not rotated through the design for at least 3 years. However, for the Micon, Nordtank, and Vestas turbines the relative level of effort is sufficiently high that the same rotating sites will be monitored more than once during a 3-year period.

The specific sites to be monitored will be selected through the development of an annual Detailed Implementation Plan (DIP). The input of experts and staff experienced with monitoring efforts in the APWRA will be solicited and synthesized in a workshop setting. This selection process is essential because the theoretical design could result in the selection of specific turbines/strings that are not accessible, that are subject to environmental nuances that could bias results, or that are otherwise not representative of the APWRA. The 2011 DIP will include a sampling design for 3 years of monitoring, and will be updated annually to address the loss of sites resulting from turbine removal, access issues, or other problems that warrant adjustment.

In addition to describing the specific monitoring sites, the annual DIP will include a Data Quality Assurance/Quality Control Plan (QAP). The QAP will address the key data management elements of the *EPA Requirements for Quality Assurance Project Plans* (U.S. Environmental Protection Agency 2005) (e.g., documentation, chain of custody, document control, and public dissemination). The DIP will be updated annually to address any changes in the control process or systems used for the collection, management, data sharing, or field aspects of the monitoring protocol.

Mortality Sampling Protocol

Changes to the Protocol

Under the revised protocol, the number of monitored locations will be reduced for widely distributed turbines. The overall sampling effort will be evenly distributed across the APWRA for each monitored turbine type. Pre- and post-search quality control (bias correction) surveys will be incorporated into the monitoring regime. Handheld data loggers will replace paper data sheets.

The proposed effort would allow for a reduction in the fulltime equivalents (FTEs) required to support regular long-term monitoring activities from an average of seven to five FTEs (including the field supervisor). Because of the logistical constraints involved in deploying the field supervisor and two field crews to separate locations, it will not be possible to reduce the number of vehicles used in the project below the three that are currently in use. Housing costs could be reduced if appropriate housing can be found for the reduced number of field staff; however, doing so would require relocating staff to different facilities.

Protocol Parameters

The search area for each turbine extends 50 meters out from the turbine on all sides, except for the enXco Tres Vaqueros site in Contra Costa County (60-meter radius), and the Vestas V-47 turbines on the Diablo Winds site (75-meter search radius). During September of each year, the field crew will conduct clearing searches at all turbines/strings that have not been monitored during the previous quarter. The clearing searches will be conducted by one or multiple field personal, with or without the assistance of a dog-handling team depending on the availability of those resources. During clearing searches the terrain within the search radius +20% will be surveyed in a biased fashion, making every attempt to locate any evidence of fatalities. The extended radius is specified to remove any fatality evidence that might be conveyed into the search radius between the clearing search and the onset of fatality monitoring. Carcasses and feather spots found during the clearing searches will be processed and removed from the search radius.

During regular fatality searches, searchers walk transects within the turbine search area. The searcher scans the ground for bird and bat carcasses and/or parts of carcasses (e.g., feathers and bones). The distance between transects in each search area averages 6–8 meters depending on terrain, height of the vegetation, and height of the individual searcher. When evidence of a fatality is found, the location of the find is marked with flagging, and the searcher then continues to search the remaining area within the plot. After completing the search of the entire plot, the searcher returns to each flagged location to record data on all the finds.

To be considered a turbine-related fatality, each find must include at least five tail feathers or two primaries from the same wing within at least 5 meters of each other, a total of 10 feathers, or any flesh and bone. Any evidence below these thresholds could be the remains of a previously documented fatality that was dragged from somewhere else; individual feathers could be the result of a bird molting at that location. When partial remains are detected, the data collected are cross-referenced with data collected for finds at adjacent turbines to avoid double-counting remains of birds found during previous monthly searches.

When remains are discovered, information on the location, condition, and type of bird or bat is recorded using a handheld data logger. The following information will be collected for each bird or bat found.

