Altamont Pass Wind Resource Area Bird Fatality Study

Alameda County Community Development Agency ■ July 2008

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Key Terms, Acronyms, and Abbreviations

ANOVA	Analysis of variance
APWRA	Altamont Pass Wind Resource Area
Baseline Study	avian fatality monitoring study, March 1998 through May 2003
Core Turbines	subset of turbines monitored during the Baseline and Current study periods
Current Study	avian fatality monitoring study, October 2005 through September 2007
Diablo Turbines	subset of high-capacity turbines monitored during the Current study period
kW	kilowatt
MW	megawatt

1 Executive Summary

This report provides the Alameda County Community Development Agency and the Altamont Pass Wind Resource Area (APWRA) Scientific Review Committee with the following information:

- Summary results of the avian fatality monitoring study conducted at APWRA from October 2005 through September 2007 (Current Study);
- Parallel analysis of baseline avian fatality monitoring conducted at APWRA between March 1998 and May 2003 (Baseline Study);
- Determination of the change in mortality in the four target raptor species (golden eagle, red-tailed hawk, American kestrel, and burrowing owl) , other raptors, and all non-raptors between the Baseline and the Current study;
- Analysis of the relationship between the annual and monthly mortality in the four target raptor species and the local abundance (bird use) and behaviors of those species;
- Parallel analysis of avian mortality associated with a select overlapping set of turbines (Core Turbines) that were included in both the Baseline Study and Current Study; and
- Comparison of avian mortality associated with a subset of modern, high capacity-rated turbines (Diablo Turbines), and that associated with the remaining monitored turbines.

Table ES-1 summarizes the average annual mortality as adjusted for search effort and detection probability, and the estimated average annual total number of fatalities throughout the APWRA. Comparisons between the Baseline Study and Current Study revealed marked increases in the annual mortality rates and total fatalities of most target species and species groups examined except the golden eagle, which decreased by 35%. When the results of all target raptor species were combined, the mortality rate for the Current Study group increased 74% over baseline. This pattern of increased mortality was also evident in the comparison of mortality rates associated with Core Turbines used in both the Baseline Study and Current Study (Table ES-2). The Diablo results (Table ES-3) revealed reduced mortality of most target species and species groups for that set of turbines relative to the remainder of the study area.

Part of the observed differences in fatality levels for the four target raptor species may be a result of differences in the number of birds using the APWRA. Linear regression analysis of fatalities and bird use showed significant positive correlations for burrowing owl ($R^2 = 0.4525$) and red-tailed hawk ($R^2 = 0.5334$) but not for golden eagle ($R^2 = 0.0003$) or American kestrel ($R^2 = 0.0018$). However, the results of the burrowing owl analysis may be biased by the bird use survey protocol, which does not yield representative estimates for that species. This bias likely resulted in an underestimation of burrowing owl use and an inflation of the use/mortality correlation value.

In conclusion, this study indicates that the combined mortality rates of the four target raptor species increased between the Current and Baseline Study periods. Only the mortality rate of golden eagles appears to have decreased. The results of the Diablo analyses suggest that avian mortality could be reduced in areas where modern high-capacity turbines are deployed.

Table ES-1. Comparison of Mortality Rates and Estimated Fatalities for the Baseline and Current Study Periods

Species/category	Baseline 1998-2003					Current Study 2005-2007					Percent Change in mortality rates and estimated fatalities
	Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			
	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	
American kestrel	0.6460	1.10709	375	219	530	0.8431	0.94233	489	239	739	30.52%
Burrowing owl	0.8267	1.94103	479	183	776	2.0823	2.26210	1,208	731	1,684	151.87%
Golden eagle	0.2111	0.73421	122	31	214	0.1378	0.16096	80	-68	227	-34.69%
Red-tailed hawk	0.5369	0.71175	311	214	408	0.7915	0.52707	459	303	615	47.42%
Total Target Species	**2.2206**	**3.24068**	**1,288**	**816**	**1,760**	**3.8547**	**3.21429**	**2,236**	**1,478**	**2,994**	**73.59%**
Small Raptors	1.4727	2.38985	854	478	1,230	2.9254	3.01770	1,697	1,092	2,302	98.64%
Medium Raptors	0.0273	0.17922	16	-8	39	0.0378	0.10355	22	-16	60	38.19%
Large Raptors	0.9586	1.27450	556	389	723	1.3705	0.69862	795	527	1,063	42.96%
Total Raptors	**2.4586**	**3.46179**	**1,426**	**921**	**1,931**	**4.3336**	**3.45873**	**2,514**	**1,702**	**3,325**	**76.26%**
Small Non-Raptors	4.6107	11.97386	2,674	1,044	4,305	11.1519	8.80057	6,468	3,848	9,088	141.87%
Medium Non-Raptors	1.0763	2.05999	624	359	889	1.4091	0.90688	817	392	1,243	30.92%
Large Non-Raptors	0.2224	0.39115	129	76	182	0.3074	0.26189	178	94	263	38.24%
Total Non-Raptors	**5.9095**	**13.76548**	**3,427**	**1,573**	**5,281**	**12.8685**	**9.44552**	**7,464**	**4,484**	**10,443**	**117.76%**

Table ES-2. Comparison of Mortality Rates and Estimated Fatalities at Core Turbines for the Baseline and Current Study Periods

Species/category	Baseline 1998-2003					Current Study 2005-2007					Percent Change in mortality rates and estimated fatalities
	Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			
	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	
American kestrel	0.5326	1.12539	308.9	25	593	1.1437	2.80493	663.4	237	1,089	114.75%
Burrowing owl	0.5987	0.99769	347.3	65	630	1.9218	2.89118	1,114.6	691	2,304	220.98%
Golden eagle	0.1337	0.42424	77.6	19	136	0.1099	0.18621	63.8	-23	151	-17.78%
Red-tailed hawk	0.6899	1.15552	400.1	228	573	0.9476	0.95119	549.6	291	808	37.35%
Total Target Species	**1.9549**	**2.42372**	**1,133.9**	**252**	**632**	**4.1230**	**4.48816**	**2,391.4**	**378**	**1,639**	**110.91%**
Small Raptors	1.1313	1.63799	656.2	235	1,077	3.0656	4.18815	1,778.0	4,278	2,410	170.97%
Medium Raptors	0.0000	0.00000	0.0	-4	4	0.0105	0.05150	6.1	-1	13	---
Large Raptors	1.0908	1.57176	632.6	407	858	1.3576	1.05166	787.4	449	1,126	24.47%
Total Raptors	**2.2221**	**2.69224**	**1,288.8**	**759**	**1,819**	**4.4337**	**4.56249**	**2,571.6**	**1,777**	**3,366**	**99.53%**
Small Non-Raptors	3.1733	3.93027	1,840.5	878	2,803	10.3100	9.38947	5,979.8	4,537	7,423	224.90%
Medium Non-Raptors	1.2592	2.64863	730.4	370	1,091	1.2471	1.10074	723.3	183	1,264	-0.96%
Large Non-Raptors	0.2700	0.52575	156.6	64	249	0.4359	0.71114	252.8	114	392	61.46%
Total Non-Raptors	**4.7025**	**5.13424**	**2,727.5**	**1,615**	**3,839**	**11.9930**	**10.22755**	**6,955.9**	**5,288**	**8,624**	**155.03%**

Table ES 3. Comparison of Mortality Rates and Estimated Fatalities for the Diablo and Non-Diablo Turbines in the Current Study Period

Species/category	Non-Diablo Turbines 2005-2007					Diablo Turbines 2005-2007					Percent Change in mortality rates and estimated fatalities
	Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			
	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	
American kestrel	0.9785	1.07278	567.6	346	789	0.1552	0.76013	90.0	-132	312	-84.14%
Burrowing owl	2.1932	2.55305	1,272.1	507	2,037	1.4454	3.75104	838.3	74	1,603	-34.10%
Golden eagle	0.1726	0.25457	100.1	41	159	0.0000	0.00000	0.0	0	0	---
Red-tailed hawk	0.9125	0.62667	529.2	417	642	0.1236	0.22668	71.7	-40	184	-86.45%
Total Target Species	**4.2568**	**3.61589**	**2,468.9**	**1,500**	**3,438**	**1.7242**	**4.46855**	**1,000.0**	**31**	**1,969**	**-59.50%**
Small Raptors	3.1718	3.39053	1,839.6	904	2,775	1.6006	4.39501	928.3	-7	1,864	-49.54%
Medium Raptors	0.0422	0.12794	24.5	0	48	0.0122	0.05986	7.1	-17	31	-71.02%
Large Raptors	1.6004	0.86578	928.2	777	1,080	0.1493	0.24623	86.6	-65	240	-90.67%
Total Raptors	**4.8144**	**3.93731**	**2,792.3**	**1,790**	**3,794**	**1.7621**	**4.45674**	**1,022.0**	**20**	**2,024**	**-63.40%**
Small Non-Raptors	13.2087	12.96473	7,661.1	5,306	10,016	2.9132	5.21336	1,689.7	-665	4,044	-77.94%
Medium Non-Raptors	1.6285	1.13725	944.5	733	1,156	0.2967	0.53202	172.1	-40	384	-81.78%
Large Non-Raptors	0.3519	0.33412	204.1	129	278	0.1241	0.28796	72.0	-2	146	-64.75%
Total Non-Raptors	**15.1892**	**13.92650**	**8,809.7**	**6,310**	**11,309**	**3.3340**	**5.10809**	**1,933.7**	**-566**	**4,434**	**-78.05%**

2 Introduction and Study Area

The Altamont Pass Wind Resource Area (APWRA) is located in central California approximately 56 miles (90 kilometers) east of San Francisco (Figure 1). The APWRA supports a broad diversity of resident and migratory bird species 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 at risk of being injured or killed (Howell and DiDonato 1991, Orloff and Flannery 1996, Howell 1997, Smallwood and Thelander 2004). Multiple studies of avian fatality at the APWRA show that golden eagles, red-tailed hawks, American kestrels, burrowing owls, barn owls, and a diverse mix of non-raptor species are killed each year in turbine-related incidents (Howell and DiDonato 1991, Orloff and Flannery 1996, Howell 1997, Smallwood and Thelander 2004). Most of those species are protected by both federal and state wildlife legislation.

Permits have been granted for 5,400 wind turbines, rated at a capacity of approximately 580 megawatts (MW), distributed over 50,000 acres (150 square kilometers) of rolling grassland hills and valleys in the APWRA. The number of functional turbines varies over time as a result of mechanical breakdowns, maintenance shutdowns, seasonal and weather-related shutdowns, and turbine removals as mitigation for avian mortality. The actual number of turbines available at any one time for power generation is expected to range between 4,500 and 5,000. Differential air temperatures between the warmer Central Valley east of Altamont Pass and the cooler marine air from San Francisco Bay cause steady winds of 15 to 30 miles per hour (25 to 45 kilometers per hour) to blow across the APWRA during the mid-afternoon and evening periods between April and September. The spring and summer high wind period is when 70 to 80% of the wind turbine power is generated at the APWRA. Winter wind speeds average 9 to 15 miles per hour (15 to 25 kilometers per hour).

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Figure 1
Location of the Altamont Pass Wind Resource Area (APWRA)

H:\ PORTLAND \ PROJECTS \ UC SANTA CRUZ \ 04 RESOURCES \ ALTAMONT_GIS \ MAPDOC \ STUDYAREA.MXD JH (07-18-08)

The current environmental management goal for the APWRA is to significantly and substantially reduce the fatalities of birds resulting from collisions with the wind turbines and other turbine-related incidents. The principal short-term management objective is to reduce the fatalities of four highly affected raptor species (golden eagle, red-tailed hawk, American kestrel, and burrowing owl) by 50% (of the baseline level) by November 2009. This is to be achieved through management actions that include, but are not limited to, a 2-month shutdown of turbines during the low wind season, and shutdown, removal, and/or relocation of turbines previously characterized as high-risk turbines (Smallwood and Thelander 2004, Smallwood and Spiegel 2005a, 2005b, 2005c). The 50% reduction criterion is based on the Settlement Agreement (Alameda County 2007) between the Wind Power Companies, Alameda County, Californians for Renewable Energy, and the Golden Gate Audubon Society. The management actions are outlined in Exhibit G-1 of the Agreement.

A process was established to inform the appointed APWRA Scientific Review Committee and the parties to the Settlement Agreement of progress towards achieving a reduction in raptor fatalities. The Altamont Pass Avian Monitoring Team was selected to help design, implement, and report on studies relevant to the Settlement Agreement. This report describes the monitoring results for the Current Study and compares them with results from the Baseline Study Period, which were documented prior to the Settlement Agreement.

3 Methods

3.1 Study Design

This report addresses data from two separate non-overlapping field investigations. The Current Study consists of bird fatality monitoring conducted at the APWRA from October 2005 through September 2007. The Baseline Study was a similar investigation conducted at the APWRA between March 1998 and May 2003 (Smallwood and Thelander 2004 & 2005). The Smallwood and Thelander data yielded a quantitative baseline of avian mortality levels at the APWRA for comparison the Current Study period. This section describes the methods used to survey for turbine-related bird fatalities in the APWRA study area, document those fatalities, and analyze those data. Field methods for the Current and Baseline Study are presented in Appendix A and B, respectively.

3.1.1 Current Study

Approximately 2,500 of the 4,500 turbines currently operating in the APWRA were identified as monitoring locations and surveyed for bird fatalities between 17 October 2005, and 30 September 2007 (Figure 2). The surveyed turbines were distributed in 84 randomly selected plots stratified by geographic location (north and south monitoring areas) and turbine size (very small at 40 to 65 kilowatt (kW); small at 100 to 150 kW; medium at 250 kW or more). Each plot included 10 to 60 turbines aligned in 1 to 7 turbine strings. The overall APWRA-wide mortality rates and total annual fatality values for different bird and species groups were estimated based on the annual adjusted mortality rates for the 2,500 surveyed turbines, extrapolated in a linear fashion to the 4,500 turbines operating across the entire APWRA.

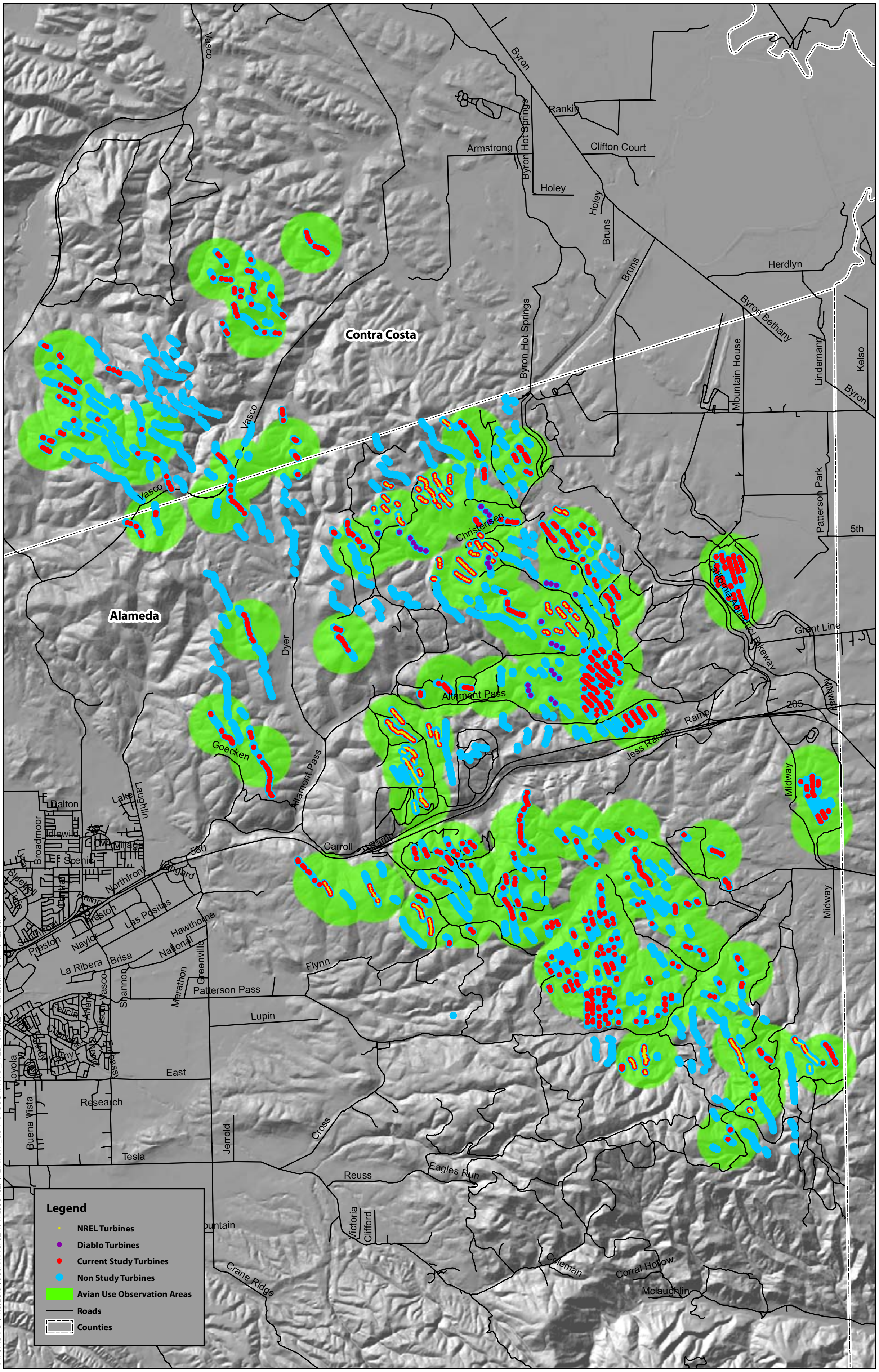

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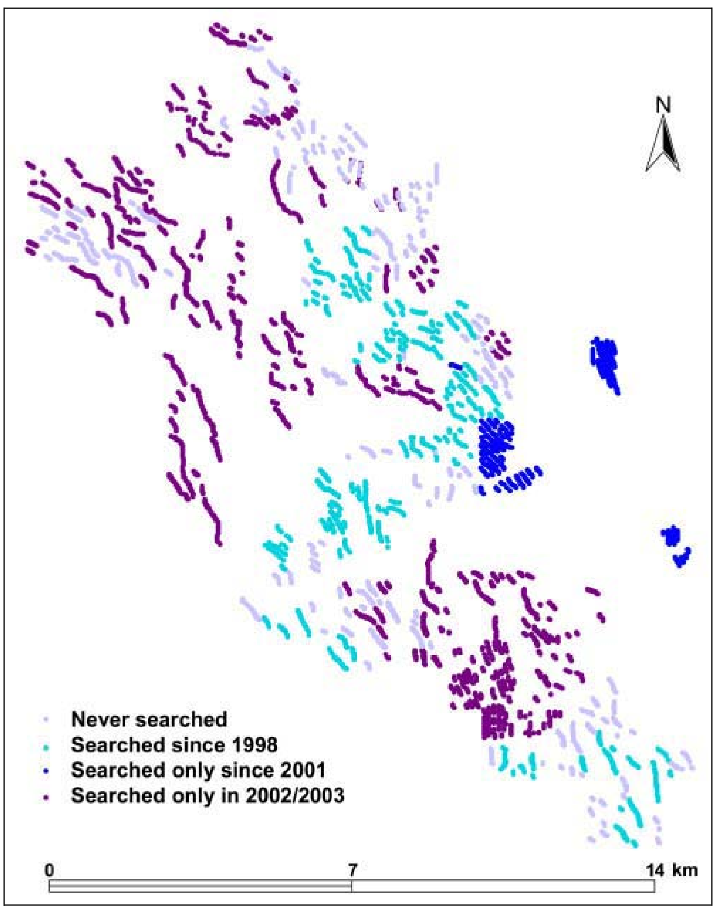
Figure 2
APWRA Bird Fatality Monitoring Locations

The area around each surveyed wind turbine was systematically searched for bird carcasses approximately every 44 days between October 2005 and March 2007, and every 37 days between early April 2007 and October 2007. Whenever a bird carcass or remains was found its location was documented and specific data on the condition of the find were recorded. A detailed description of these methods, including the survey protocol, the specific information recorded for each find, and the criteria for determining the cause of death is provided in Appendix A.

3.1.2 Baseline Study

A total of 4,074 turbines were identified as monitoring locations and surveyed for the Baseline Study between March 1998 and May 2003 (Figure 3). The study was divided into two phases. Phase I included 1,526 turbines (NREL group) that were surveyed between March 1998 and September 2002. The average search interval for this group of turbines was 53 days. Phase II included 2,548 turbines (CEC group) that were surveyed between September 2002 and May 2003. The average search interval for this group of turbines was 90 days. A detailed description of the survey protocol used during the Baseline Study is provided in Smallwood and Thelander (2004).

Figure 3. Baseline Study Turbines



Source: Smallwood & Thelander 2004

3.2 Bird Use Monitoring

To test the hypothesis that avian abundance is a predictor of turbine-related mortality, seasonal bird abundance (use) was monitored through 10-minute monthly sample counts at 288 observation points across the study area from November 2005 to November 2007 (Figure 2). At least one observation point was selected for each fatality monitoring plot. During each 10-minute survey period, all birds observed with a 500-meter radius of the observation point were recorded by 1-minute intervals. Birds the size of mourning doves and smaller were casually tallied in the notes. For the larger birds we recorded sequence ID (e.g., A2 = first [A] bird recorded in the second [2] minute), species, and flight height (meters), and plotted the relative position and direction of flight on maps. At the beginning and end of each survey, we recorded time, percent cloud cover, temperature, average wind velocity, maximum wind velocity, wind direction, visibility, precipitation, and percent of active turbines in viewshed. Surveys were conducted between the hours of 0800 and 1700. Surveys were divided between morning and afternoon start times and were rotated monthly. Bird use monitoring was conducted only during the Current Study.

3.3 Data Quality Control and Filtering

Bird fatality data were collected for both the Baseline Study and Current Study during field surveys, as incidental observations made by the survey biologists between surveys, and from ancillary observations made by wind facility technicians. However, not all of the records compiled during the Current Study were used in the final analyses. Records were excluded from analysis if they:

- occurred outside survey period (October 2005 through September 2007, when backdated);
- contained insufficient information to fully describe the mortality, such as
    - the carcass or remains could not be classified into a defined avian group, or
    - the location of the carcass was not provided;
- were located outside the designated survey area (125 meters from the turbine string);
- consisted only of old bones or other evidence indicating probable time of death was > 90 days prior to discovery; or
- indicated that a bird death was not turbine related (e.g. electrocution; nestling).

Figure 4 illustrates the decision-making process used to filter the fatality data. The process for assigning cause of death is outlined in Figure 5.

Figure 4. Process for Filtering Data in the APWRA Fatalities Database

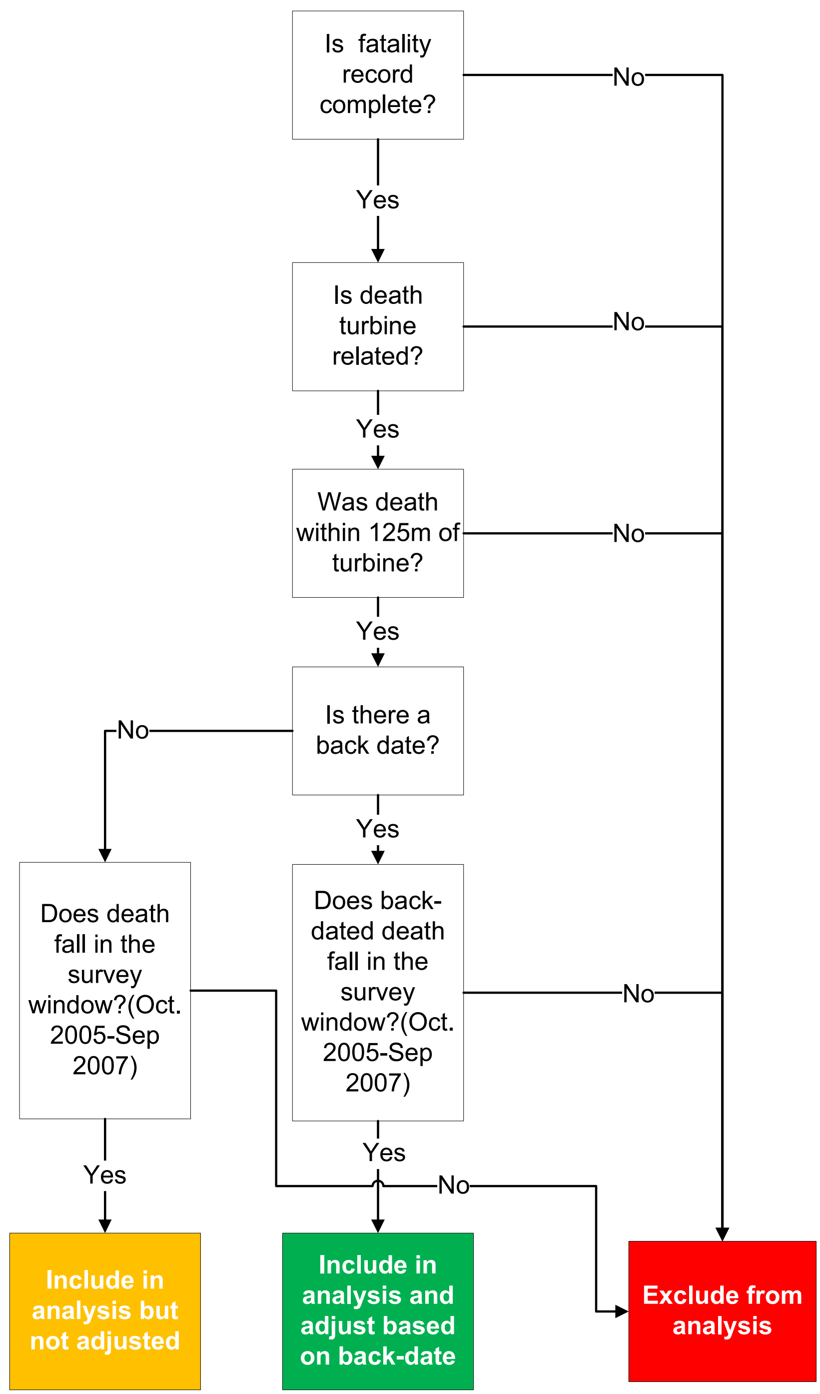
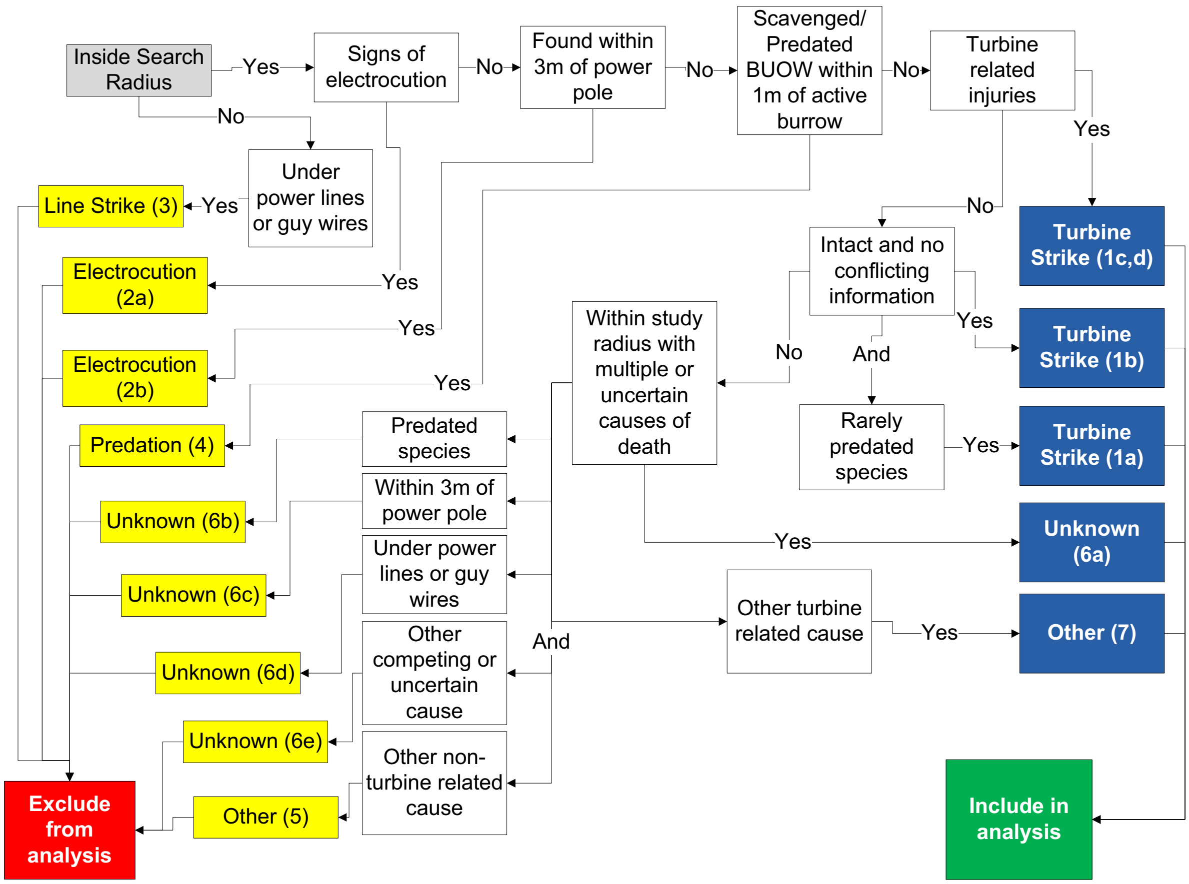


Figure 5. Process for Assigning Cause of Fatality to Records in the APWRA Fatalities Database



Back-dating was used to estimate the time of death for each recovered bird carcass or remains. This metric also provided a measure of the probability of scavenger removal for fatalities that were turbine-related. Back-dating was done in the field, or was based on photos taken of each specimen. Figure 6 shows the process for determining and assigning a back date to carcasses, feather piles, and bones. Carcasses that could not be assigned a back date were used for calculating the total number of fatalities, but not for scavenger removal estimates. Old feather piles consisting of brittle feathers and bones were excluded from the analysis because no back date could be associated with those finds.

3.3.1 Baseline Data Code Conversion

Most variables for the fatality records could be easily compared between the Baseline Study and Current Study (e.g., *species, date, distance from turbine*, and *bearing*). Some variables, such as *cause of death*, had to be recoded. For example an electrocuted bird in the Baseline Study might be coded with the value 2, while in the Current Study the same electrocution would be coded with the value 3. The *cause of death* values from the Baseline Study were recoded to reflect comparable values for the Current Study. This conversion did not result in a different set of records included in analysis between Baseline and Current Study.

When the death date of a fatality preceded the start of either the Baseline Study period or the Current Study period, that record was removed from the analysis. Smallwood and Thelander (2004 & 2005) allowed fatalities to be backdated to a period before the start of surveys. For example, if the first survey was in March 1998 and a red-tailed hawk was detected and back-dated to February 1998, that record may have been included in the analysis. Our protocols excluded such records.

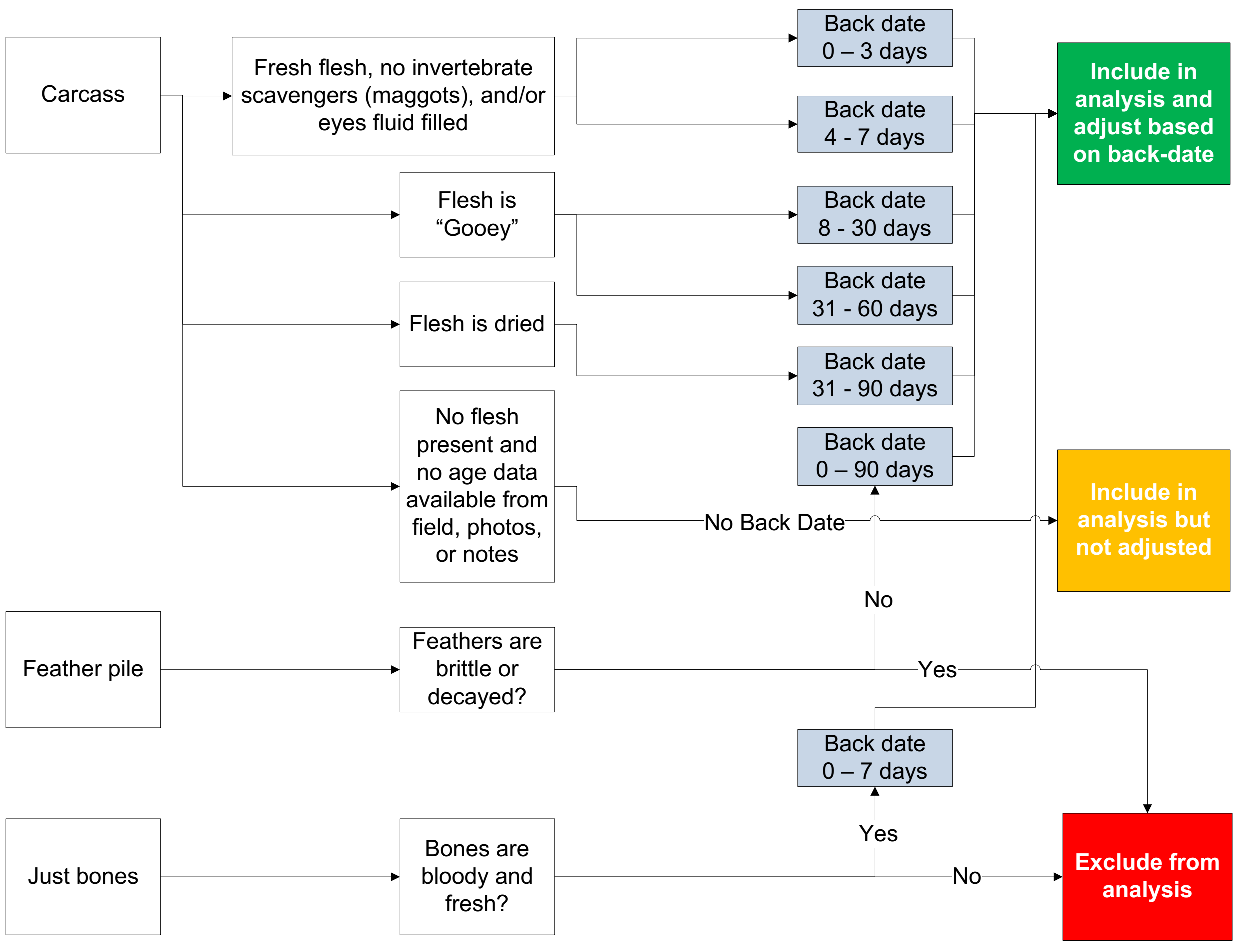
3.4 Data Analysis

This section presents the analytical methods used to determine the survey effort, and to calculate the unadjusted mortality (documented), adjusted mortality, and APWRA-wide mortality. A comprehensive example showing the calculation of each metric is provided at the end of this section.

3.4.1 Survey Effort

The survey effort represents the amount of wind power capacity (the rated MW capacity for each turbine) surveyed each month, summarized across survey strings by month and year. For this analysis, a year and month system was used where each month is expressed as "year.month" (for example, 2000.10 represents October of 2000). This format ensures compatibility with a variety of data management tools such as the statistical platform used in this report (JMP version 7.1, SAS Institute 2008).

Figure 6. Process for Back-Dating Records in the APWRA Fatalities Database



The rated MW capacity of each string was included as an index of the amount of wind power capacity surveyed within each year and month. Rated MW capacity was summed by string and month as an index of survey effort, and to standardize fatality observations by survey effort.

3.4.2 Unadjusted (Documented) Fatality Data

Fatality records that met the filtering criteria (Figure 4) were summarized by detection month, year, and survey string. All accepted fatality records were summed for each string over the entire study period. The mean number and standard deviation of fatalities were then calculated for the number of strings surveyed. The annual estimate of fatalities per MW surveyed was calculated based on the rated MW capacity of each string.

It is important to note here that the documented number of fatalities is only a subset of the actual number of fatalities that occur within the study area. Between turbine surveys the carcasses of birds that are killed by those turbines can be removed from the survey area by scavengers and would therefore not be detected by surveyors during the next survey. Surveyors do not always find all fatalities during each survey, particularly those of smaller birds or remnants of scavenged carcasses. In order to estimate the true total number of fatalities that have occurred at each site, the observed number of fatalities of each species has to be adjusted by a detection probability factor that incorporates both scavenger removal and searcher efficiency metrics. This estimation procedure is described in the following section.

3.4.3 Adjusted Mortality and Detection Probability

Adjusted mortality can be estimated using the following equation:

$$Mortality_{adjusted} = M_u / R\, x P \qquad \text{(Equation 1)}$$

Where $\mathbf{M_u}$ is the unadjusted mortality expressed as either the documented number of fatalities per wind turbine per year or the number of fatalities per MW or rated capacity per year (Smallwood 2007). ***R*** is an estimate of the carcass removal rate, as measured by the proportion of carcasses remaining since the last fatality search (estimated by scavenger removal trials) and ***P*** is a measure of search efficiency, representing the proportion of carcasses found by the searchers during a survey as estimated by searcher detection trials.

3.4.3.1 Searcher Efficiency (P)

Searcher detection trials were not conducted for this study at the request of the Scientific Review Committee. Instead, estimates of detection efficiencies were obtained from Smallwood (2007). Based on review of numerous studies of searcher detection efficiency conducted in APWRA (e.g., Orloff and Flannery 1992, Johnson et al. 2002, Anderson et al. 2004 and 2005), Smallwood determined that the average searcher detection efficiency was 100% for large-bodied raptors, 80% for large non-raptor birds, 79% for medium sized raptors, 78% for medium-sized non-raptor birds, 75% for small raptors, and 51% for small non-raptor birds. These estimates were used for all calculations of adjusted mortality in this report.

3.4.3.2 Scavenger Carcass Removal Rate Estimate (R_c)

The **R** value in Equation 1 is the cumulative number of bird carcasses remaining at the survey site (**R_c**) after a specified time period, where time can be measured as days from the last survey (average search interval) or the estimated time since death of the bird (dead days). In this study, time since death was used to calculate **R_c** since it provided a more representative (record-specific) measure of the probability for scavenger removal.

R_c can be calculated using the following equation:

$$Rc = \frac{\sum_{I}^{i=1} Ri}{I \; x \; 100} \qquad \text{(Equation 2)}$$

Where **R_i** is the percent of carcasses remaining on the **i**th day since the estimated time of death as described by the following logarithmic model (Smallwood 2007):

$$R_i = a + b\ln(i+1) \qquad \text{(Equation 3)}$$

and **a** and **b** are derived from fitting the logarithmic model to empirical data gathered during multiple scavenger removal trials, and **i** is the record specific estimated time since death**.** For the purpose of this analysis, we considered "days dead" for fatalities detected in the field to be synonymous with "days a carcass was on the ground" in the carcass removed studies summarized by Smallwood (2007). Therefore, we considered the percent of carcasses remaining on the ground on the **i**th day to be synonymous (or equivalent) with the probability that a specific carcass would still be on the ground on the **i**th day.

Smallwood (2007) showed that the logarithmic curves describing the percent of carcasses remaining at a survey site over time were specific to different bird sizes. Small birds are generally scavenged at a higher rate than larger raptors. Table C-1 and C-2 in Appendix C show the predicted percentages of bird carcasses remaining each day into a bird mortality study for small and large raptors respectively. Tables of **R_i** values that define these curves are provided with these figures. Those data were used in this study to calculate adjusted mortality as described below.