- Incident number. This is a unique identifier for all birds/bats collected, regardless of cause of death, reflecting the year, month, date, and a sequential number representing the number of finds for the day. For example, the third bird found October 10, 2005, would be #20051010-03.
- Species. The species is identified as accurately as possible (e.g., red-tailed hawk, unknown Buteo, unknown hawk, California myotis). If the taxon cannot be identified, it is listed as “unknown small bird” (smaller than a mourning dove), “unknown medium bird” (between a mourning dove and a raven), “unknown large bird” (red-tailed hawk or larger), or “unknown bat”.
- Age and sex. These attributes should be noted if it is possible to make such a determination.
- Site. The site access gate behind which the fatality was found, including the company that manages it. The turbines behind a particular gate may be managed by multiple companies. Typically, multiple plots are accessed through each gate.
- String number. This is a number representing the groups of sampled turbine addresses in a string.
- Photo ID number. At least five photographs are taken with a digital camera: four of the fatality before it is disturbed and one of the surrounding area (e.g., overhead lines, turbines, fences, electrical poles, roads). The photo ID number is recorded and photos are regularly downloaded from the camera and transferred the project’s FTP site.
- Turbine number. This is the address of the nearest intact turbine (defined as having a motor and three blades). This information is included even if the find is far from any turbine or appears to be an electrocution.
- Degree. The searcher will record the compass bearing from the nearest intact turbine to the find.

- Distance. The searcher will measure the distance from the nearest intact turbine to the find in meters.
- Nearest structure. The searcher will describe the structure (e.g., met tower, power pole, derelict turbine) nearest the find if it is closer to the find than an intact turbine.
- GPS location. The search will record the location in UTMs (datum NAD27).
- Body parts. The searcher will describe all body parts found (e.g., whole bird; right wing; flight feathers only; skull, vertebrae, and sternum). Bone measurements are included here.
- Cause of death. The searcher will record the probable cause of death as determined by carcass location and condition (e.g., turbine blade collision, electrocution, predation, overhead lines, hit by car, unknown).
- Death factor. The searcher will provide additional details about the perceived cause of death.
- Evidence. The searcher will provide a reason for a determination of the cause of death when a cause other than "unknown" is circled (e.g., fatality has broken right humerus, <10 m from turbine).
- Estimated time since death. The searcher will record the estimated age of the fatality (0–3 days, 4–7 days, <1 month, >1 month, >90 days). Factors informing this determination include presence and type of insects, condition of flesh and eyes, whether or not leg scales or bones are bleached, and coloration of marrow in bones. The categories are broad because of the difficulty of determining age after approximately 1 week.
- How identified. The searcher will record how the species was identified (e.g., plumage, bone measurements). If the fatality is of a special-status species, provide details of the determination in "Notes."
- Scavenger/predator. The searcher will characterize the type of scavenger or predator (vertebrate or invertebrate) if possible, and describe the effects of scavenging/predation.
- Insects present. The searcher will describe any insects observed on the carcass.
- Decay. The searcher will describe the stage of decay and exposure of the carcass to degrading elements (e.g., fresh, flesh and feathers, feathers and bone, feathers only).
- Flesh. The searcher will describe the condition of the flesh of the carcass (fresh, gooey, dried); the condition of the eyes (round and fluid-filled, sunken, dried, empty skull); the condition of enamel (if the waxy covering on the culmen and claws is present); and color (if the color of the leg scales or cere has begun to fade).
- Notes. The searcher will use this field to record additional information such as details regarding identification of special-status species, band number, obvious injuries, and potential cause of death if other than those listed above.
- Searchers. The searcher will record the first and last initials of all individuals present in case of future questions. The searcher recording the data lists his/her initials first.