3.4.4 APWRA-Wide Mortality

Adjusted mortality measures provide estimates of fatality across the study area. However, bird fatalities also occur at other turbines in the APWRA but outside the study area. To estimate the total annual mortality across the APWRA it was necessary to extrapolate the adjusted observed fatalities to the entire APWRA. This was done by first calculating the adjusted fatalities per month per surveyed MW capacity, then calculating the average monthly mortality rate (sum of monthly mortality rates divided by the number of months surveyed), then multiplying by 12 to provide an annual estimate. That estimate is then multiplied by 580, the rated MW capacity for the entire APWRA turbine field, to provide the average annual APWRA-wide fatality and average monthly APWRA-wide mortality rate.

3.4.5 Example of Calculations for Estimated Adjusted Fatality, Adjusted Mortality, and APWRA-Wide Fatality

Figure 7 shows the data and analytical procedures used for calculating adjusted mortality, adjusted fatality, and APWRA-wide fatality. Please refer to this figure while reading the procedures presented below.

The example given is for hypothetical American kestrel fatalities occurring over a 3-month period. In the first month two kestrel fatalities were found (one was 2 days dead, one was 19 days dead), none were found in the second month, and one was found in the third month (45 days dead). The rated MWs surveyed each month were 203.34 MW, 223.08 MW, and 248.23 MW, respectively. **P** is determined by looking up the searcher efficiency probability on Table C-1 in Appendix C. For small raptors **P**=0.75 for all calculations. $\mathbf{R_c}$ is determined by looking up the scavenger removal probability on Table C-2 in Appendix C. For a time interval of 2 days (days dead), $\mathbf{R_c}$ = 0.91; for 19 days $\mathbf{R_c}$ = 0.45. The combined detection probability (**Rc** times **P**) =0.75 x 0.91 = 0.6825 for an American kestrel 2 days dead. For a kestrel 19 days dead, ***R*** x ***P*** = 0.3375.

3.4.5.1 Adjusted Fatality

The adjusted fatality for the first American kestrel (2 days dead) during the first month is 1/R_c x ***P*** = 1/0.6825 = 1.46520. The adjusted for the second kestrel is 1/0.3375 = 2.9629.The total adjusted fatality for the American kestrel during the first month is simply the sum of the individual adjusted fatalities or 4.42816. For the second month no fatalities were found. For the third month the summed adjusted fatality for the single kestrel found was 6.34021. The principal difference in this determination was the scavenger probability (0.21), which was estimated based on a time interval of 45 days dead (Table C-2 in Appendix C).

3.4.5.2 Adjusted Mortality

The adjusted mortality rate for any species is simply the summed adjusted fatality divided by the search effort, here rated MW capacity. For the first month surveyed the mortality rate for the American kestrel = 4..42816/2.034 MW = 0.02177 fatalities /MW. For the third month this value is 0.02558.

3.4.5.3 APWRA-Wide Fatality

The APWRA-wide fatality estimate is the adjusted mortality rate (fatalities/MW) multiplied by the rated MW capacity of the entire APWRA. For the American kestrel first month estimate, the APWRA-wide fatality = 0.021177 x 580 =12.6. For the third month this value is 14.8.

To calculate the annual APWRA-wide fatality the average monthly mortality rate must be calculated first, then it is pro-rated across 12 months. Table C-2 in Appendix C shows the sequential calculations used to estimate APWRA-wide fatality for the American kestrel (here 110 birds) based on the 3-month survey period used for this example.

3.4.6 Bird Mortality and Bird Use

Bird use surveys were uneven in their distribution through time and space. Therefore, it was necessary to develop an index of bird use that could be related to mortality estimates. Within months when bird use surveys were conducted, there were always several individual survey dates. On each survey date, the number of bird use minutes was recorded for each species. Those values were truncated to the first ten minutes of each survey date, and then used to calculate the monthly average of bird minutes per 10 minutes of observation. This provided a monthly index of bird use. This index was plotted against raw fatalities and adjusted fatalities per MW surveyed for all months in which both bird surveys and bird fatalities occurred for each of the four focal raptor species using simple univariate linear regression.

Figure 7. Example of Calculations for Estimated Adjusted Fatality, Adjusted Mortality, and APWRA-wide Fatality

Step down calculation of APWRA-wide average annual fatality estimate

[1] Look up Searcher probabilitly for small raptors seacher probability in table C-1 appendix C; P=0.75

[2] Determine scaveger probability from small bird scavenger table C-2 appendix C for specific days dead value of 2; Rc=0.91

[3] Cumulative detection probability
= P×Rc
= 0.75×0.91
= 0.6825

[4] $fatality_{adjusted}$ =1/(P×Rc)
=1/(0.75×0.91)
= 1.46520 (fatalities)

[5] Summed adjusted fatalities
= 1.46520 + 2.96296
= 4.42816 (fatalities)

[6] Mortality rate
= summed adjusted fatalities/MW searched
= 4.428164 / 203.34 MW
= 0.02178 (fatalities/MW)

[7] APWRA-wide fatality estimate
= Mortality rate × APWRA-wide rated capacity
= 0.02177 (fatalities/MW) × 580 (MW)
= 12.6 (fatalities)

Month & Year	Jan 08					Feb 08					March 08				
MW searched	203.34					223.08					248.23				
American kestrel unadjusted fatalities (raw finds)	2					0					1				
American kestrel adjustment calculation	Days Dead	Searcher Probability[1] (P)	Scavenger Probabilty (Rc)[2]	Cumulative[3] detection probability	Adjusted[4] Fatality	Days Dead	Searcher Probability	Scavenger Probabilty	Cumulative detection probability	Adjusted Fatality	Days Dead	Searcher Probability	Scavenger Probabilty	Cumulative detection probability	Adjusted Fatality
	2	0.75	0.91	0.6825	1.4652	0					45	0.75	0.21	0.1575	6.34921
	19	0.75	0.45	0.3375	2.96296										
American kestrel[5] summed adjusted fatalities	4.42816					0.00000					6.34921				
American kestrel[6] Adjusted mortality rate (summed adjusted fatalities/ MW searched)	0.02177					0.00000					0.02558				
American kestrel[7] APWRA wide fatality estimate (adjusted mortality * 580MW)	12.6					0.0					14.8				

Average monthly mortality rate = (sum month mortality rates)/ the number of months = (2008.01 + 2008.02 + 2008.03) / 3 = (0.02177 + 0 + 0.02558) / 3 = 0.01579 (fataltities/MW)	American kestrel average monthly mortality rate	0.01579
Average annual mortality rate = Average monthly mortality x 12 months = 0.01579 x 12 = 0.18942 (fatalities/MW)	American kestrel average annual mortality rate	0.18942
Average monthly APWRA-wide fatality estimate = (sum month APWRA-wide fatality estimates)/ the number of months= (2008.01 + 2008.02 + 2008.03) / 3 = (12.6 + 0 + 14.8) / 3 = 9.1 fataltities	American kestrel average monthly APWRA-wide fatality estimate	9.1
Average annual APWRA-wide fatality estimate = Average monthly mortality x 12 months = 9.1 x 12 = 109.9 (fatalities/MW)	American kestrel average annual APWRA-wide fatality estimate	109.9

Average monthly mortality rate
= (sum month mortality rates)/ the number of months
= (2008.01 + 2008.02 + 2008.03) / 3
= (0.02177 + 0 + 0.02558) / 3
= 0.01579 (fataltities/MW)

Average annual mortality rate
= Average monthly mortality x 12 months
= 0.01579 x 12
= 0.18942 (fatalities/MW)

American kestrel average monthly mortality rate	0.01579
American kestrel average annual mortality rate	0.18942
American kestrel average monthly APWRA-wide fatality estimate	9.1
American kestrel average annual APWRA-wide fatality estimate	109.9

4 Results

4.1 Survey Effort

Table 1 summarizes the survey effort and search periods for this study based on the summed rated MW capacity of all turbines surveyed for the Current Study, Baseline Study, Core comparison, and the Diablo comparison. The Baseline dataset included surveys of a cumulative total of 396 MW over 62 months from March 1998 through May 2003. The Current Study included surveys of 273 MW over a 24-month period from October 2005 through September 2007. The Core turbine subset comprised a total capacity of 50 MW, and was surveyed between March 1998 and September 2002 (Baseline) and concurrent with the Current Study period. Note that the 396 MW Baseline Survey effort included both the Phase I and Phase II turbines, as detailed in Figure 8. The Current Study also included two sets of turbines, identified in Figure 8 as the A and B turbines. The A turbines were surveyed over the 24-month survey period; the B turbines were surveyed from March 2007 through September 2007.

Table 1. Survey Effort of Study Comparisons

	MW searched		Search period	
Grand Comparison	Baseline [1]	Current study [2]	Baseline	Current Study
	396	273	March 1998 - May 2003	October 2005 - September 2007
Core comparison	50	50	March 1998 - September 2002	October 2005 - September 2007
Diablo comparison	Current study		Current study	
	Non-Diablo	Diablo	Non-Diablo	Diablo
	252.54	20.46	October 2005 - September 2007	

[1] 396 MW is the summed MW capacity of Phase I and Phase II turbines (see Figure 8)

[2] 273 MW is the summed MW capacity of A and B turbines (see Figure 8)

Figure 8. Megawatts Searched per Month in Baseline and Current Studies

Study	Study group [1]		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Baseline	Phase I	1998	—	—	—	14.67	25.56	40.58	40.86	30.26	52.59	39.92	22.99	47.07
Baseline	Phase I	1999	90.1	63.01	70.84	70.19	44.75	73.96	71.62	73.69	50.76	72.27	63.71	94.1
Baseline	Phase I	2000	46.87	72.9	58.32	74.33	34.82	58.35	33.58	72.55	33.75	11.16	33.1	36.705
Baseline	Phase I	2001	51.765	34.425	56.865	47.25	2.4	43.29	87.815	76.79	74.155	0	81.1	48.525
Baseline	Phase I / Phase II	2002	101.915	9.005	67.275	96.895	76.165	103.195	106.125	78.575	9.4	89.18	75.58	47.325
Baseline	Phase II	2003	97.655	76.815	101.42	46.205	—	—	—	—	—	—	—	—
Current Study	A	2005	—	—	—	—	—	—	—	—	—	115.84	177.19	185.02
Current Study	A	2006	238.61	77.05	162.06	0	102.37	180.16	225.34	112.69	134.15	204.79	161.95	105.51
Current Study	A / A + B	2007	223.395	282.225	248.5	203.34	248.23	215.42	281.27	230.36	175.64	—	—	—

[1] Phase I = 1,526 turbines, Phase II = 2,548 turbines, A = 2100 turbines, B = 500 turbines

4.2 Fatality Record Filtering Summary

Prior to conducting bird fatality analyses, fatality records from the current and baseline data sets were filtered to exclude records that did not occur within the study period, were incomplete, represented fatalities older than 90 days, were not turbine-related, or were more than 125m from turbines. The records were sequentially filtered using a step-down process, as summarized in Table 2 and illustrated in Figure 5. Table 3 shows the number of records that met or were excluded by each individual criterion, as well as the number of records that were documented outside the study period.

Table 2. Step Down Record Filter

Step-down Record Filter	**Baseline**		**Current**	
Total Records	**1213**		**2022**	
Filter Criteria	Records Excluded	Records Retained	Records Excluded	Records Retained
Complete Records?	224	989	183	1839
Days Dead less that 90?	178	811	115	1724
Fatality is turbine related?	23	788	32	1692
Fatality is within 125 m of turbine?	8	780	16	1676
Total Filtered	433	**780**	346	**1676**

Table 3. Individual Criteria Filter

Filter Criteria	**Out** [1]	**Baseline**	**Current**
Is the record Complete?			
Total records before filter	247	1213	2022
Yes - Included	168	989	1839
No - Excluded	79	224	183
Is the fatality Days Dead less than 90?			
Total records before filter	247	1213	2022
Yes - Included	245	1035	1907
No - Excluded	2	178	115
Is the fatality Cause of Death turbine related?			
Total records before filter	247	1213	2022
Yes - Included	246	1190	1990
No - Excluded	1	23	32
Is the fatality within 125m of turbine			
Total records before filter	247	1213	2022
Yes - Included	246	1205	2006
No - Excluded	1	8	16

[1] Fatalities that occurred outside of the study periods.

Of the 1,213 total Baseline fatality records, 433 were excluded because they did not meet one or several of the filter criteria (Table 2). For the Current Study, 346 of the 2,020 records were excluded from the analysis. The final numbers of fatality records retained for this analysis were 780 from Baseline and 1,676 from the Current Study.

4.3 Unadjusted Fatalities

Table 4 summarizes the number of filtered fatality records that were documented for all bird species in the Baseline and Current Study. The bird size class, avian group, and species code are also provided. These records are not comparable between studies because they have not been adjusted for survey effort. However, within each study group, general trends in fatalities for individual species and species groups can be discerned from these data. For example, rock pigeons (297) were the most frequent avian fatality recorded during the Current Study (Table 4). Raptor fatalities were also common, and included 258 red-tailed hawks, 158 burrowing owls, 60 American kestrels, and 48 golden eagles, over the course of the Current Study.

Table 4. Unadjusted Fatalities (Raw Finds) for Baseline and Current Study

Common Name	species	Bird Size	Avian Group	Baseline	Current Study
American avocet	AMAV	l	Non-raptor	1	0
American crow	AMCR	l	Non-raptor	2	7
American kestrel	AMKE	s	Raptor	49	60
American pipit	AMPI	s	Non-raptor	0	1
barn owl	BNOW	l	Raptor	38	98
black-crowned night-heron	BCNH	m	Non-raptor	2	0
black-necked stilt	BNST	m	Non-raptor	0	1
black-throated gray warbler	BTGW	s	Non-raptor	1	0
Brewer's blackbird	BRBL	s	Non-raptor	12	13
brown-headed cowbird	BHCO	s	Non-raptor	1	2
burrowing owl	BUOW	s	Raptor	59	158
California gull	CAGU	l	Non-raptor	6	1
cattle egret	CAEG	m	Non-raptor	1	0
cliff swallow	CLSW	s	Non-raptor	4	6
Cockatiel	COCK	m	Non-raptor	1	1
common raven	CORA	l	Non-raptor	9	24
Cooper's hawk	COHA	m	Raptor	0	0
double-crested cormorant	DCCO	m	Non-raptor	1	0
European starling	EUST	s	Non-raptor	42	178
ferruginous hawk	FEHA	l	Raptor	0	2
golden eagle	GOEA	l	Raptor	26	48
great blue heron	GBHE	l	Non-raptor	0	1
great egret	GREG	l	Non-raptor	0	1
great-horned owl	GHOW	l	Raptor	8	25
Hammond's flycatcher	HAFL	s	Non-raptor	0	2
hoary bat	HOBA	s	Mammal	4	4
golden eagle (continued)	GOEA	l	Raptor	26	48
horned lark	HOLA	s	Non-raptor	19	16
house finch	HOFI	s	Non-raptor	9	1

Common Name	species	Bird Size	Avian Group	Baseline	Current Study
house sparrow	HOSP	s	Non-raptor	1	0
house wren	HOWR	s	Non-raptor	0	1
killdeer	KILL	s	Non-raptor	0	2
lesser yellowlegs	LEYE	m	Non-raptor	1	0
Lincoln's sparrow	LISP	s	Non-raptor	0	1
loggerhead shrike	LOSH	s	Non-raptor	4	17
mallard	MALL	l	Non-raptor	21	12
medium bird	MEBI	m	Non-raptor	0	15
Mexican free-tailed bat	MFTB	s	Mammal	0	1
mountain bluebird	MOBL	s	Non-raptor	4	6
mourning dove	MODO	m	Non-raptor	22	33
northern flicker	NOFL	m	Non-raptor	6	1
northern harrier	NOHA	l	Raptor	3	3
northern mockingbird	NOMO	s	Non-raptor	1	2
pacific-slope flycatcher	PSFL	s	Non-raptor	0	0
pied-billed grebe	PBGR	m	Non-raptor	0	1
prairie falcon	PRFA	m	Raptor	3	3
red-shouldered hawk	RSHA	l	Raptor	0	1
red-tailed hawk	RTHA	l	Raptor	136	258
red-winged blackbird	RWBL	s	Non-raptor	10	15
red-winged blackbird	RWBL	s	Raptor	1	0
ring-billed gull	RBGU	l	Non-raptor	3	0
ring-necked duck	RNDU	m	Non-raptor	1	0
rock pigeon	ROPI	m	Non-raptor	124	297
rock wren	ROWR	s	Non-raptor	0	2
sandhill crane	SACR	l	Non-raptor	0	1
savannah sparrow	SAVS	s	Non-raptor	1	0
Say's phoebe	SAPH	s	Non-raptor	0	1
small bird	SMBI	s	Non-raptor	0	23
Swainson's hawk	SWHA	l	Raptor	0	1
Swainson's thrush	SWTH	s	Non-raptor	0	1
Townsend's warbler	TOWA	s	Non-raptor	0	0
tree swallow	TRSW	s	Non-raptor	0	1
tricolored blackbird	TRBL	s	Non-raptor	1	0
turkey vulture	TUVU	l	Raptor	3	8
unidentified accipiter	UNAC	m	Raptor	0	1
unidentified bat	UNBA	s	Mammal	0	2
unidentified bird	UNID	m	Non-raptor	4	28
unidentified blackbird	UNBB	s	Non-raptor	1	14
unidentified bluebird	UNBL	s	Non-raptor	0	3
unidentified buteo	UNBU	l	Raptor	0	6
unidentified dove	UNDV	m	Non-raptor	0	8
unidentified duck	UNDU	m	Non-raptor	0	2
unidentified empidonax	UNEM	s	Non-raptor	0	1
unidentified gull	UNGU	l	Non-raptor	3	19
unidentified hawk	UNHA	l	Raptor	0	0
red-tailed hawk (continued)	RTHA	l	Raptor	136	258
unidentified large bird	UNLB	l	Non-raptor	0	9
unidentified owl	UNOW	m	Raptor	0	1

Common Name	species	Bird Size	Avian Group	Baseline	Current Study
unidentified passerine	UNPA	s	Non-raptor	10	10
unidentified puddle duck	UNPD	m	Non-raptor	0	1
unidentified raptor	UNRA	m	Raptor	0	5
unidentified sparrow	UNSP	s	Non-raptor	0	1
Vaux's swift	VASW	s	Non-raptor	0	0
violet-green swallow	VGSW	s	Non-raptor	1	0
western kingbird	WEKI	m	Non-raptor	1	0
western meadowlark	WEME	s	Non-raptor	79	200
western red bat	WRBA	s	Mammal	0	1
western scrub-jay	WESJ	s	Non-raptor	0	1
western tanager	WETA	s	Non-raptor	0	1
white-tailed kite	WTKI	m	Raptor	0	1
white-throated swift	WTSW	s	Non-raptor	0	2
wild turkey	WITU	l	Non-raptor	1	2
yellow warbler	YEWA	s	Non-raptor	1	0
Totals				**742**	**1676**

4.4 Adjusted APWRA-Wide Fatalities

4.4.1 Baseline - Current Study Comparison

Mortality rates, estimated APWRA-wide fatalities, and arithmetic and statistical comparisons of Baseline and Current Study values are detailed in Table 5. The arithmetic mean of adjusted APWRA-wide fatalities increased in the Current Study over the Baseline period for American kestrels, burrowing owls, and red tailed hawks, but decreased for golden eagles (Table 5). Based on a One-Way Analysis of Variance (ANOVA), the two study periods were statistically different for burrowing owls ($p<0.05$), but not for other species ($p>0.05$). However, for all four target species, study period was a poor predictor of monthly fatality rates ($R^2<0.10$ all cases). For all target species, the arithmetic mean monthly fatalities increased between the Baseline and Current periods ($p=0.03$), but the differences were poorly explained by the study period ($R^2=0.05$). We did not conduct multivariate or other analyses to determine if the unexplained variance in fatalities was due to random factors or other variables.

4.4.2 Core Turbine Comparison

Mortality rates, estimated APWRA-wide fatalities, and arithmetic and statistical comparisons of Baseline and Current Study periods within the Core turbines are detailed in Table 6. The results are similar to those found in the Baseline - Current Study comparison described above. The arithmetic mean of adjusted APWRA-wide fatalities from Core turbines increased over the Baseline period for American kestrels, burrowing owls, and red tailed hawks, but decreased for golden eagles (Table 6). Based on a One-Way ANOVA, the two study periods were statistically different for burrowing owls and for all target species combined ($p<0.05$), but not for American kestrels, golden eagles, or red tailed hawks alone ($p>0.05$). Study period was a poor predictor of monthly fatality rates ($R^2<0.10$) for American kestrels, golden eagles, and red tailed hawks, but explained a larger amount of the variance in fatality rates for burrowing owls (R^2=0.10) and all target species combined (R^2=0.09).

4.4.3 Diablo Turbine Comparison

Mortality rates, estimated APWRA-wide fatalities, and arithmetic and statistical comparisons of the Diablo and non-Diablo turbines for the Current Study period are detailed in Table 7. Those results revealed consistently lower mortality, based on arithmetic means, within the Diablo turbine group. One-way ANOVA revealed significant differences ($p<0.05$) between the mean values for American kestrels, red-tailed hawks, combined target raptors, total raptors, total non-raptors, total large raptors, and total small, medium, and large non-raptors. Some of the variance between groups was explained by turbine type (Diablo vs. non-Diablo) for all target species (R^2=0.09), American kestrels (R^2=0.16), and red tailed hawks (R^2=0.42), but not for burrowing owls. The absence of golden eagle fatalities precludes statistical testing, but represents a notable mortality rate difference of 0.17.

Table 5. Comparison of Mortality Rates and Estimated Fatalities for the Baseline and Current Study Periods

Species/category	Baseline 1998-2003					Current Study 2005-2007					Percent Change in mortality rates and estimated fatalities	ANOVA		
	Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities						
	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI		R^2	F ratio	p value
American kestrel	0.6460	1.10709	375	219	530	0.8431	0.94233	489	239	739	30.52%	0.007076	0.5986	0.4413
Burrowing owl	0.8267	1.94103	479	183	776	2.0823	2.26210	1,208	731	1,684	151.87%	0.073377	6.6518	0.0116*
Golden eagle	0.2111	0.73421	122	31	214	0.1378	0.16096	80	-68	227	-34.69%	0.002809	0.2366	0.6279
Red-tailed hawk	0.5369	0.71175	311	214	408	0.7915	0.52707	459	303	615	47.42%	0.029527	2.5557	0.1137
Total Target Species	**2.2206**	**3.24068**	**1,288**	**816**	**1,760**	**3.8547**	**3.21429**	**2,236**	**1,478**	**2,994**	**73.59%**	**0.050389**	**4.4573**	**0.0377***
Small Raptors	1.4727	2.38985	854	478	1,230	2.9254	3.01770	1,697	1,092	2,302	98.64%	0.061800	5.5332	0.021*
Medium Raptors	0.0273	0.17922	16	-8	39	0.0378	0.10355	22	-16	60	38.19%	0.000866	0.0728	0.7880
Large Raptors	0.9586	1.27450	556	389	723	1.3705	0.69862	795	527	1,063	42.96%	0.026244	2.2639	0.1362
Total Raptors	**2.4586**	**3.46179**	**1,426**	**921**	**1,931**	**4.3336**	**3.45873**	**2,514**	**1,702**	**3,325**	**76.26%**	**0.057448**	**5.1197**	**0.0262***
Small Non-Raptors	4.6107	11.97386	2,674	1,044	4,305	11.1519	8.80057	6,468	3,848	9,088	141.87%	0.066422	5.9764	0.0166*
Medium Non-Raptors	1.0763	2.05999	624	359	889	1.4091	0.90688	817	392	1,243	30.92%	0.006928	0.5860	0.4461
Large Non-Raptors	0.2224	0.39115	129	76	182	0.3074	0.26189	178	94	263	38.24%	0.011444	0.9725	0.3269
Total Non-Raptors	**5.9095**	**13.76548**	**3,427**	**1,573**	**5,281**	**12.8685**	**9.44552**	**7,464**	**4,484**	**10,443**	**117.76%**	**0.058617**	**5.2304**	**0.0247***

*statistically significant difference, $p < 0.05$

Table 6. Comparison of Mortality Rates and Estimated Fatalities at Core Turbines for the Baseline and Current Study Periods

Species/category	Baseline 1998-2003					Current Study 2005-2007						ANOVA		
	Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities						
	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	Percent Change in mortality rates and estimated fatalities	R^2	F ratio	p value
American kestrel	0.5326	1.12539	308.9	25	593	1.1437	2.80493	663.4	237	1,089	114.75%	0.024406	1.9012	0.1720
Burrowing owl	0.5987	0.99769	347.3	65	630	1.9218	2.89118	1,114.6	691	2,304	220.98%	0.106116	9.0222	0.0036*
Golden eagle	0.1337	0.42424	77.6	19	136	0.1099	0.18621	63.8	-23	151	-17.78%	0.000908	0.0691	0.7934
Red-tailed hawk	0.6899	1.15552	400.1	228	573	0.9476	0.95119	549.6	291	808	37.35%	0.011902	0.9155	0.3417
Total Target Species	**1.9549**	**2.42372**	**1,133.9**	**252**	**632**	**4.1230**	**4.48816**	**2,391.4**	**378**	**1,639**	**110.91%**	**0.091591**	**7.6628**	**0.0071***
Small Raptors	1.1313	1.63799	656.2	235	1,077	3.0656	4.18815	1,778.0	4,278	2,410	170.97%	0.102275	8.6585	0.0043*
Medium Raptors	0.0000	0.00000	0.0	-4	4	0.0105	0.05150	6.1	-1	13	---	0.029221	2.2876	0.1346
Large Raptors	1.0908	1.57176	632.6	407	858	1.3576	1.05166	787.4	449	1,126	24.47%	0.007511	0.5752	0.4506
Total Raptors	**2.2221**	**2.69224**	**1,288.8**	**759**	**1,819**	**4.4337**	**4.56249**	**2,571.6**	**1,777**	**3,366**	**99.53%**	**0.086074**	**7.1577**	**0.0091***
Small Non-Raptors	3.1733	3.93027	1,840.5	878	2,803	10.3100	9.38947	5,979.8	4,537	7,423	224.90%	0.229170	22.5950	<.0001*
Medium Non-Raptors	1.2592	2.64863	730.4	370	1,091	1.2471	1.10074	723.3	183	1,264	-0.96%	0.000006	0.0005	0.9829
Large Non-Raptors	0.2700	0.52575	156.6	64	249	0.4359	0.71114	252.8	114	392	61.46%	0.017108	1.3228	0.2537
Total Non-Raptors	**4.7025**	**5.13424**	**2,727.5**	**1,615**	**3,839**	**11.9930**	**10.22755**	**6,955.9**	**5,288**	**8,624**	**155.03%**	**0.188455**	**17.6486**	**<.0001***

*statistically significant difference, $p < 0.05$

Table 7. Comparison of Mortality Rates and Estimated Fatalities for the Diablo and Non-Diablo Turbines in the Current Study Period

Species/category	Non-Diablo Turbines 2005-2007					Diablo Turbines 2005-2007						ANOVA		
	Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities			Average annual mortality rate (Adjusted fatalities/MW/year)		Estimated APWRA - wide average annual fatalities						
	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	Mean	Standard Deviation	Mean	0.95 LCI	0.95 UCI	Percent Change in mortality rates and estimated fatalities	R^2	F ratio	p value
American kestrel	0.9785	1.07278	567.6	346	789	0.1552	0.76013	90.0	-132	312	-84.14%	0.169861	9.4124	0.0036*
Burrowing owl	2.1932	2.55305	1,272.1	507	2,037	1.4454	3.75104	838.3	74	1,603	-34.10%	0.013974	0.6519	0.4236
Golden eagle	0.1726	0.25457	100.1	41	159	0.0000	0.00000	0.0	0	0	---	---	---	---
Red-tailed hawk	0.9125	0.62667	529.2	417	642	0.1236	0.22668	71.7	-40	184	-86.45%	0.422329	33.6302	<.0001*
Total Target Species	**4.2568**	**3.61589**	**2,468.9**	**1,500**	**3,438**	**1.7242**	**4.46855**	**1,000.0**	**31**	**1,969**	**-59.50%**	**0.091965**	**4.6588**	**0.0361***
Small Raptors	3.1718	3.39053	1,839.6	904	2,775	1.6006	4.39501	928.3	-7	1,864	-49.54%	0.040125	1.9229	0.1722
Medium Raptors	0.0422	0.12794	24.5	0	48	0.0122	0.05986	7.1	-17	31	-71.02%	0.022921	1.0791	0.3043
Large Raptors	1.6004	0.86578	928.2	777	1,080	0.1493	0.24623	86.6	-65	240	-90.67%	0.575546	62.3745	<.0001*
Total Raptors	**4.8144**	**3.93731**	**2,792.3**	**1,790**	**3,794**	**1.7621**	**4.45674**	**1,022.0**	**20**	**2,024**	**-63.40%**	**0.120835**	**6.3224**	**0.0155***
Small Non-Raptors	13.2087	12.96473	7,661.1	5,306	10,016	2.9132	5.21336	1,689.7	-665	4,044	-77.94%	0.220712	13.0283	0.0008*
Medium Non-Raptors	1.6285	1.13725	944.5	733	1,156	0.2967	0.53202	172.1	-40	384	-81.78%	0.369910	27.0054	<.0001*
Large Non-Raptors	0.3519	0.33412	204.1	129	278	0.1241	0.28796	72.0	-2	146	-64.75%	0.122201	6.4038	0.0149*
Total Non-Raptors	**15.1892**	**13.92650**	**8,809.7**	**6,310**	**11,309**	**3.3340**	**5.10809**	**1,933.7**	**-566**	**4,434**	**-78.05%**	**0.249953**	**15.3295**	**0.0003***

*statistically significant difference, $p < 0.05$

4.5 Bird Use

A total of 288 observation points were surveyed for bird use between November 2005 and November 2007. Figure 9 shows the temporal pattern and average monthly number of target raptor species observed. Figures 10 through 13 show the temporal relationship between bird mortality and bird use for these species. The average monthly mortality was significantly correlated with bird use for burrowing owls (Figure 12b: $R^2 = 0.45$, $p = 0.023$) and red-tailed hawks (Figure 11b: $R^2 = 0.53$, $p = 0.001$), but it was not significant for American kestrels or golden eagles.

Figure 9. Monthly Avian Use of the Four Target Raptor Species During the Current Study

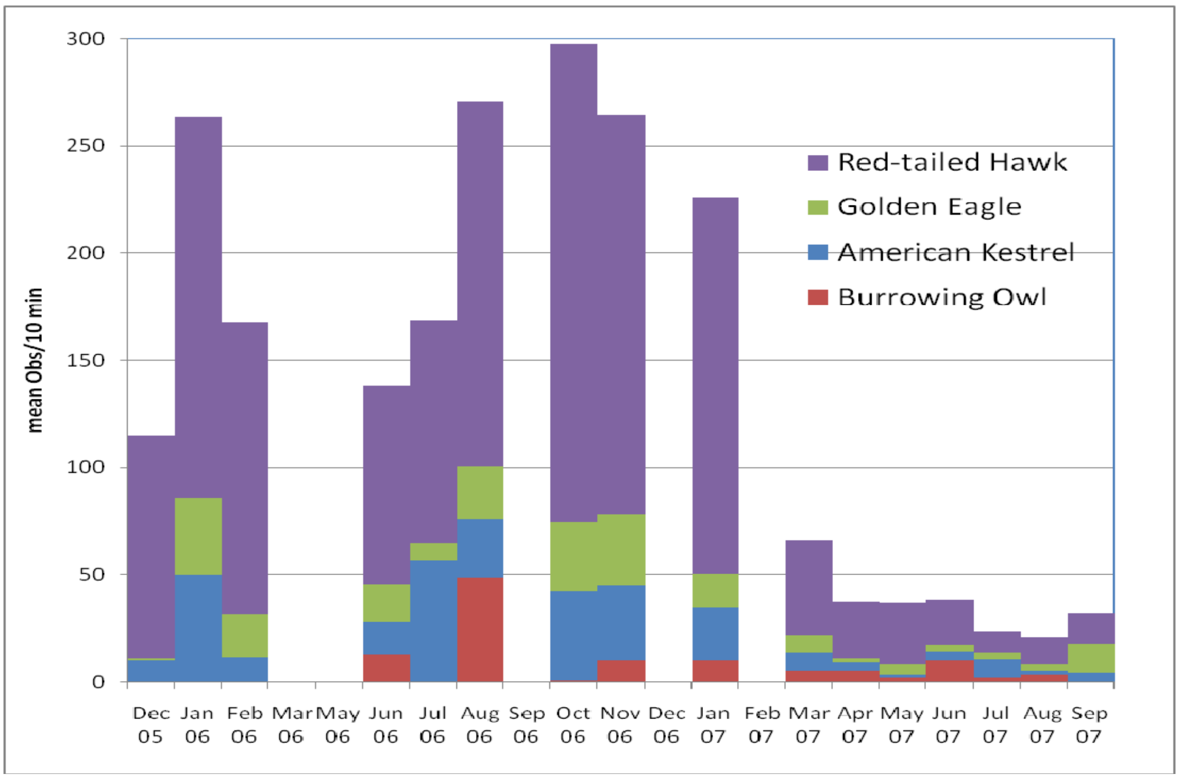


Figure 10a. Monthly Avian Use and Mortality for Golden Eagles During the Current Study

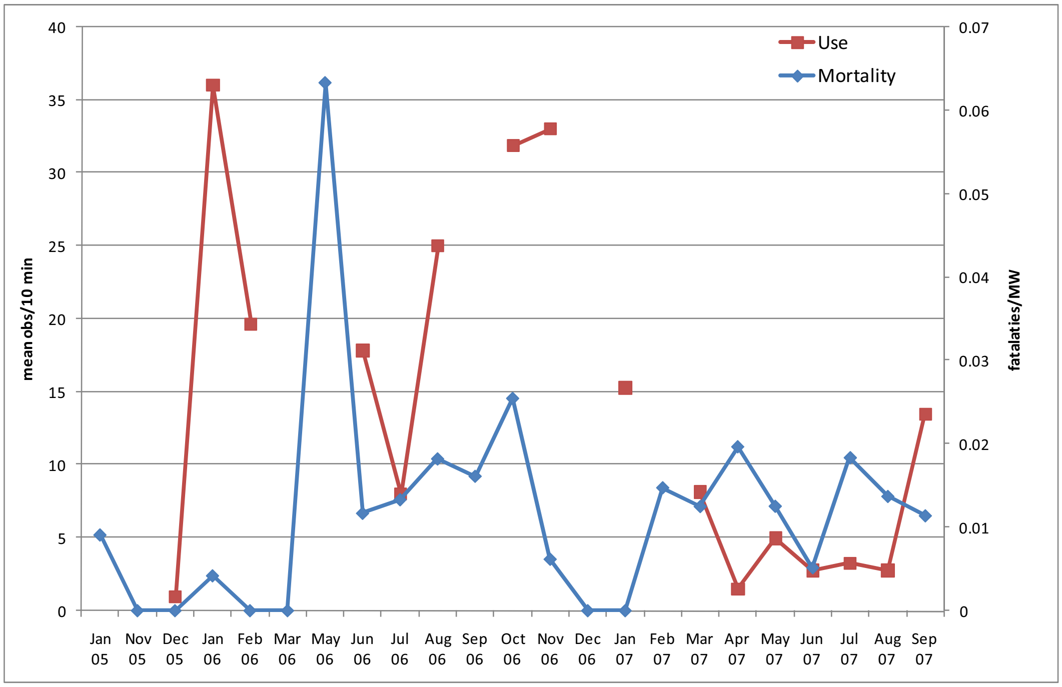


Figure 10b. Regression of Avian Use and Mortality for Golden Eagles During the Current Study

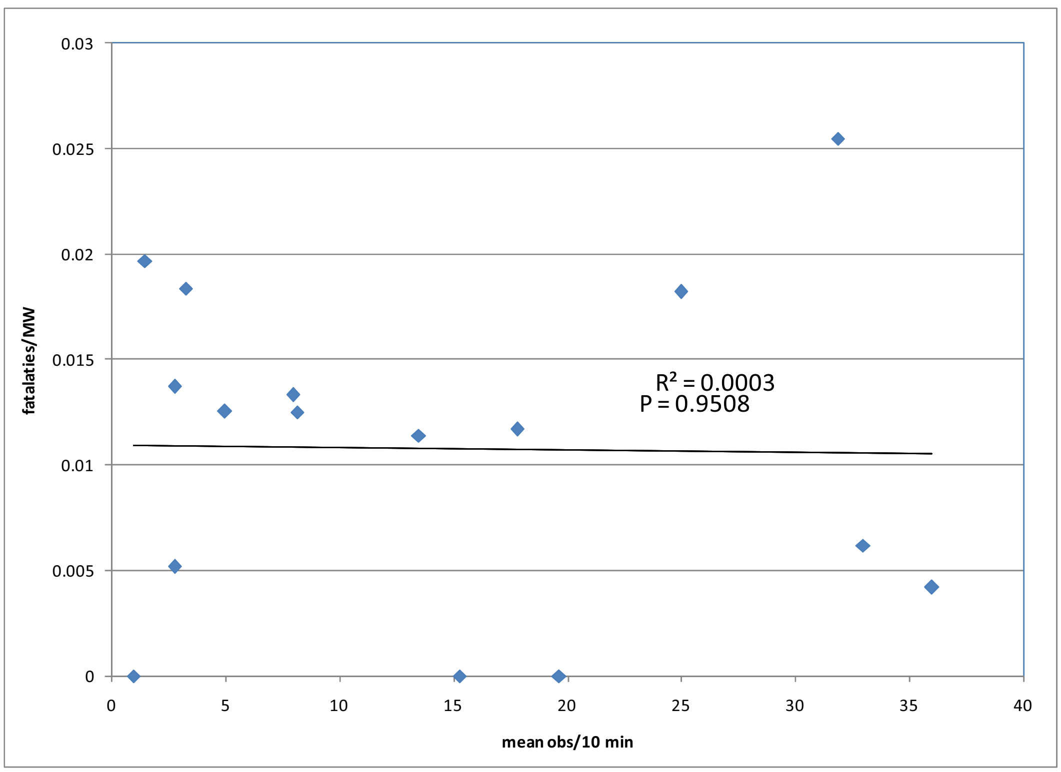


Figure 11a. Monthly Avian Use and Mortality for Red-tailed Hawks During the Current Study

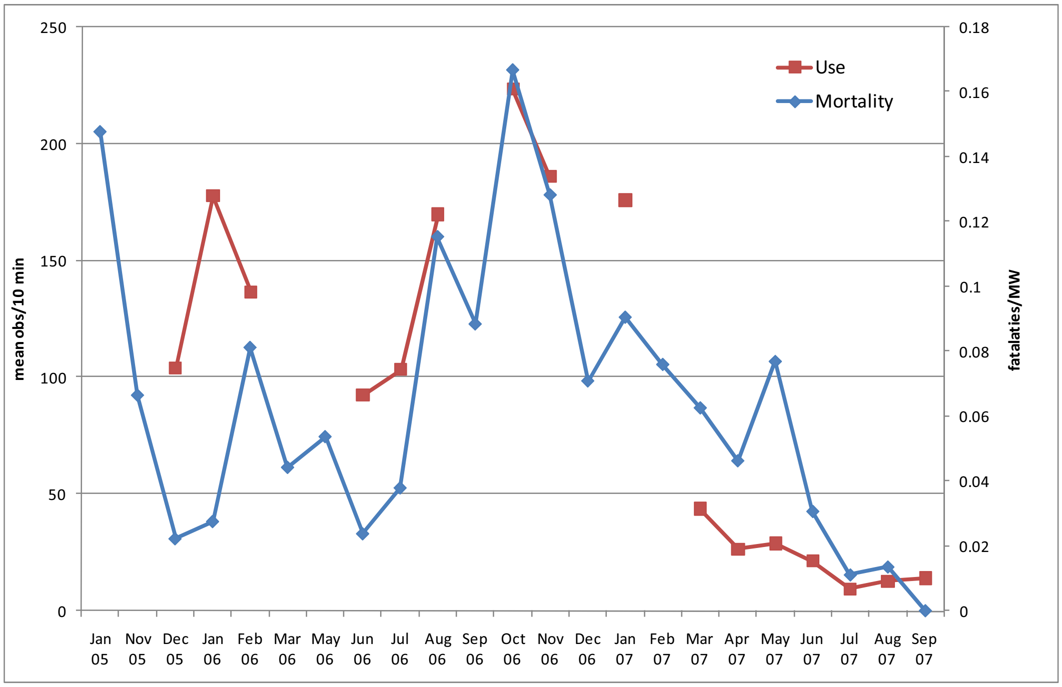


Figure 11b. Regression of Avian Use and Mortality for Red-tailed Hawks During the Current Study