If a state- or federally listed species (e.g., golden eagle) is found, data on the find are collected and the find is flagged to mark its location. This information is reported to the Livermore Operations office (925-245-5555) at the end of the day. The find is then collected and processed by a designated Altamont Infrastructure Company (AIC) employee. If a nonnative species (rock pigeon, European starling, or house sparrow) is found, data on the fatality are collected, and the searchers remove and dispose of the carcass offsite. All other species are individually placed in separate bags with an identification label that includes the following information: incident number, site, turbine number, species, and date found, and placed in the TEAM freezer at the field house. If the species cannot be identified in the field, the carcass may be taken by a TEAM member to the UCD Wildlife Museum to attempt identification. When the freezer is full, carcasses are taken to the U.S. Fish and Wildlife Service office in Sacramento for disposal. Disposal will be coordinated with Rene Culver, the AIC biologist.

All suspected electrocutions are documented as described above, marked with an orange pin flag, and left in the field. These fatalities are also reported to the Livermore Operations office at the end of the day they are found and are subsequently picked up by an AIC employee.

Fatalities found by turbine maintenance personnel within designated search areas are documented by Rene Culver, marked with black electrical tape on the legs, and left in place for TEAM searchers to find. When TEAM searchers find these marked remains, standard data are collected and documented as for any other remains. These finds will not be used to supplement the data on searcher efficiency.

If an injured bird or bat is found at any time on site, Operations is contacted immediately and a designated AIC employee will come to take the bird to a local rehabilitation facility.

Fatalities found incidentally outside the turbine search areas are documented and collected following the same protocol for fatalities found during searches. However, for those fatalities a note is added at the top of the datasheet indicating the find was incidental.

Bird Observations

The primary objectives of bird observations are to estimate the relative use of the project area by species, and to provide data on the behavior of birds relative to topography, weather, and facility/turbine characteristics that can be used in resource planning and management. This work traditionally entails bird use monitoring and bird behavior monitoring. Observation stations were previously established in the monitoring area to overlook the monitored plots. Currently bird use surveys are conducted twice each month at each station. Bird behavior monitoring was abandoned during recent study years but is being reinstated.

Bird Use Monitoring

Bird use is monitored during a 10-minute point count survey. Surveys are not conducted when the average wind speed reaches more than 55 km/hr or if there is heavy rain or fog. For each observation session, data on ambient environmental conditions are recorded at the beginning and end of the session: temperature (C°), average and maximum wind speeds (km/hr), wind direction, percentage cloud cover, visibility, and precipitation.

During the 10-minute survey, the observer scans the entire plot (360° coverage) throughout the observation period. When a bird (American kestrel size and larger) is detected, data are recorded on a datasheet. Each observation (individual bird or flock of birds) is designated by an alphanumeric coding system, with the letter corresponding to the individual bird or flock and the number corresponding to the minute in which the bird was observed. Using a topographical map with an overlay of a 500-meter observation buffer, the observer records the location of each bird or flock observed during the 10-minute survey with the alphanumeric code, and draws an arrow indicating the direction of movement. Observers will make note of any raptor prey species detected from the observation station and any unusual raptor behavior observed.

Bird Behavior Monitoring

Bird behavior monitoring will be reinstated. Observation points will be reviewed and revised as part of the DIP to ensure that the active locations cover monitored strings and also include a subsample of non-monitored areas. Observation points will follow the spatial distribution of monitored areas, and will therefore be evenly distributed across the APWRA. The sequence and schedule for bird observations will be randomized to follow best scientific practices for survey design.

Bird observations last for 30 minutes: the first 20 minutes are devoted to gathering behavioral data, and the last 10 minutes are used to conduct the 10-minute point count. Separate maps and datasheets will be used for the 20-minute behavioral observations and 10-minute point counts. During the 20-minute behavior observation session, the observer surveys an area consisting of a 180° coverage area focused on a turbine string or strings of interest within 500 meters of the observer.

The location of the 20-minute behavior survey may be offset from the 10-minute point count survey to ensure good views of the turbine strings. These coverage areas should be selected to include areas within which birds are most likely to demonstrate representative behaviors in response to the presence and operation of the turbines. At every 30-second interval during the observation period, if a bird has been detected, its location, flight characteristics (type, height in meters), and other relevant behavioral information is recorded on a map as well as the datasheet.

For each bird detected during the behavioral survey, the following information is recorded.