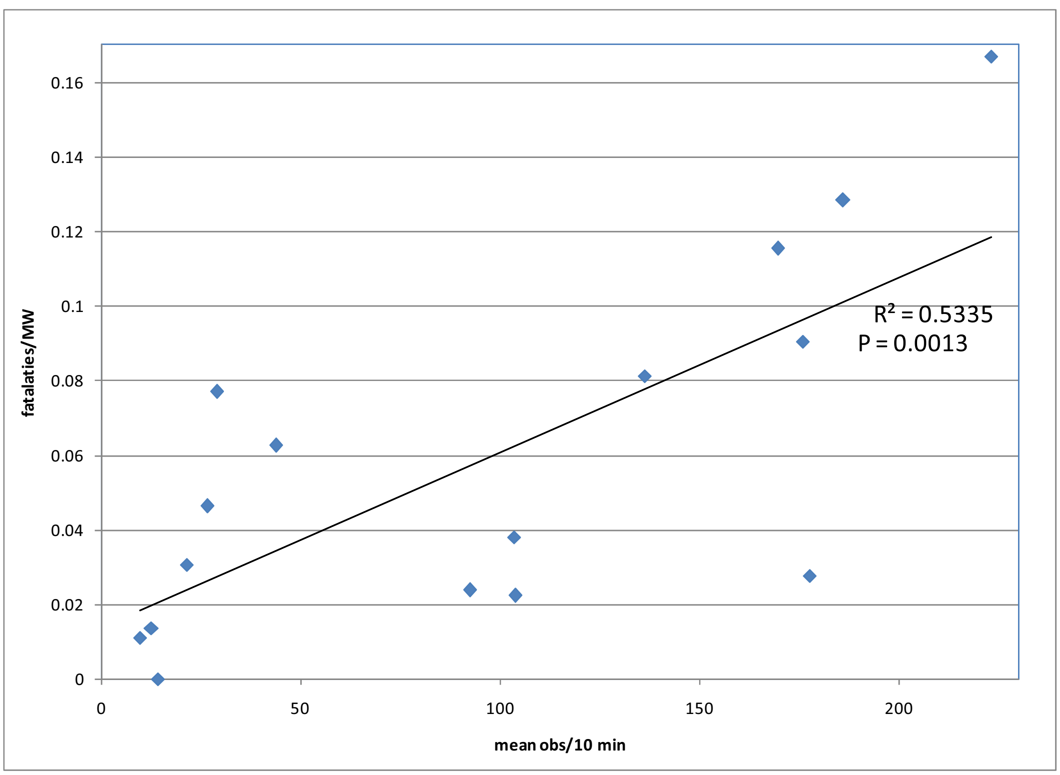


Figure 12a. Monthly Avian Use and Mortality for Burrowing Owls During the Current Study

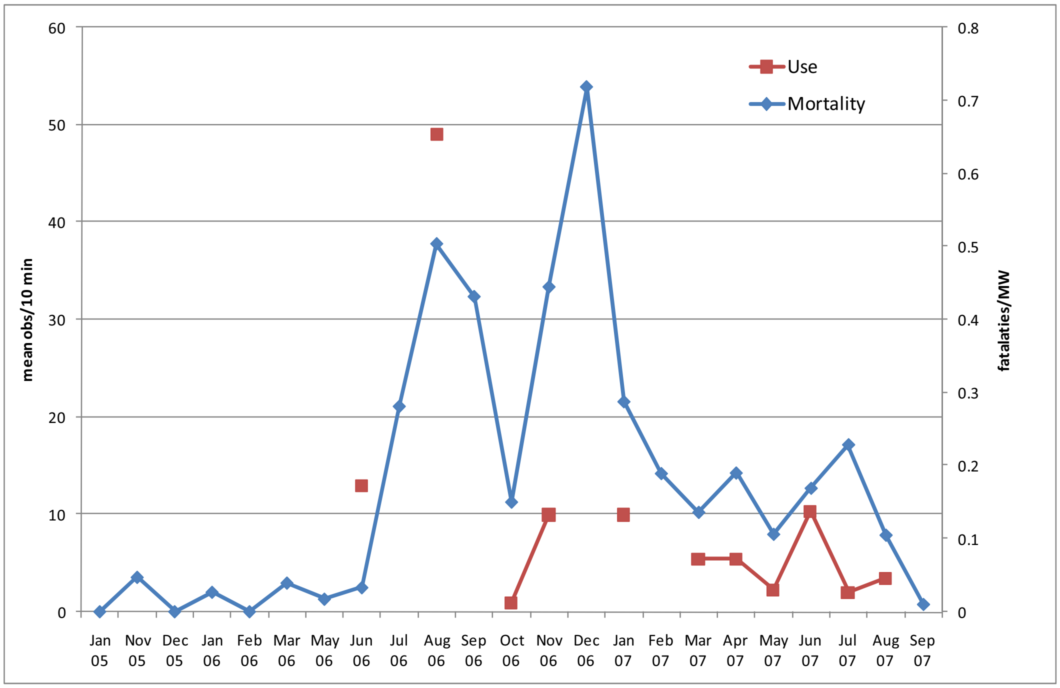


Figure 12b. Regression of Avian Use and Mortality for Burrowing Owls During the Current Study

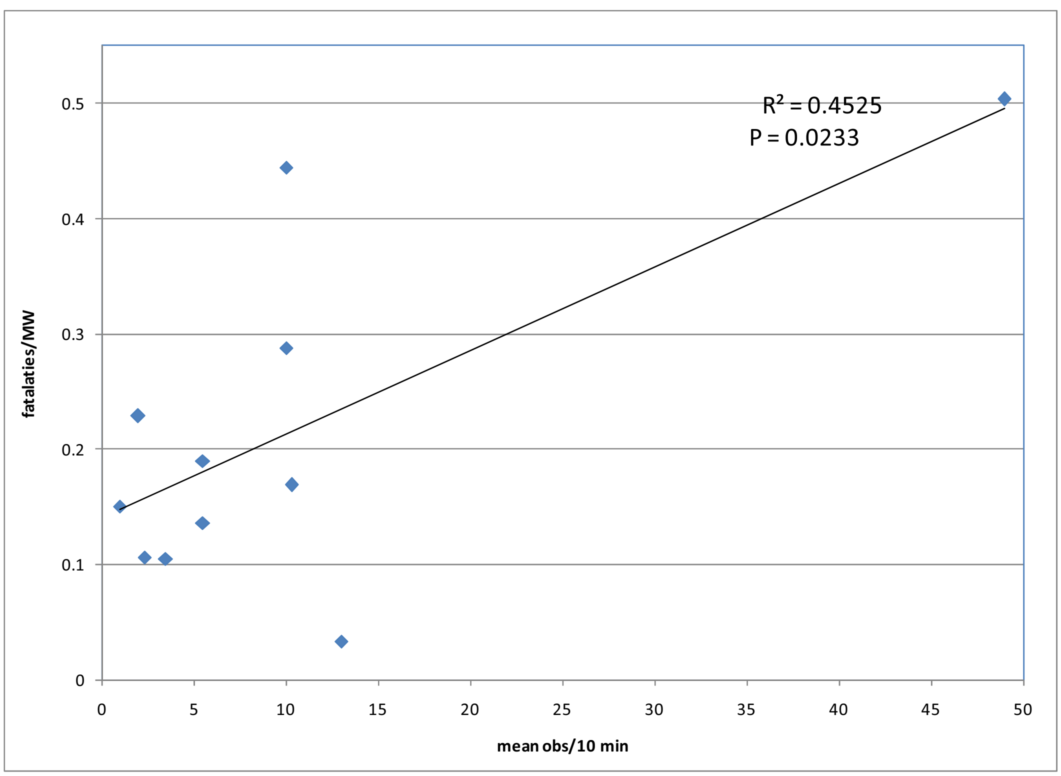


Figure 13a. Monthly Avian Use and Mortality for American Kestrels During the Current Study

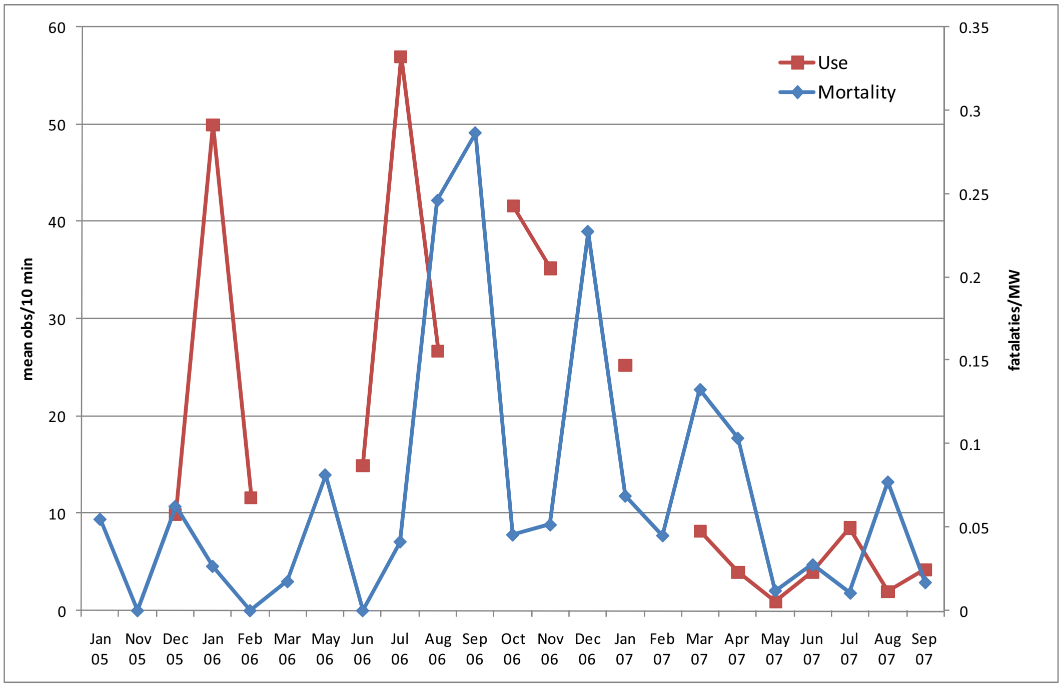
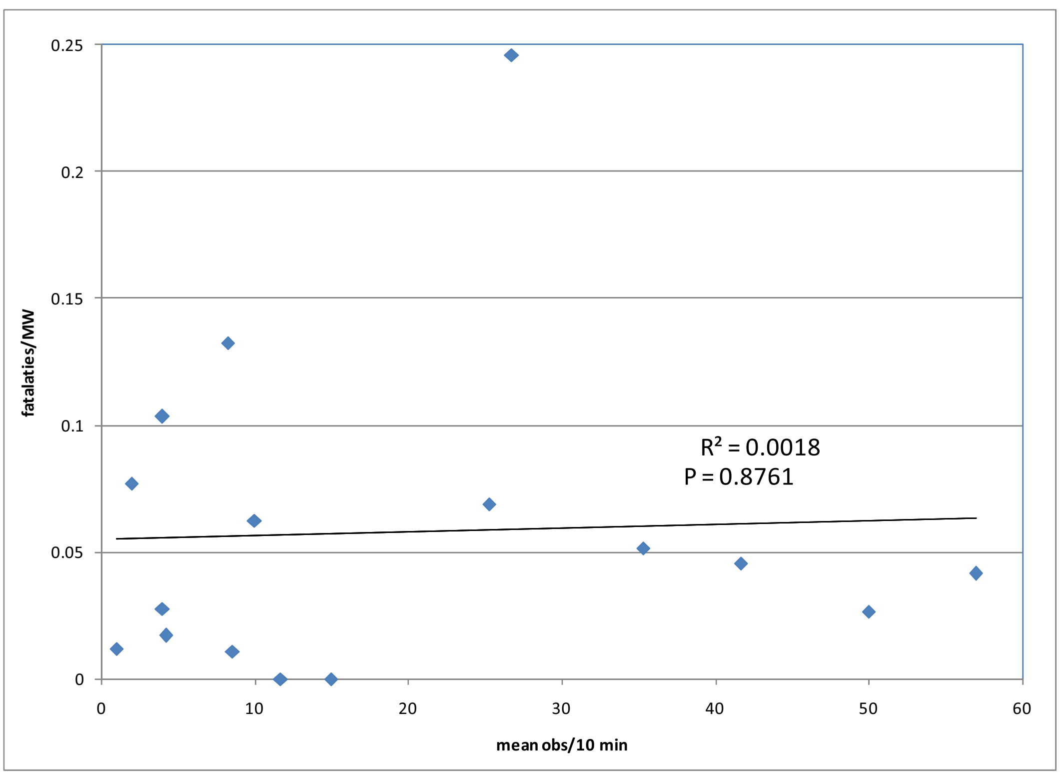


Figure 13b. Regression of Avian Use and Mortality for American Kestrels During the Current Study



5 Discussion

Analysis of the Baseline and Current data revealed marked increases in the annual mortality rates and total fatalities of most target species and species groups examined, except the golden eagle, for which fatalities decreased by 35%. When the results of all target raptor species were combined, the mortality rate for the Current Study group increased 74% over Baseline. This pattern of increased mortality was also evident in the comparisons between Core turbines used in both the Baseline Study and Current Study. These results clearly show that, to date, avian mortality has not been reduced for the for target raptor species at the APWRA. High seasonal and annual fluctuations in bird use of the APWRA may have contributed to the observed differences in mortality for these species, particularly for burrowing owls and red-tailed hawks.

Conversely, the Diablo comparisons revealed a marked reduction in the average annual mortality and fatalities of all target species and species groups for that set of turbines relative to the remainder of the study area. Those results suggest that avian mortality could potentially be reduced in areas where modern high-capacity turbines are deployed.

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Appendix A

Current Study Field Methods

Appendix A: Current Study Field Methods

Altamont Bird Fatality Field Survey Methods

Each of the 2,100-2,600 turbines was searched for bird carcasses. The overall average time between searches for the original 2100 turbines was 44 ± 18.6 (mean ± sdev). The average search interval was tightened at the end of March/early April 2007 was 37 ± 4 days and an additional 500 turbines were added to the study at that time. Searches were alternated daily between North and South monitoring areas to avoid site- and time-based biases, and turbines were searched in a similar order each month. At each turbine, a survey biologist walked along linear transects (6 to 8 meters apart depending on the terrain, height of the vegetation, and the height of the searcher) within a rectangular search plot encompassing the turbine or turbine string. The search area extended out 50 m from the turbines except at the EnXco Tres Vaqueros site in Contra Costa County where the turbines were larger and the search radius was extended out to 60 m and at Diablo Winds site where the search radius was 75 m. When evidence of a fatality was found, the location of the find was flagged and the searcher continued to search the remaining area within the plot. After completing the search of the entire plot, the searchers return to each flagged location to record data on all the finds.

To be considered a turbine-related fatality, each find had to include at least 5 tail feathers or 2 primary feathers within at least 5 meters of each other, or a total of 10 feathers. When partial remains were detected, the data collected was cross-referenced with data collected for finds at adjacent turbines to avoid double-counting of remains from birds found during previous monthly searches.

When bird remains were discovered at a site, the following information was recorded on a standard datasheet (see Appendix B) for each specimen:

- Incident number (a unique number for all birds/bats collected, regardless of cause of death, that includes the year, month, date, and a number corresponding to the number found each day. For example, the third bird found Oct. 10, 2005 would be #20051010-03).

- Species- Species is identified as accurately as possible (e.g., red-tailed hawk, unknown buteo, unknown hawk, and California myotis). If the identity of the specimen could not be determined, it was listed as "unknown small bird" (smaller than a mourning dove), "unknown medium bird" (between a mourning dove and raven), "unknown large bird" (red-tail hawk-sized or larger) or "unknown bat".
- Site- the site access gate at which the fatality was found, including the company that manages it. The turbines behind a particular gate can be managed by multiple companies. Typically there are multiple plots that are accessed by each gate.
- Plot - The identifying plot number was recorded.
- Age & Sex- if known.
- Photo Number- At least 5 photographs are taken with a digital camera: 4 of the fatality before it was disturbed and 1 of the surrounding area (such as overhead lines, turbines, fences, electrical poles, roads). The photo ID numbers are recorded and photos are regularly downloaded from the camera and transferred to Monitoring Team's ftp site.
- Turbine Number- the nearest intact turbine (has a motor and blades). This information was included even if the remains were far from any turbines or if the fatality appeared to be due to an electrocution.
- Degree- the compass bearing from the nearest intact turbine to the remains.
- Distance- the distance from the nearest intact turbine to the remains in meters. An intact turbine was defined as having motor and 3 blades.
- Nearest Structure (if closer to fatality than an intact turbine) – the nearest structure to the fatality (met tower, power pole, derelict turbine, other)
- GPS location- in UTMs (datum NAD27).
- Body parts- all body parts found (for example, "whole bird" or "right wing" or "flight feathers only" or "skull, vertebrae, and sternum"). Bone measurements were also included here.
- Cause of Death – the probable cause of death as determined by carcass location and condition (turbine blade collision, electrocution, predation, overhead lines, hit by car, etc.) (See below for detailed description of how this determination was made).
- Evidence—a code derived from the Determination of Cause of Death (see below) was used to summarize the evidence of cause of death. (1A blade strike/collision of rarely-predated species, 6AB unknown cause possible blade strike/collision or predation, etc.)
- Estimated Time Since Death – age of fatality (fresh, <1 week, <1 month, >1 month.) Presence and type of insects, condition of flesh and eyes, whether or not leg scales or bones were bleached, coloration of marrow in bones, etc. Were used to estimate time since death. Due to difficulty of determining age after ~1 week, categories were often quite large.
- How ID'ed –how a species' identification was determined (e.g., plumage, bone measurements, etc.). If the specimen was determined to be a rare species, descriptive details of how the identity determination was made were included in the "Notes" section of the datasheet.

- Scavenger/Predator- the type of scavenger or predator (vertebrate or invertebrate) was determined, if possible, and the effects of scavenging/predation were described.
- Insects Present – if the bird has insects on it or not when discovered.
- Types –the type of insects observed on the specimen.
- Decay- stage of decay of the carcass (e.g., fresh, flesh and feathers, feathers and bone, feathers only).
- Flesh- the condition of the flesh of the carcass (fresh, gooey, dried).
- Eyes –the condition of the eyes (round and fluid-filled, sunken, dried, empty skull)
- Enamel- if the waxy covering on the culmen and claws is present or not.
- Color- if the color of the leg scales or cere have begun to fade.
- Notes- additional information such as carcass condition and location, details for identification of rare species, band number if banded, obvious injuries, and potential cause of death if other than those listed above.
- Searchers- first and last initials of all present in case of future questions. The searcher recording the data lists his/her initials first.

Determination of Cause of Death

The following guidelines are used to determine the most likely cause of death for each fatality encountered in the field. Cause of death is judged on the basis of 3 main variables: 1) species (*rarely-predated species* versus *all other species*), 2) proximity to turbines, power lines, and other structures, and 3) the condition of the carcass including type of injury and scavenging. The cause of death is circled on the fatality data form. If a cause of death cannot be determined, the unknown option is circled and the most likely cause(s) is underlined. Justification for the determination of cause of death is provided on the data form. Illness/old age, crippling bias, or scavenger removal is not accounted for in our determination of cause of death due to the general lack of possible evidence supporting these determinations in the field. See glossary at end of document for definitions of terms used.