- Alphanumeric code.
- Species identification.
- Number of individuals.
- Height above ground.

The observer documents the estimated distance to the turbines in the observation area and whether the turbines closest to the birds are actively turning. Age and sex of bird is noted whenever possible. If the bird being observed is perching, the type of perching structure and height (meters) is also recorded. To ensure that all perched birds within the observation area are identified, a scan of the entire plot is conducted with binoculars immediately before and after the 30-minute survey period.

Because some of the observation areas have large numbers of gulls flying between the landfill and the reservoirs, major flight routes (i.e., gull corridors) will be indicated on the maps with one letter used to designate flocks of gulls flying in one direction, and another letter used to designate gulls flying in the other direction or along another main flight route. At the end of the observation period, the width of the corridor will be indicated on the map and an estimate of the total number of gulls that flew through each corridor will be recorded on the datasheet. Any large group of gulls observed settling within plot boundaries will be recorded on the map and given a separate alphanumeric code to distinguish them from the gulls passing through the plot.

Detection Probability Monitoring

Quality Control Protocols

The number of fatalities detected during the carcass surveys is not equal to the actual number of fatalities in the APWRA. Carcasses and feather spots can be missed by surveyors or can be removed from the search area during the interval between deposition and the survey, resulting in a downward bias of the annual estimate. Conversely, some fatalities discovered during carcass monitoring may be unrelated to turbine conditions, resulting in an upward bias of the annual estimate. Quality control monitoring (called "bias correction monitoring" in some relevant literature) develops estimates of these biases and provides a mechanism to estimate the actual annual turbine-related fatalities. Detection probabilities will be estimated using quality control monitoring of searcher efficiency, scavenger removal rates, and background mortality.

The field supervisor will conduct quality control searches at monitored locations to estimate the proportion of fatalities that are missed by searchers. Quality control searches will be conducted prior to and following approximately 2% of fatality searches. The pre- and post-survey monitoring will occur 1–14 days before or after the regular survey following a randomization routine. Quality control surveys will utilize the same turbine transects, data collection, and fatality determination methods as the regular carcass surveys. However, with the exception of golden eagles (which must be removed upon detection), fatalities discovered during the quality control surveys will be left in the field to be discovered during the regular carcass surveys. The field supervisor will place small, medium, or large carcasses or feather spots at some of the quality control search locations where no natural fatality is identified. The field supervisor will use a random number generator to determine the type of carcass, distance, and direction of placement prior to conducting bias correction surveys. Each carcass will be marked by taping the legs with electrical tape and cutting the flight feathers, and the locations will be documented using handheld GPS units. The field supervisor will place a sufficient number of carcasses and feather spots such that the combination of placed and found carcasses provides at least 15 opportunities for detection by the monitoring team per month.

Fatalities that are found or placed by the field supervisor, missed by the monitoring team, and found again during the subsequent quality control survey will be considered "missed" by the searchers. The proportion of fatalities missed during the regular searches will be used to estimate the searcher efficiency for the program. To the extent possible, searcher efficiency will be estimated for individual team members and for specific bird types; however, the proposed level of effort may not be sufficient to estimate individual efficiencies.

With the exception of golden eagles, fresh raptor carcasses and feather spots (>2 days old) will be monitored closely to estimate removal rates. The field supervisor and/or field crew will conduct daily follow-up visits at all fresh and placed fatalities. Searchers will record the location and condition of evidence and determine if the evidence qualifies as a fatality using the criteria presented above. Searches will continue for 4 days after the fatality is determined to be "missing" or is no longer considered to qualify as a fatality. The length of time that evidence remains available will be used to estimate removal rates based on the approach presented by Smallwood (2006).

Finally, the field crew (not the field supervisor) will search open areas without turbines to estimate *background mortality*—or fatalities that are not turbine related that might be discovered by the field crew during regular surveys. The crew will search open plots of land equal in size and similar in topography to the turbine search areas. The design will include three empty search plots in each of the gridded panels where turbines will be monitored in the APWRA. These plots will be selected non-randomly during the development of the DIP by selecting plots that are representative of the turbine footprints. The locations will be marked using GPS and field stakes, and searched once every 1–2 weeks using protocols that are identical to those used around turbines. Any fatalities discovered will be processed using the same techniques as the regular carcass surveys. The number, density, and type of fatalities discovered will be reported as an estimate of the background mortality rate. The DIP will include a data quality control plan for information collected during the detection probability monitoring, and will address chain of custody requirements and specific data management techniques.

Data Analysis

Adjustment Factors

Searcher efficiency and fatality removal rates will be estimated using the quality control elements of the proposed monitoring program specific to the monitoring team and search interval achieved annually. These variables will be estimated seasonally and annually across the APWRA, and will be used to derive the actual annual fatality rate (fatalities per megawatt of installed capacity) from the raw detections. To allow for comparability with other studies in the region adjusted fatality rates will be estimated using the formula that is typical of projects in the region (Smallwood, 2006):

Equation 1

$$\mathrm{Ma} = \left(\frac{\mathrm{Mu}}{(\mathrm{Sv}_i \times \mathrm{Se})}\right)_{\mathrm{s,t,g,b}}$$

Where:

Mu = observed mortality numbers from regular carcass searching
Ma = adjusted mortality reflecting scavenger removal and searcher efficiency
Sv_i = Estimate of the percent of fatalities remaining for the achieved search interval
Se = Percent of carcasses found by searchers in efficiency trials
s = season (of the bird year)
t = turbine type
g = Grid ID
b = bird group

Expansion

The annual fatality estimate will be expanded to the installed capacity of the APWRA as a function of:

Equation 2

$$\mathrm{AF} = \sum_{\mathrm{s}=1}^{\mathrm{F}} (r \times c)_{\mathrm{s,t,g,b}}$$

Where:

AF = annual fatalities
F = fatalities
r = rate of fatalities in animals per megawatt
c = installed capacity in megawatts
s = season (of the bird year)
t = turbine type
g = Grid ID
b = bird group

The estimate of installed capacity will be provided by the companies to the monitoring team on a quarterly basis. Fatality rates will be estimated from the monitoring program results for the Bonus, Micon, Nordtank, Vestas, V-47 and Kenetech 56-100 turbines. Information from the current and baseline monitoring programs will be used as a proxy of rates for the WEG 250kw, Enertech, Howden, KVS 33, Polenko, and Windmatic turbines.

Measurement of Treatment Effect

Hazardous Turbine Removal

The SRC has ranked turbines based on their perceived collision risk and observed fatality estimates. The removal of hazardous turbines is hypothesized to have a disproportionate impact on mortality rates relative to the general decommissioning of turbines. The SRC and monitoring team will continue to work with the APWRA companies to account for the decommissioning of turbines, hazardous and otherwise.

The relationship between hazardous rankings and mortality rates has not been fully analyzed. The monitoring design includes hazardous turbines that are scheduled for removal. Published analyses of the APWRA fatality data have failed to document a significant decrease in mortality rates in locations where hazardous turbines were removed. However, the previous design did not representatively monitor areas where hazardous turbines were removed.

We will test for the effects of hazardous turbine removal by monitoring the relationship between the relative portion of hazardous turbines removed and the absolute change in fatalities per megawatt. For any turbine type, panel, and bird group, we hypothesize that the correlation between turbine removal rates and decreases in fatalities per megawatt will increase through time if hazardous turbine removal is effective. We will also test for the effects of hazardous turbine removal using MANOVA (Multivariate Analysis of Variance). For any turbine type and bird group, we hypothesize that panels with higher relative proportions of hazardous turbines removed will have lower fatalities per megawatt than panels with smaller proportions of hazardous turbines removed.

Winter Shutdown

Winter shutdown has been implemented since 2005 to varying degrees, using multiple methodologies, and in tandem with turbine removal. The effects of shutdown have been notably difficult to estimate. We hypothesize that winter shutdown will decrease fatalities per megawatt during the shutdown period, and that this may result in increased fatalities per megawatt once operation is resumed.