Blade Strike/Turbine Collision

A. Fatality is any *rarely-predated species* (i.e., golden eagle, red-tailed hawk or other large buteo, great-horned owl, etc.), found within the search area.

B. Fatality is an *intact* (no evidence of scavenging) carcass with no apparent injuries and is found within the search radius.

C. Fatality is any bird or bat species that has not been scavenged and has injuries consistent with a turbine blade strike or tower collision (i.e., blunt force trauma, severed wings, legs or torso, decapitation, etc.). This determination is usually made when the carcass has not been scavenged by vertebrates, as scavenging may obscure or mimic turbine-induced injury.

(Exceptions: electrocutions, line strikes, and BUOW fatalities at burrows; see sections 2, 3, and 4B below)

Electrocution

A. Carcass exhibits obvious signs of electrocution (i.e., singed feathers, clenched talons, etc.).

B. *Intact* carcass with no apparent injuries is found within 3m of a power pole, and is greater than 10m from turbine string axis (see Blade Strike, part B)

Line Strike

A. *Intact* carcass with or without apparent injury is found outside of search radius beneath power lines or guy wires (within 3m of line), and no evidence of electrocution (see Electrocution).

Predation

A. Fatalities of *rarely-predated species* (i.e., GOEA, RTHA, SWHA, FEHA, and GHOW) are never attributed to predation due to the general lack of possible evidence supporting this determination in the field.

B. *Scavenged/predated* BUOW fatality within 1m of an *active burrow* is always considered predation, regardless of proximity to other sources of mortality.

Other

This category is reserved for any other obvious or suspected cause of death. Evidence to support this assessment is provided on the data form. These may include but are not limited to:

- Fence collisions
- Auto collisions
- Collisions with other structures such as transformer boxes or buildings
- Entanglement in netting (present on some non-operational turbines to prevent perching)
- Nestling fatalities found at base of turbine when young birds fall from the nest or when old nests are cleaned out of turbine housing.
- Significant turbine oil/grease on feathers

Unknown

A. Blade strike/turbine collision underlined:

- Intact or scavenged carcass of any species with competing or uncertain causes of death. (For exception see Predation, part 4

B. Predation underlined:

- *Scavenged/predated* carcass of *rarely-predated species* found outside of search area with competing or uncertain causes of death.
- *Scavenged/predated* carcass of *any other species* found within or outside of search area with competing or uncertain causes of death.

C. Electrocution underlined:

- Any bird species found within 3m of a power pole with competing or uncertain causes of death.

D. Line Strike underlined:

- Any bird species found within 3m of power lines or guy wires with competing or uncertain causes of death.

E. **Other underlined:**

- Carcass of any species exhibiting evidence of non-listed (other) source of mortality with competing or uncertain causes of death.

Example Fatality Scenarios

Fatality Scenario	Determination of Cause of Death	
	Circled	Underlined
Intact RTHA found 40m from turbine	Blade Strike	
Scavenged RTHA found 40m from turbine	Blade Strike	
Intact RTHA found 75 from turbine	Blade Strike	
Scavenged RTHA found 75m from turbine	Blade Strike	
Intact WEME 40m from turbine (Rare occurrence)	Blade Strike	Blade Strike
Scavenged/Predated WEME 5m from string axis	Unknown	Blade Strike, Predation
Intact WEME 5m from string axis	Blade Strike	
Intact RTHA with no injuries 1m from power pole, 75m from turbine	Electrocution	
Intact RTHA with no injuries 1m from power pole, 40 m from turbine	Electrocution	
Intact RTHA with no injuries 1m from power pole, 8m from string axis (Rare)	Unknown	Blade Strike, Electrocution
Scavenged/Predated CORA 1m from power pole, 40 m from turbine	Unknown	Blade Strike, Electrocution
Intact with no injury BUOW 5m from string axis (Rare)	Blade Strike	
Intact BUOW with no injury 40m from turbine (Rare)	Blade Strike	Blade Strike

Fatality Scenario	Determination of Cause of Death	
Scavenged/Predated BUOW 5m from string axis	Unknown	Blade Strike, Predation
Scavenged/Predated BUOW at active burrow, 5m from string axis	Predation	
Scavenged/Predated BUOW at active burrow, 75m from turbine	Predation	
Scavenged BNOW 75m from turbine	Unknown	Blade Strike, Predation

Appendix B

Baseline Study Field Methods

Appendix B: Baseline Study Field Methods

Note: This appendix was excerpted from Smallwood & Thelander 2004. All citations and references are as originally published in that report.

We sampled 1,526 individual wind turbine and tower configurations from March 1998 through September 2002, which we refer to as the first set of wind turbines. During the course of the project, we periodically added groups of wind turbines into this set as access to these turbines became available. By September 20025 the first set of wind turbines included 182 strings (i.e., rows of wind turbines). From November 2002 until May 2003 we sampled a second set of wind turbines, including 2,548 turbines arranged in 380 strings. Access to this second set of wind turbines was not granted until only six months remained in our study. In total, we sampled about 75% of the wind turbines in APWRA.

Gauthreaux (1996) suggested that searches for bird fatalities should be circular around each wind turbine, the minimum radius to be determined by the height of the wind turbine. Because all wind turbines in our study area were arranged in strings, we searched them efficiently by walking strip transects along both sides and around the ends. Thus, we shoes the string of turbines as one of our study unites because searched were efficiently performed on them. All wind turbines composing a turbine string shared common search dates, frequency of searching, and time span during which the searches were performed. For reasons beyond our control, we were unable to search all turbine strings throughout the study or equally in frequency, so our fatality searched among turbine strings varied by time spans and seasonal representation. Most turbine strings were given roughly similar search effort over the time spans they were searched (Figures 3-1 and 3-2), averaging 7.2 searches per year.

Two people explored the ground around each string of wind towers, using one of two searching methods, one for the level terrain and the second for hillsides (Figure 3-3). In either case, each person walked in line with the string, 50 m away from the first tower, and 50 m in the opposite direction away from the string centerline. Previous studies reported that about 77% of all carcasses were found within a 30-40 m radius from the wind towers (Orloff and Flannery 1992; Munsters et al. 1996; Howell 1997), and we recently found that 85%-88% of the carcasses occurred within 50 m of the wind towers (Smallwood and

Thelander in review). Both searchers walked toward and outwards from the string of turbines in a zigzag pattern from wind tower to wind tower until they reached the last one in the string.

On hillsides or steep terrain, the searchers walked parallel to the string of wind turbines; whereas, on level terrain they walked perpendicular to it. The distance between each zigzag characterizes a different approach to this technique as compared with previous fatality search studies, such as Orloff and Flannery (1992). In this study, we kept a tight, closed, zigzag pattern, approximately four meters between each turn. The expected advantage of this ground-surveying technique was to increase the probability of detection of all bird remains, including small passerines.

The ground around each wind tower was searched in 8-10 minutes. Five hours per day was devoted to fatality searches, and two-person crews managed to search 30-40 wind turbines per day. With two to three people searching 120-150 wind turbines per week, 685 turbines could be sampled once every five to six weeks, thus completing approximately eight fatality search cycles in 12 months during 1998 though 1999, when we were limited to 685 turbines. Not all turbine strings were searched every month due to changes in field strategies or for reasons out of our control, such as fire hazards and flooded roads. As we were allowed to search around additional wind turbines, our search rotations took longer and our frequency of searches per year declined.

All carcasses or body parts, such as groups of flight feathers, head, wings, tarsi, and tail feathers, found during each search within a 50-m radius of the wind turbine were documented and flagged as fatalities. We carefully examined these to determine species, age, sex, and probable cause of death. The time of death was estimated by carefully analyzing the carcass condition (e.g., fresh, weathered, dry, bleached bones) and decomposition level (e.g., flesh color, presence of maggots, odor), using methods and standards described in the following paragraphs.

To determine the cause of death, we evaluated the general condition of intact carcasses. For dismembered or mutilated remains we evaluated carcass position, the distance and compass reading to the nearest wind turbine or electrical pole or wire, and the type(s) of injury. Each fatality was classified as a “fresh kill” or as “old remains,” depending on the estimated time since death. Fatalities were considered fresh when carcasses and small remains were estimated <90 days since death. Old remains included highly decomposed and dismembered carcasses with weathered and discolored feathers, missing flesh, and bleached, exposed bones. These carcass characteristics led observers to believe that the time since death was before the initiation of search rotations at the particular wind turbines. The above data, as well as the distance and angle to the wind turbine closest to the carcass, were recorded on a standard data sheet. Biologists photographed each fatality at the time of discovery.

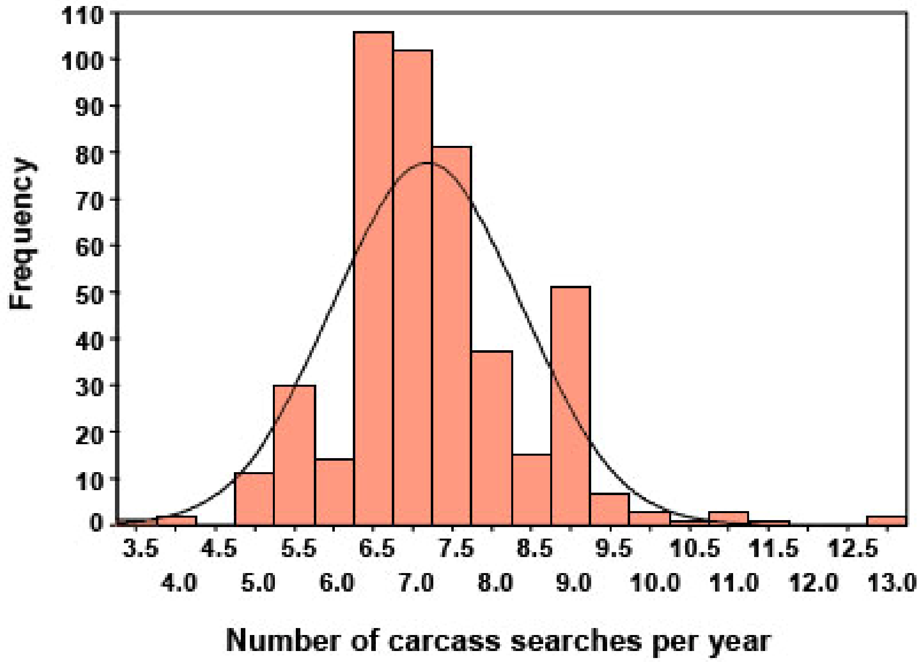

Figure 3-1. Frequency distribution of the annual number of carcass searches performed per wind turbine string during our study. Most turbine strings were searched between 6 and 9 times per year.

We expressed mortality as the number of fatalities per MW per year (see Appendix A), where the MW were the sum of the rated power output of the wind turbines composing the string, and the number of years or fractions of a year were the time spans over which searches were performed at that string of wind turbines. To the number of years used in the mortality estimate, we added three months to every wind turbine string, to represent the time period when fresh carcasses could have accumulated prior to our first search. We assumed that the same number of fatalities would have been found during a given year regardless of whether twelve searches or eight searches were performed, but it is likely that reduced search frequency resulted in lower carcass detection rates, especially for smaller-bodied bird species. Old remains were not included in the calculations.

Searcher detection and scavenger removal rates were not studied, because it had already been established that mortality in APWRA is much greater than experienced at other wind energy generating facilities. We were unconcerned with underestimating mortality, and in fact we acknowledge that we did so. We were more concerned with learning the factors related to fatalities so that we can recommend solutions to the wind turbine-caused bird mortality problem. This, we put our energy into finding bird carcasses rather than estimating how many birds we were missing due to variation in physiographic conditions, scavenging, searcher biases, or other actions that may have resulted in carcasses being removed.

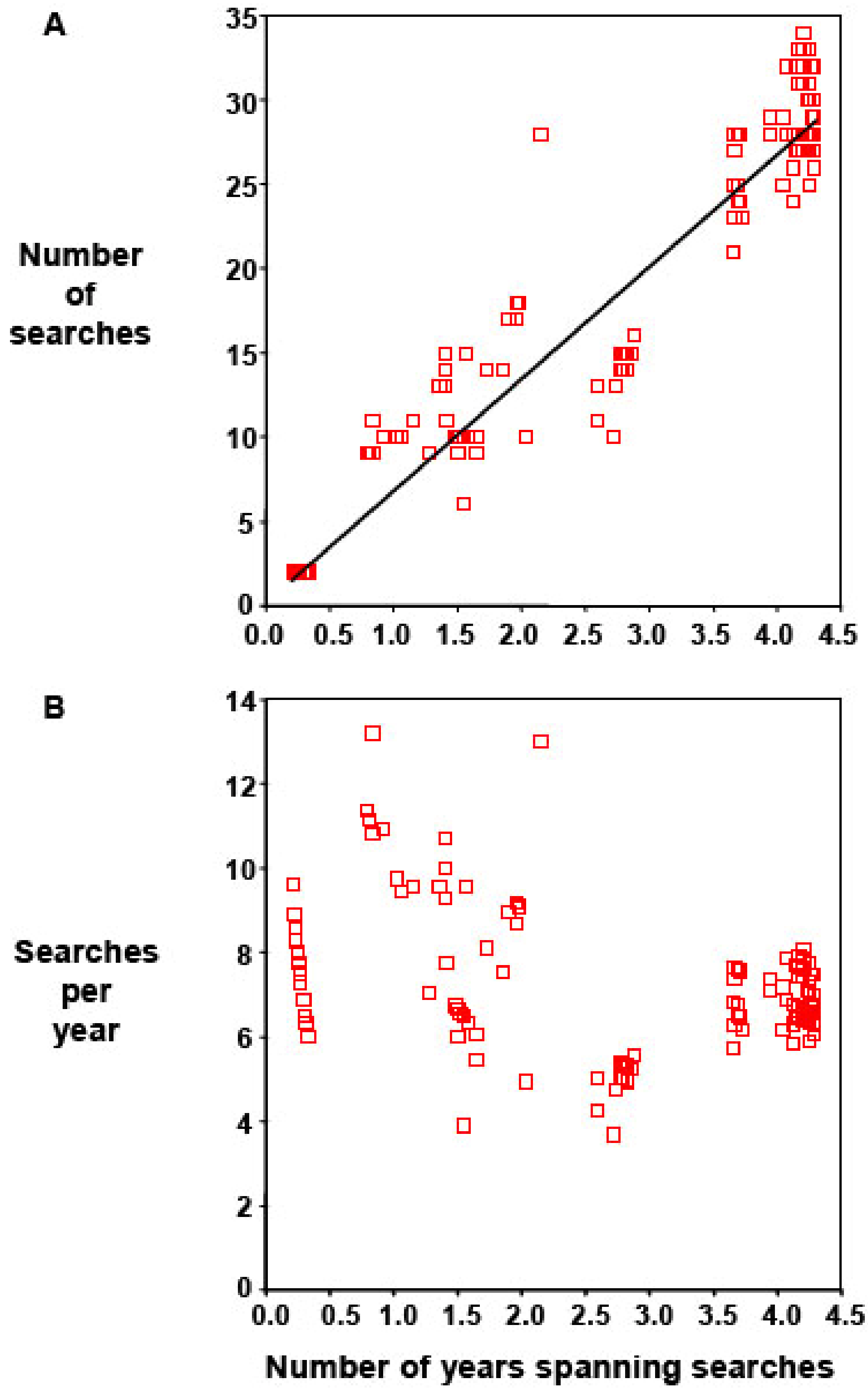

Figure 3-2. The number of carcass searches performed at each turbine string was a simple linear function of the span of time the searches were performed there (A). The searches per year decreased slightly with span time (B).

Because we did not perform trials to estimate searcher detection and scavenger removal rates, we relied on published estimates from other studies. Orloff and Flannery (1992) estimated searcher detection of 85% of raptor carcasses in APWRA, so we used this value for raptors. For non-raptors, we used the mean between the Johnson et al. (2002) estimate of 38.7% and the Erikson et al. (2003) estimate of 43%, which was 40.85% and rounded to 41%. We divided raptor mortality by 0.85 and non-raptor mortality by 0.41.

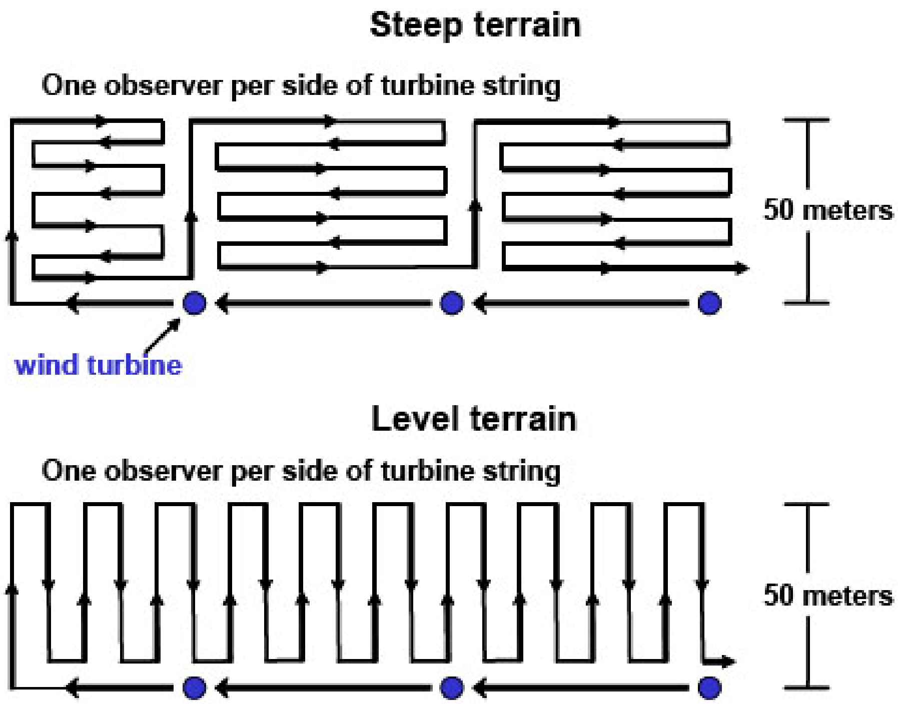

Figure 3-3. Fatality searches were performed in a regular pattern, which was adjusted to fit the terrain but that never compromised on the coverage of the 50-m search radius.

To these, we added the species/group-specific fraction of carcasses located >50 m from wind turbines, assuming we missed detecting just as many outside our search radius. Adjustments for searcher detection rates were made prior to factoring in scavenger removal rates.

Erikson et al. (2003) estimated that after 40 days, 58.6% of carcasses of large-bodied species removed on average, and that 80.2% of carcasses of small-bodied species were removed. Our average search interval was 53 ± 11.6 days for the first set of 1,526 wind turbines included in our first rotations, and 90 days for the second set of 2,548 wind turbines. Therefore, we adopted the carcass removal rates of Erikson et al. (2003) for the first set, assuming scavenger rates were similar between 40 days in their study and 53 days in ours, and we added 10% to these rates for the second set of 2,548 wind turbines, resulting in estimates of 68.6% of carcasses of large-bodied species removed between searches and 90.2% of carcasses of small-bodied species. To adjust our mortality estimates so that they included the carcasses removed by scavengers and those that we did not detect, we divided the raw mortality estimates by the proportion of carcasses detected by Erikson et al. because the carcasses had not been removed yet by scavengers. For the first set of wind turbines searched, we divided mortality by 0.198 and 0.414 for small-bodied and large-bodied species, respectively. For the second set of wind turbines searched, we divided mortality by 0.098 and 0.314 for small-bodied and large-bodies species, respectively. Based on our experience with raptor carcasses in APWRA, we did not believe that these scavenger removal rates were accurate for raptors, and we halved the removal rate estimates reported by Erikson et al. (2003). Mortality of small raptor species at the first set of wind turbines searched was divided by 0.828, and by 0.628 at the second set.

After adjusting for searcher detection bias and the rates of carcass removal by scavengers, some error remains due to the WRRS (Wildlife Reporting Response System) and other human actions. We found one raptor carcass buried under rocks and another stuffed in a ground squirrel burrow. One operator neglected to inform us when a golden eagle was removed as part of the WRRS. Based on these experiences, it is possible that we missed other carcasses that were removed. For these reasons, our mortality estimates might be conservative.