There is no experimental design for evaluating winter shutdown. The majority of widely distributed turbine types will be shut down during the winter in the APWRA as an avoidance measure. Diablo Winds V-47 turbines will be operated during the winter and can provide one estimate of the seasonal patterns in fatalities that might be observed if turbines were not shut down. However, the representativeness of the Diablo Winds data is uncertain because of its small sample size and more modern turbines.

Theoretically, fatalities detected during the winter shutdown period reflect background mortality that is not related to the turbines. Previous attempts to estimate background mortality have been confounded by difficulties involving clearing searches and backdating fatalities. The proposed design includes a rigorous clearing search, a constant search interval, and a single 2-week simultaneous shutdown of all turbines. We will estimate the fatalities per megawatt for each bird group during the shutdown period to evaluate the presence and potential of background fatalities at each turbine type.

Measuring Change

Turbine attrition, hazardous turbine removal, and seasonal shutdown are the treatments that have been implemented in the APWRA. During the 2005–2009 monitoring period, approximately 1,000 turbines were removed from the APWRA, and winter shutdown was implemented to a varying degree each year. This period resulted in a 3-year estimate of fatalities under the conditions that prevailed during that time. Attempts to measure change between the current study and the baseline study (1998–2002) have been difficult because the baseline monitoring design differed substantially from the current study design.

The future 3 years of monitoring will coincide with ongoing winter shutdown and a variety of turbine removal activities. We hypothesize that the continued removal of turbines will result in a significant decrease in the per-megawatt fatality rates and the overall number of annual fatalities for any given bird group and turbine type. Comparisons between the next 3 years of monitoring and the 2005–2009 period will be practical because the overall monitoring approach will not change. The monitoring program will continue to have a broad spatial coverage of the APWRA, will use an approximately 30-day search interval, and will otherwise follow the same field techniques. Reductions in effort will be handled through the accounting of turbine status and the use of the weighted-expansion of fatalities depicted in Equation 2.

The monitoring team will continue to work with the companies and the SRC to update the estimates of winter shutdown, turbine removal, and installed capacity each season of each monitored year. We will use ANOVA (Analysis of Variance) to compare fatalities and fatality rates between study periods for each season, turbine type, Grid ID, and bird group. In addition we will use trend analysis to monitor changes in fatality rates over time. The focus will be on evaluating changes in the 3-year average conditions, although annual and seasonal changes in fatalities will be reported as well.

References

Howell, J. A. 1997. Avian Mortality at Rotor Swept Area Equivalents, Altamont Pass and Montezuma Hills, California. *Transactions of the Western Section of the Wildlife Society* 33:24–29.

Howell, J. A., and J. E. DiDonato. 1991. *Assessment of Avian Use and Mortality Related to Wind Turbine Operations, Altamont Pass, Alameda and Contra Costa Counties, California, September 1998 through August 1989*. Final Report submitted to U.S. Windpower, Inc., Livermore, CA.

Orloff, S., and A. Flannery. 1992. *Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano county Wind Resource Areas, 1989–1991*. P700-92-001. Report to California Energy Commission, Sacramento, CA. Santa Cruz, CA: Biosystems Analysis, Inc.

Smallwood, K. S., and C. G. Thelander. 2004. *Developing Methods to Reduce Bird Fatalities in the Altamont Wind Resource Area*. Final Report by BioResource Consultants to the California Energy Commission, Public Interest Energy Research—Environmental Area. Contract No. 500-01-019 (L. Spiegel, Project Manager).

Smallwood, S. 2006. Estimating wind turbine-caused bird mortality. *Journal of Wildlife Management*. 71(8):2781–2791.

Stevens, D. L., and A. R. Olsen. 2003. Variance Estimation for Spatially Balanced Samples of Environmental Resources. *Environmetrics* 14:593–610.

———. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* 99(465):262–278.

U.S. Environmental Protection Agency. 2001. *EPA Requirements for Quality Assurance Project Plans*. EPA QA R-5.