Appendix C

Searcher Efficiency and Scavenger Removal Probability Tables

Table C-1. Searcher Probability

Species group	Bird Size Code [1]	Searcher Efficiency [2]
Large Raptor	lRaptor	1
Medium Raptor	mRaptor	1
Small Raptor	sRaptor	0.75
Larger Non-Raptor	lNon-raptor	0.78
Medium Non-Raptor	mNon-raptor	0.78
Small Non-Raptor	sNon-raptor	0.51

[1] See table 4 Unadjusted fatalitites

[2] From Smallwood 2007

Table C-2. Scavenger Probability

Days Dead	Small Birds	Medium/Large Birds	Days Dead	Small Birds	Medium/Large Birds
1	0.979086964	1	45	0.213659604	0.911847714
2	0.90906314	1	46	0.20901483	0.910843033
3	0.852600069	1	47	0.204567706	0.90985799
4	0.805100088	1	48	0.200305878	0.908891825
5	0.764005326	0.996402127	49	0.196218003	0.907943821
6	0.727734878	0.990983612	50	0.192293643	0.9070133
7	0.695238594	0.986128927	51	0.18852318	0.906099624
8	0.665781099	0.981728213	52	0.184897734	0.905202188
9	0.638826211	0.977701368	53	0.181409097	0.904320419
10	0.613970287	0.973988092	54	0.17804967	0.903453774
11	0.590901465	0.970541794	55	0.174812403	0.902601739
12	0.56937355	0.967325695	56	0.171690753	0.901763825
13	0.549188631	0.96431023	57	0.168678635	0.900939568
14	0.530185119	0.961471257	58	0.165770382	0.900128525
15	0.512229301	0.958788801	59	0.162960715	0.899330275
16	0.495209227	0.956246138	60	0.160244703	0.898544419
17	0.47903019	0.953829119	61	0.15761774	0.897770574
18	0.463611333	0.951525665	62	0.155075519	0.897008375
19	0.448883057	0.949325378	63	0.152614003	0.896257475
20	0.434785001	0.947219242	64	0.150229409	0.895517539
21	0.421264474	0.945199383	65	0.147918187	0.894788251
22	0.408275194	0.943258888	66	0.145677003	0.894069306
23	0.395776281	0.941391651	67	0.143502719	0.893360412
24	0.383731448	0.939592249	68	0.141392385	0.89266129
25	0.372108328	0.937855848	69	0.13934322	0.891971672
26	0.360877929	0.936178116	70	0.137352602	0.891291301
27	0.350014175	0.934555158	71	0.135418059	0.890619931
28	0.339493526	0.932983457	72	0.133537252	0.889957325
29	0.329294661	0.931459828	73	0.131707975	0.889303255
30	0.319398199	0.929981375	74	0.129928137	0.888657503
31	0.309786478	0.928545461	75	0.128195762	0.888019859
32	0.300443347	0.927149672	76	0.126508976	0.887390119
33	0.291354005	0.925791797	77	0.124866002	0.886768089
34	0.28278477	0.924469804	78	0.123265156	0.886153582
35	0.274705205	0.923181822	79	0.121704838	0.885546415
36	0.267074505	0.921926122	80	0.120183527	0.884946415
37	0.259856275	0.920701107	81	0.11869978	0.884353414
38	0.253017952	0.919505294	82	0.117252222	0.883767248
39	0.246530312	0.918337307	83	0.115839544	0.883187761
40	0.240367054	0.917195867	84	0.114460502	0.882614802
41	0.234504443	0.916079779	85	0.113113908	0.882048224
42	0.228921004	0.914987928	86	0.11179863	0.881487886
43	0.22359726	0.913919275	87	0.110513588	0.880933651
44	0.218515504	0.912872841	88	0.109257752	0.880385386
			89	0.108030137	0.879842964
			90	0.106829802	0.879306261

SRC COMMENTS ON AUGUST 2008 FATALITY MONITORING REPORT, M21

2 September 2008

Alameda County Scientific Review Committee

The Altamont Pass Avian Monitoring Team recently produced a draft monitoring report of fatalities and utilization rates in the Altamont Pass Wind Resource Area (APWRA). The Scientific Review Committee (SRC) reviewed the report and discussed its comments with the Monitoring Team during a conference call on 14 August 2008. Because the Monitoring Team expressed reluctance to immediately revise the report according to the SRC's comments, the SRC agreed to submit this statement of concerns to Alameda County. An overview of the SRC's concerns appears on this page, and detailed comments on the report appear in the following pages.

Whereas the SRC found multiple reasons to praise the Monitoring Team for its latest draft of M21, it also expressed frustration with the following patterns:

- Multiple SRC recommendations were not implemented;
- The Monitoring Team did not involve the SRC Subcommittee that had been formed to help the Monitoring Team develop the report so that it is consistent with SRC recommendations;
- Conclusions of mortality changes were presented with more certainty than the SRC felt was justified;
- Limitations of the data and methodology were not discussed.

The SRC is skeptical of the mortality estimates and changes in mortality estimates between the baseline and current monitoring programs. The major methodological reasons for the SRC's skepticism are the following:

- The Monitoring Team used the midpoint value in ranges of estimated days since death of bird carcasses, but these ranges were large in most cases (0-90 days, 31-90 days, etc.) and the implied error was not carried through the calculation of mortality;
- The Monitoring Team excluded 36% of the fatality records gathered in the baseline effort, but excluded only 17% of the records from the more recent effort, thus possibly biasing mortality higher in the more recent effort;
- The Monitoring Team excluded fatalities that occurred prior to the first fatality search at each wind turbine, thereby using only one search per turbine at 2,548 turbines when estimating baseline mortality;

- The analysis and presentation of the bird utilization data were confusing, and possibly biased due to the metric consisting of the number of minutes of activity rather than an index of the number of birds observed during point counts;

- The report is unclear in its definition of different metrics, such as mortality and fatality rates; and,

- Comparing fatality rates that were estimated by month produced potential monthly biases because different subsets of wind turbines were surveyed each month, so one portion of the APWRA might have been represented one month, and another portion of the APWRA was represented the next month (The SRC had recommended that the minimum time unit be season, but if the Monitoring Team was to use month anyway, then the SRC recommended a moving average to help smooth over the month-to-month differences in turbines searched).

The SRC recommends that the Monitoring Team revise M-21. If M-21 is not revised, then the SRC recommends that these comments in P-107 accompany M-21 as an attached document.

Smallwood Review of Monitoring Team Report of July 2008 (M21)

12 August 2008

I appreciate the monitoring team producing the report, though I think it should have been delayed longer. I think the data base needed more work and discrepancies between the monitoring team's report and my reports should have been examined carefully. I think more of the SRC's recommendations should have been followed. Also, I cannot accept certain methodological changes to the estimation of mortality, though their use did demonstrate a general robustness of the mortality estimates. Anyhow, I hope my comments are taken in the spirit of constructive scientific review, and I hope there is an opportunity to revise the report.

Page Para. Line

2-3 1 8

Smallwood and Thelander (2004) is an inappropriate reference here, since they neither recommended a winter shutdown or relocations of Tier 1, 2, or 3 turbines. Also, it should be clarified that Smallwood and Spiegel (2005a,b,c) recommend a 4-month shutdown, not a 2month shutdown.

Also, the paragraph addresses the settlement agreement, but says nothing about non-settling companies and their permit conditions.

2-3 2

The monitoring process was established a year and a half before the settlement agreement. This summary could be more accurate on the history of the permit conditions and the goals and objectives of the Avian Protection Program.

3-3 2 last

Probably a better citation would be of Smallwood and Thelander (2008), since it was more recent and went through peer review at a scientific journal.

3-4 1

I found the description of the point count methods a little confusing. I realize the protocol changed at least once, if not more than once, while the SRC and monitoring team deliberated this method over the past two years. Maybe this is why I'm confused by this description. The problem is that point counts typically do not involve on-the-minute recordings of bird observations. Instead, they count all the birds seen during the time period of the point count. If the point count was limited to on-the-minute observations, then all the birds that were detected between the on-the-minute recordings would not be recorded. Perhaps the monitoring team is performing point counts in the traditional manner now, but used the on-the-minute observations over the last two years to be comparable? Maybe a little clarification is needed here.

3-4 2

The third bullet is a little misleading. The search area was smaller than 125 m.

3-7 3

Why did the monitoring team use a different protocol for including/excluding fatality records found during initial surveys? The methods state that the protocol differed, but no reason for the difference was given. Does the monitoring team realize what this protocol means for the 2,548 wind turbines that were searched only twice during the Smallwood and Thelander study? Their standard leaves only one search per each of these turbines. In my opinion, this protocol makes unsuitable any APWRA-wide comparison between the baseline and recent monitoring data, unless the monitoring team omits the Set 2 turbines. Basing mortality estimates on one search is unacceptable.

3-8 Fig. 6

This figure does not inform the reader how many carcasses were backdated 0-90 days, 31-90 days and so on. I think the reader needs to know this, because most of the records were assigned large ranges of days since death. Also, these estimates are later used to estimate mortality, which I think is another fatal flaw of the report.

3-10 1

I disagree with the method of using estimates of days since death of carcasses as the adjustment term for estimating mortality. I think this is a fatal flaw of this report. The data are unsuitable for this purpose, consisting of large ranges of days since death. They were also categorically applied, leading to potential biases in estimates of days since death. I found, for example, that a disproportionate number of eagles were estimated to have died within 3 days of the search, whereas a disproportionate number of burrowing owls were estimated to have died 0-90 days since the search.

When I first heard of this method, it interested me and I thought there was some merit in investigating it. However, after reviewing the monitoring team's data, I realized that the estimates of days since death were usually very large ranges, and were unsuitable for this approach. I produced two reports (P-101 and P-97) warning that such an approach would not be appropriate.

Whereas the monitoring team routinely estimated days since death in ranges of values – usually large ranges – many of the "baseline" fatalities were reported as point values, without ranges. The method of reporting days since death shifted between studies, largely due to differences in opinions between the search crews. I'm concerned about a serious bias in this comparison.

Furthermore, it looks to me as though the error terms associated with scavenger removal and searcher detection rates were not carried through the calculations of mortality, such as by using the Delta Method. Why not? How did the monitoring team handle the large error in the estimates of days since death? It looks to me like the team ignored this error, but I don't see how anyone could ignore error on the order of 0-90 days since death.

The methods of Smallwood (2007) and Smallwood and Thelander (2008) were peer-reviewed at the world's leading scientific journal on wildlife biology, so I'm wondering why the monitoring team abandoned use of the average search interval and in its place adopted an approach for which the data are unsuitable. I had worked out a tool-kit, so to speak, for using average search interval, which also allowed me to largely ignore the error around estimates of days since death, because days since death were not directly used to make the mortality estimates. On the other hand, the monitoring team used these shaky estimates of days since death and didn't appear to develop any means for handling the error in the estimates. I think the new approach was a good idea, but turned out to be inappropriate because the data were unsuitable for it.

3-10 last

Also, the estimation of mortality by month was inconsistent with the standing SRC recommendation (see meeting notes from February 2008), asking that the minimum units be mortality per string and per *season*.

3-12 2

The comparison of relative abundance is actually of relative activity level. Relative abundance, as usually quantified in point counts, would be of the average number of individuals detected, and not the average number of minutes the birds were observed. A perched bird would be assigned a value of 10 for 10 minutes of perching during a 10-minute point count, even though it was one bird, so one can get a 10-fold swing in "relative abundance" per record, depending on whether the number of minutes or the counts of individuals are compared. Another significant problem with this approach is that perching behavior could vary seasonally, so one could get a lot of values of 10 for golden eagle during one season and only values of 1 during another season when it really might be the same eagles perching during seasons of slower wind and flying by fleetingly during seasons of strong winds. So during one season you could have a lot of eagle presence due to perching when in fact it's the same eagles expressing different behaviors. I think the monitoring team needs to compare the average number of birds, as I recall suggesting in our last in-person meeting.

Methods Section

Nowhere in the Methods section were statistical tests described. This was an important omission because I couldn't understand the test results that appeared in the Results section.

4-1 1 6

Why was the capacity of the core turbine capacity only 50 MW? I had it at 82.63 MW (see P-76).

4-1 1 7

The baseline study involved 418.255 MW of capacity, not 396 MW. How did the monitoring team come up with 296 MW? Check Smallwood and Thelander (2004, 2008).

4-2 Table 1

The data I received from the monitoring team indicated the capacity of the regularly searched turbines other than Diablo Winds totaled 285.34 MW, but Table 1 identified 273 MW as the capacity. Why the difference?

Also, how did the monitoring team handle data from the turbines on property held by East Bay Regional Parks District? How was Buena Vista dealt with?

4-2 Fig. 8

How does MW searched per month help the reader understand the mortality estimates? Speaking for myself, I don't see the point of listing these values in a table.

4-3 Table 2

The monitoring team excluded 36% of the fatality records gathered in the baseline effort, but excluded only 17% of the records from the more recent effort. One reason for this disparity in records omissions was a difference in the number of "complete records." I'm not sure what this means. I should have asked what this means in the last in-person SRC meeting, when it was presented in outline form. My worry is that this omission standard was arbitrary and second-guesses the professional judgment exercised by the author of the baseline mortality estimates (OK, that would be me). Furthermore, I worry that this disparity in omission rates resulted in erroneous conclusions that mortality increased for some species. Furthermore, these omission rates are high – higher than I used, and I wonder whether they are appropriate. I cannot imagine tossing out more than a third of the fatality records we bothered to collect from 1998 to 2003.

4-4 Table 4

Does this table include all fatalities found, or only those that were passed by the monitoring team's filters? I ask because Table 4 states that only 26 golden eagles were found in the baseline study, but I recall 54 golden eagles were found. Maybe the table needs clarification.

4-5 Table 4

Why was red-tailed hawk "continued?" Counts of red-tailed hawk and golden eagle appeared twice in the table. Also, red-winged blackbirds are listed twice, once as a non-raptor and once as a raptor. Table 4 needs to be cleaned up.

4-6 1

The report states, "However, for all four target species, study period was a poor predictor of monthly fatality rates (R2<0.10 all cases)." What is this R^2 value based on? What test? What is the "period?" If it is regression, isn't the notation wrong? And how could a regression be performed on two data points? I just don't get it.

4-6 2

The results reported by the monitoring team differ from mine using the same comparisons of time periods and turbines (see P-76), but the monitoring team's capacity figures don't compare to mine, and neither do their fatality record omissions and handling of scavenger removal.

4-6 2 last

Again, what are these R^2 values referring to, and what is "study period?"

4-7 1

According to the report, some of the differences in mortality between Diablo and non-Diablo turbines were due to turbine type, and there's an R^2 and P-value associated with this conclusion. All the turbines in the Diablo group are of a different model than all the turbines in the comparison group, so I guess I don't understand why the monitoring team feels it was necessary to point out that some of the variance was explained by turbine type. Am I missing something here?

4-7 1 last

The monitoring team reported that no golden eagles were killed by Diablo winds, which highlights a problem I have with their data omission standards. According to the data supplied to me by the monitoring team, Diablo Winds killed a golden eagle on about 27 August 2006, which was two months before the eagle was found by the monitoring team near a wind turbine. The carcass was complete and met all the inclusion standards (as far as I could tell) except the one that dumped all records estimated to have been caused prior to the comparison period. My method would have included this eagle, and I think it should have been included. What is the point of performing fatality searches if one is going to omit the fatalities that are found?

The way I originally dealt with the fatalities estimated to have been killed within 90 days of the first search was to include the fatalities and add 90 days to the monitoring period, so a 2 year period might become a 2.25 year period. Later, I used the average search interval for the particular group of turbines as my standard, so if a fatality was backdated before the first search, but within the average search interval, then I would include the record and I added one search interval to the monitoring period. I recall the SRC deliberating the first search problem, and it agreed that my general approach would be used. Again, the monitoring team's new approach also reduces the number of searches among Set 2 turbines in the baseline monitoring period to 1, which is unacceptable for estimating mortality. Using only 2 searches was bad enough (that would be my doing), but deriving mortality estimates from 1 survey won't work.

4-11 Fig. 9

Does this Figure depict numbers of minutes or numbers of birds?

4-12 Figs. 10 and 11

What became of using moving averages, as the SRC recommended?

4-12 Fig. 10b

There is no point in showing the reader this graph of a non-significant regression. It uses a lot of report space.

4-13 Fig. 11b

I would like to know what units are used in the figure. Are these minutes of activity or numbers of birds? If the former, I'd be cautious about drawing any conclusions from the relationship.

4-14 Fig. 12b

As I pointed out on July 8, this regression is inappropriate. It is dominated by one data point, the removal of which would kill the r^2 value. I think this test is over-reaching. I recommend that it be dropped.

4-15 Fig. 13b

Again, there is no point in showing the reader a graph of a non-significant regression.

5-1 1

According to the report, "Analysis of the Baseline and Current data revealed marked increases in the annual mortality rates and total fatalities of most target species and species groups examined, except the golden eagle, for which fatalities decreased by 35%. When the results of all target raptor species were combined, the mortality rate for the Current Study group increased 74% over Baseline." However, I am not convinced the report leads to these conclusions. I don't believe it was appropriate to adjust mortality by the estimates of days since death, and I see significant discrepancies in the numbers of fatalities and MW compared between the reporting by the monitoring team and by me (P-76). I do not believe the mortality of target species increased, let alone increased by 76%.

A-1 2 1

This fatality definition has been challenged by the SRC since the SRC first saw it. As late as 11 July 2007 the SRC provided written comments challenging this definition (also see P-39).

C-2

The source of these scavenger probabilities should probably be noted.

General comments

In February 2008 the SRC recommended that the monitoring team use seasonal moving averages, as the monitoring team had presented them in the February meeting. This report did not do that.

The SRC had recommended that caveats be provided on the limitations of the data. However, I did not see much discussion in this report on data limitations. I think that where a discussion of data limitations is most needed is on the use of estimates of days since death in estimating mortality. The implied uncertainty in the estimates of days since death was huge for most fatality records, so I'm surprised the monitoring team made no effort to discuss their use of these estimates.

The SRC had recommended that the monitoring team compare the number of birds seen during point counts, or relative abundance, to fatality data. However, the monitoring team compared minutes of activity, though I'm not sure this is what the monitoring team really did. If it was minutes of activity, that is not relative abundance or numbers of individuals, and it was not the type of unit one normally derives from point counts.

The SRC asked the monitoring team to estimate mortality separately for small, medium, and large turbines, because these classes of turbines were not all randomly selected by WEST, Inc. However, the monitoring team appears to have treated all turbines the same. Furthermore, there was no mention of how data from East Bay Regional Parks District were used. In my opinion, having analyzed those data, I don't think the monitoring team should have included those data in its mortality estimates. Also, there was no mention of Buena Vista or Northwind energy.

The SRC and monitoring team had agreed in February that an SRC subcommittee would work with the monitoring team to complete the report. The sub-committee was not asked by the monitoring team to help with this draft, other than many questions directed my way about data base issues. The sub-committee could have checked that the monitoring team was addressing the SRC's recommendations. I offered comments when I did hear about methodological changes, but I felt like my comments were not of interest to more than one member of the monitoring team. I feel that the SRC should have been informed of the monitoring team's intention to use estimates of days since death, because I feel that the experienced biologists on the SRC could have provided some useful feedback on this method.

Finally, I am concerned about the posting of the data used by the monitoring team. When I worked with the monitoring team on the data base in July, I found some significant problems with the data. I feel good about noticing these and helping the monitoring team to clean up the data set, but I have to admit that I doubt all the problems were fixed. The discrepancies in numbers of fatalities and numbers of MW compared also worry me about the posting of the data. I think the data should be examined more carefully before being posted.

Joanna Burger

COMMENTS ON THE MONITORING REPORT

OVERVIEW: I appreciate the time and consideration that went into this report. The subject is complicated by a number of issues, not the least of which is the changing mitigation measures, the difficulty of defining mortality rates in the absence of population data, and the problems of comparing present data to a baseline.

My overvall comments revolve around 4 issues:

1. The importance of clarifying at each point the data being presented, and if it is a rate, what the rate represents.
2. The importance of having sufficient discussion of the caveats to the data, methodology, analysis, and conclusions.
3. The importance of resolving the differences in final mortality estimates for the data as the Monitoring Team computed it and Shawn's methods.
4. The description, and indeed the execution, of the point count data is confusing, difficult to follow, and it should be clear exactly what was done, and why. There is a vast difference between ten birds and one bird seen for each of ten minutes.

MY SPECIFIC COMMENTS AND QUESTIONS

1. 1.1: I am concerned that the report is already a year old, and some people will miss that these data only went through September of last year (2007). This should be clarified.
2. 1.2 Rate should not be used, especially in the executive summary unless it is defined.
3. 1.2: I cannot agree with the statement as written "that the mortality rates of the four target species increased" You need to make clear if you mean each species separately, or all four together.
4. 2-3: I would have the beginning sentence refer to the actually mortality that is the target (e.g. 50%).
5. 2-3: Again, in the second paragraph, the dates of the current study, and of the baseline should be stated.
6. 3.-4 and table. There should be a little more explanation of the boxes.
7. 3.-7. Each method should be justified, including why different methods were used one time compared to another.
8. This method section: it should be clear that the study did not examine relative abundance, but use as measured by presence in each minute.
9. 4-11: Can there be some measure of variance on the graphs?
10. 4-12: again, can there be some measure of variance on avian use?
11. The above comment goes for many of the graphics. How did the variance change by study plot and by time within each month?
12. Discussion: This section needs some work in that there are many issues that need to be at least mentioned, and some of them discussed. It is rather surprising to have such an increase in mortality, given the mitigation measures, and some discussion of this in terms of both reality, measurement error, design error, and other considerations needs to be stated. At the least, there should be some discussion of the limited time of the study (it does not include the last year).

13. I would feel more comfortable with there being some discussion about the species differences, confidence of the team in the data, and what they mean in terms of monitoring and future work

Jim Estep

Altamont Pass Wind Resource Area Bird Fatality Study, July 2008
Comments – Estep (August 20, 2008)

Initial General Comment

Overall, the report is well-written with a very readable report structure and design. It is a significant improvement over the previous version.

Cover and Title Pages

Recommend changing the name of the report as follows to reflect its purpose and sequence in the monitoring process:

Altamont Pass Wind Resource Area Bird Fatality Study
Annual Report, Years 1 and 2
July 2008

Executive Summary

The first paragraph of the ES should also more clearly state the nature of this report and its sequence in the process by indicating that it is the annual progress report that summarizes data from Years 1 and 2 of the study.

I think it might also be a good idea to state up-front that the methods and results included in the document remain issues of discussion and concern by the SRC and that future progress reports will continue to reflect the results of these discussions and incorporate SRC recommendations.

Forth bullet: the term 'local abundance (bird use)' is a bit confusing. Abundance and use are two different things and this suggests that the terms are being used here interchangeably. Also, the bullet indicates that behaviors were analyzed. The results in the report do not present any data or discussion of bird behavior and the relationship to turbine-related mortality.

The conclusion statement might also be modified to reflect the interim nature of these conclusions and the ongoing debate regarding methods and analysis. The conclusion statement (i.e., "In conclusion, the study indicates…") may be overly definitive. Might modify with "the results to date suggest" or something along those lines.

I would also recommend including an additional paragraph at the end of the ES as well as in the Discussion that describes the limitations and/or ongoing discussion regarding study methods and data analysis.

Section 2. Introduction and Study Area

Page 2-1. First paragraph, last sentence.

I would briefly describe applicable laws and regulations (i.e., CESA, ESA, BGEPA, MBTA, Fish and Game Code) in order to provide a little context to the uninformed reader.

Page 3-3. 3.1.2 Baseline Study

Might expand this description to include the differences between the number of searches conducted between the current study and the CEC study. This may be a limitation of the comparative analysis that should be acknowledged.

Page 3-4. 3.2 Bird Use Monitoring

There is some confusion here about how 'abundance' is defined and its relationship with bird 'use'. The method that was used (1-minute intervals for 10 minutes) is a little different than a typical point count survey, which uses raw count data collected continuously over the survey period to estimate relative abundance.

There are variations, including some that are interval-based, used to establish time-of-detection and can then be used in a sort of capture-recapture model. But the terminology should be clarified and more detail provided for the data collection and analysis methods, including citations for the methods used.

As it currently reads, it appears that the way the 1-minute interval technique was used allows for multiple counting of the same bird, which might be useful in terms of evaluating use, but can create problems for relative abundance estimates. Generally, when attempting to calculate relative abundance through point count surveys, attempts are made to avoid multiple counting of the same bird.

Page 3-12. 3.4.6 Bird Mortality and Bird Use

So it would seem that the estimates derived from bird observations were based on bird use, not relative abundance. This might be interesting and useful, but the SRC was interested in investigating the relationship between changes in relative abundance over time and mortality.

Page 4-4. First paragraph

Given that approximately twice as many records were excluded from the baseline study vs. the current study, it seems like this should warrant additional explanation in terms of the specific reasons and any consequences in terms of potential limitations in interpreting the results.

Page 4-4. Table 4

Why are golden eagle and red-tailed hawk rows repeated in the table and referred to as 'continued'?

Page 4-11. 4.5 Bird Use

Same issue here as above. It's a little unclear what is actually being correlated. Its not relative abundance, but instead an estimate of bird use. I'm not sure what this is really telling us (the longer a red-tailed hawk remains in a given area, the greater likelihood for collision mortality?). I think the SRC was more interested in investigating correlations between the changes in seasonal abundance of different species in the APWRA and mortality.

Figure 9

I'm a little confused by Figure 9. The text above it describes it as "…average monthly number of target raptor species observed". January '06 shows about 270 red-tailed hawks recorded during point count surveys. Or at least I'm assuming this is the total number recorded for that month (and not the mean number of observations per 10 minute interval as the table suggests). If so, what's being averaged? How are these numbers derived using mean obs/10 min.? I'm sure it is explained easily, but I'm having difficulty seeing it.

Figures 10a – 13a

Why don't the monthly totals for the four target species in Figures 10a, 11a, 12a, and 13a match the monthly totals in Figure 9?

Also, while these figures are fairly self-explanatory, I would like to see some additional text explaining the relationships in each figure. Figure 12b in particular could use some explanation given it is a single outlier point that determines the relationship in this case.

Page 5-1. Discussion

Given that this is an interim annual report and the limitations in the analysis, I would limit the definitive statements regarding the mortality estimates (e.g., "These results clearly show that….).

The discussion section is very brief. Given the interim nature of this report, I don't have a problem that it is brief; however, it would seem that there are relevant issues to discuss at this point, particularly since the results suggest a fairly dramatic increase in mortality. I would also include a discussion that describes the limitations of the analysis and describes the changes that will be implemented (e.g., QA/QC study) that might help to improve the analysis.

Review of the July 2008 Monitoring Report (M21)
By Julie Yee
August 18, 2008

Here are *Report Comments* based on my review of the Monitoring Report (M21) released July 2008. After the SRC discussed this report with the Monitoring Team during the conference call on August 14, 2008, I had further thoughts about some of the questions that were raised during the call. These include the use of midpoint for determining days dead, the reason for conducting detection trials (or not conducting as the case was in the early part of study), and the modeling approach for statistical inference. So, in addition to *Report Comments*, I have expanded on the *Midpoint*, *Detection*, and *Modeling* issues.

Report Comments

Page 1-2. Bottom of 1st paragraph. "This bias likely resulted in an underestimation of burrowing owl use and an inflation of the use/mortality correlation value." Avoid making this statement unless you also discuss this in the report. Also change "correlation" to "rate" if that is what was intended. Otherwise it makes no sense.

Page 1-5. The comparison with Diablo Wind turbines in Table ES 3 is interesting, but I'd like to see the potential confounders addressed or at least mentioned. For example, the two sets represent separate parts of the Altamont. Also, would bird strikes at the larger turbines tend to fall farther away from the turbine? A bias will occur if turbine-related fatalities are falling outside the search radius at a higher rate at Diablo turbines compared to other turbines.

Page 3-4. Bottom of 1st paragraph. Bird use monitoring was conducted during the Baseline Study, so the statement is misleading.

Page 3-5 (Figure 4) What happened to incidental finds (WRRS fatalities)?

Page 3-6 (Figure 5) I have trouble following this flow chart. Do the item numbers (i.e. Turbine Strikes 1a, 1b, 1c, 1d) correspond to anything meaningful for the reader? What is meant by "conflicting information"? What is meant by "Other turbine related cause" [decision flows to this box only when "Turbine related injuries" was No in the upper right box – this seems contradictory]?

Page 3-8 (Figure 6) Why are there two different back date ranges for certain carcass conditions (i.e. 0-3 or 4-7 days for fresh flesh, and 8-30 and 31-60 days for gooey flesh)?
I appreciate that there is some attempt to backdate the age of the fatality, and I trust the experienced biologists to have the knowledge to assign a reasonable range of days dead as well as to admit when the range cannot be reliably made more precise. I can accept a biological judgment that a carcass is 0-90 days dead. Where I get worried is when a precise date for days dead is assumed (i.e. such as a midpoint of 45 days) in place of the full range. Also, the midpoint assumption was never even stated in the report. The report needs to further explain the decision rules leading to the different ranges of backdates. Also, what midpoint was defined for

0-3 days, 4-7 days, and 0-7 days? As for the midpoint assumption, see *Midpoint* comment below.

Page 3-9. 2nd paragraph. There were no means or standard deviations for unadjusted fatalities are reported. Remove description if no longer current.

Page 3-9. equation. Put parentheses around "RxP" otherwise this expression "M/RxP" would conventionally be interpreted as (M/R)xP which is not correct.

Page 3-9. top of last paragraph. As a clarification, the SRC did not request to not conduct searcher detection trials. Some information on searcher detection rates was already available, and it was not a priority to conduct further study until this year. See *Detection* comment below.

Page 4-3. There is a striking difference in the proportion of records retained between Baseline (64%) and Current study (83%). Someone should examine the data to assess whether the excluded records followed any patterns that could contribute to biases. Perhaps the exclusion rules need to be revisited. Also, I would rather see these numbers tallied for the four focal species or separately by focal species, rather than all birds combined. (I would even suggest doing this before changing any of the exclusion rules).

Page 4-6. I'm not completely comfortable with this ANOVA. The nice thing about it is that it compares the two study periods in a straightforward manner. But this is an unweighted ANOVA, so all months are weighted equally despite the large variation in monthly effort. According to Figure 8, the effort ranged 2.4 – 106 MW/month during the Baseline, and 77 – 282 MW/month during the Current study. The low effort months are subject to higher variance and more outliers because of the decreased likelihood of finding a fatality; and when a fatality is found, the per MW rate spikes. The high effort months should be more stable and therefore arguably should have greater weight in determining the mean. However, if the monthly rates are weighted, then this could lead to disproportionate weights among seasons or years. If this is the case, then this could be a concern because of the potential bias associated with placing uneven weight on high vs low mortality seasons, or high vs low mortality years.
If there's going to be an ANOVA, then I at least request that the residuals be examined for gross violations of the ANOVA assumptions. The report need not contain a full residual analysis, but at least document whether the ANOVA assumptions appear satisfactory.
I would not discourage using the ANOVA (unless severe biases were discovered). But I would have more confidence if the data were analyzed by other models based on different assumptions, and the results showed robustness to the analysis approach. See *Modeling* comment below.

Pages 4-8 through 4-10. It would be valuable to have standard errors and confidence intervals on those final statistics on percent change (Tables 5-7).

Midpoint Issue

There was a lot of concern expressed during our Aug 14 conference call about the differences between Shawn Smallwood's estimates and the Monitoring Team's July 2008 estimates. This issue is complicated, but I contemplated all the differences (which boil down to three main features, below) and found I prefer a combination of aspects from both estimation approaches. By assessing a separate R_C correction for each fatality, the monitoring team appears to have followed part of my recommendations from my review of the February 2008 report (document P80, comment #4). I had recommended using the search interval that corresponded to the fatality on a case by case basis. For example, if a fatality was found following a 40-day search interval for that particular location, then adjust the fatality using R_C based on 40 days. I was not fond of applying a blanket correction based on 37-day or 44-day average search intervals, and I still am not.
There is another difference, in which the Monitoring Team applied their correction to individual unadjusted fatalities prior to summing the resulting adjusted fatalities, in contrast to Smallwood's approach in which he summed the unadjusted fatalities before applying the correction to get the adjusted total. When the intervals are equal, then the outcome of both calculations are identical [i.e. $\sum_i (X_i/R_c) = (\sum_i X_i)/R_c$], so this is a relatively minor difference compared to the issue of what to use for R_C.

Summary of differences between two approaches:

Smallwood approach, and MT Feb 2008 draft report	Monitoring Team July 2008 report
• Add fatalities, then adjust rate • Use average search interval • Intervals are either 37 or 44 days (see MT Feb 2008 report)	• Adjust first, then add adjusted rates • Use midpoint of range of days dead • Typical intervals include: 45 (when 0-90 or 31-60 days dead) 60 (when 31-90 days dead) 19 (when 8-30 days dead)

The MT used the same function for R_C as found in Smallwood (2007), where the only difference is that MT used "Days Dead" as their look-up value and Smallwood used "Time since last search (d)." The function was derived by Smallwood and works under the assumption that the fatality occurred between 0 to d days prior to its discovery, with equal likelihood it occurred on any day between 0 and d. For example, for a 37-day search interval, then implicit in Smallwood's method is that the Days Dead falls within the range of 0-37 days. So the notion of Days Dead is present in both approaches, although Smallwood does not call it that. The MT is doing nothing new by assuming a range of Days Dead. But the MT altered the procedure in two very significant ways. First, they have allowed some very short ranges and some very long ranges (i.e. 0-3 days and 31-90 days) to incorporate additional information on carcass condition (or lack thereof) and the possibility of searcher error; this could be a great enhancement to the procedure after developing consensus among biological experts on the range classification. The second change is: they took the midpoint of the range, presumably as an unbiased guess for the number of days the carcass was in the field. This is a problem because R_C works as a function of upper range, not a function of estimated actual days in field. So, for example, when a carcass was estimated to be 0-90 Days Dead and the MT set Days Dead = 45, then they got instead the correction for a carcass that is for 0-45 Days Dead. As another example, when the carcass is estimated to be 31-90 Days Dead, then the midpoint is 60 days and the correction is actually for 0-60 Days Dead.

I agree with different aspects of both Smallwood and MT approaches. I agree (with MT) with adjusting fatalities on a case-by-case basis, because different fatalities are associated with different ranges of plausible days since death. I disagree (with Smallwood) on the use of average search interval, but can accept using search interval in some way to determine the correction R_C. On the other hand, I realize that some fatalities can be older than the interval when the area was last searched, and can accept the classification of fatalities into intervals of up to 60 or 90 days. I disagree (with MT) on setting days dead to the midpoint of large intervals, and I believe this was a misuse of R_C. Smallwood's derivation of R_C makes it unnecessary to estimate Days Dead to the day.

Finally, referring to a comment made in the Aug 14 conference call, I agree (with MT) that further information about searcher detection and carcass removal processes could help inform a more appropriate way to determine an R_C type of adjustment.

Detection Issue

In the July in-person meeting, an audience member asked why there was 0% confidence in the current approach on correction factors (including detection), and I gave what I felt was an unsatisfying response by saying that the FPLE statistician Bill Warren-Hicks would not accept the current approach. Meanwhile, the MT stated in their report that the SRC had requested detection surveys not be done. I believe that the public and MT do not understand how the decision for the SRC to recommend detection studies at this late stage evolved, and I would like to set the record straight (speaking for myself).

At the time the SRC began meeting, the monitoring protocol was underway. One year of data had already been collected, and the only aspect of the survey that I felt the SRC had the influence to modify was the number of turbines. We discussed the issue of detection and scavenger errors at length, and whether or not it was even necessary to adjust raw fatality rates (i.e. why not compare average raw counts between the Baseline and Current studies?). There were two reasons I found most compelling for continuing to develop the adjustment rates. Firstly, the Settlement Agreement was focused on 50% reduction of estimated total mortality of the four focal species, so we could not simply look at raw fatality counts. Secondly, the different lengths of search intervals between the Baseline and Current study, combined with scavengers' effect on reducing raw fatalities, had strong potential to bias the comparison. We discussed detection error, but I viewed this as less of a source of bias than scavenger error, because there was no obvious reason to expect the detection error to be any less appropriate for the Current Study than it had been for the Baseline Study. If the detection errors were biased because they were produced from outside surveys, then they would be equally biased for both the Baseline and Current Study. If our goal was to compare apples to apples and look for 50% reduction in size, then there was no compelling reason to consider proposing an additional detection study.

When Bill Warren-Hicks criticized the current approach, he made two main arguments. The first argument was that the detection rate is dependent on the scavenger removal rate, and the two

rates cannot be estimated independently as they were in the current approach. I continue to disagree with this argument. We exchanged discussions on this for some time and could not get one another to budge from our respective views [While I agree that marginal probability of detection is dependent on the probability of scavenging, I also maintain that the estimator in question used for the correction factor is the conditional probability of detection, given the carcass is unscavenged, and that this estimator is not dependent on the probability of scavenging]. His second argument was that the scavenger removal and detection surveys were from outside studies and could not be reliably applied to the Altamont. Nobody disagreed, and there was no better way to resolve that issue than by developing the QA/QC study.
I continue to have reasonable confidence in the current approach, but it relies on assumptions that FPLE has challenged and which cannot be resolved without conducting the independent QA/QC survey in the Altamont. I believe the current approach is acceptable for purposes of comparing Baseline to Current Study, but I also believe that the Current Study with the QA/QC approach is a more ideal survey because it will enable a more reliable estimate of current rates of fatalities. This would be critical if the Current Study were to ever become the new baseline.

Modeling Issue

The analyses presented by the monitoring team so far are sample-based. In other words, they are statistically valid only because the turbine sites were randomly selected and evenly sampled each month across exactly two years. When the sampling is performed unevenly, then this introduces the possibility that certain parts of the year or certain parts of the Altamont are more heavily represented than others. The Current Study is less vulnerable to this than the Baseline Study, which had much more uneven sampling across space and time. This concerns me somewhat. I would prefer that the comparison be explored via model-based inference as well as sample-based. The advantage of a model-based inference is that it can be made more robust to differences in how the data were sampled, and can be used as a check on the sample-based analysis. I don't have a model proposal for the MT, but I did roughly outline some ideas in my last review (document P80, item #8).

Sue Orloff

Comments on the July 2008 Monitoring Report (M21)
By Sue Orloff, August 25, 2008

I have read over all the comments by other SRC members. Since many of my concerns have already been addressed by them, I will only cover those issues that have not.

Page 3-7 (3.3.1 second paragraph): The first two sentences appear to contradict each other. The first sentence says that the Baseline Study removed fatalities that preceded the start date. The second sentence says Smallwood and Thelander studies (which I believe is what you are calling the Baseline Study) allowed fatalities to be backdated before the start of surveys. I think I know what you are trying to say but it is very confusing. Please clarify in text.

Page 4-6 (4.4.1): Julie has already said she has problems with the ANOVA and I agree with her concerns. In addition, I would like to see how each separate year of the current study compares to baseline. So far the current study shows a big difference between 2006 and 2007 in abundance (use?) and mortality. But you should probably wait until the last three months of 2007 are added to the data set to complete the year.

Page 5-1 (5.0 first paragraph): In the sentence "*These results clearly shows that, to date, avian mortality has not been reduced* ..." – besides not using words like clearly shows as other SRC members have suggested, it might help to use the word decrease rather than reduce. Using the word reduce in this sentence suggests that the mitigation measures have not had any effect on mortality. But we really don't know that yet. Mortality could have been reduced by the mitigation measures but an increase in avian abundance since the baseline study could have resulted in increased mortality. We need to factor in abundance data first.

Lastly, in the new section on limitations of the data (which everyone has suggested you add to the report), please include a discussion on the large annual variability in abundance and mortality (as shown in the current study) and how this will affect the comparisons to baseline.