Bird Fatality Study at Altamont Pass Wind Resource Area October 2005 to September 2007

DRAFT REPORT

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Introduction

This report, submitted to the Scientific Review Committee (SRC) by the Monitoring Team (MT), describes the results of avian fatality monitoring of approximately 2500 wind turbines conducted at Altamont Pass Wind Resource Area (APWRA) between October 2005 and October 2007. We analyzed data from the first two years of this study to calculate average annual mortality rates and an APWRA-wide fatality estimate for all species as well as for four raptor species (golden eagle, red-tailed hawk, American kestrel, and burrowing owl) separately and combined. We then analyzed the results for inter-annual and seasonal variations. We derived these estimates using methods and criteria that make them comparable to baseline mortality estimates, provided by the SRC, that were derived from earlier studies (Smallwood and Thelander 2004).

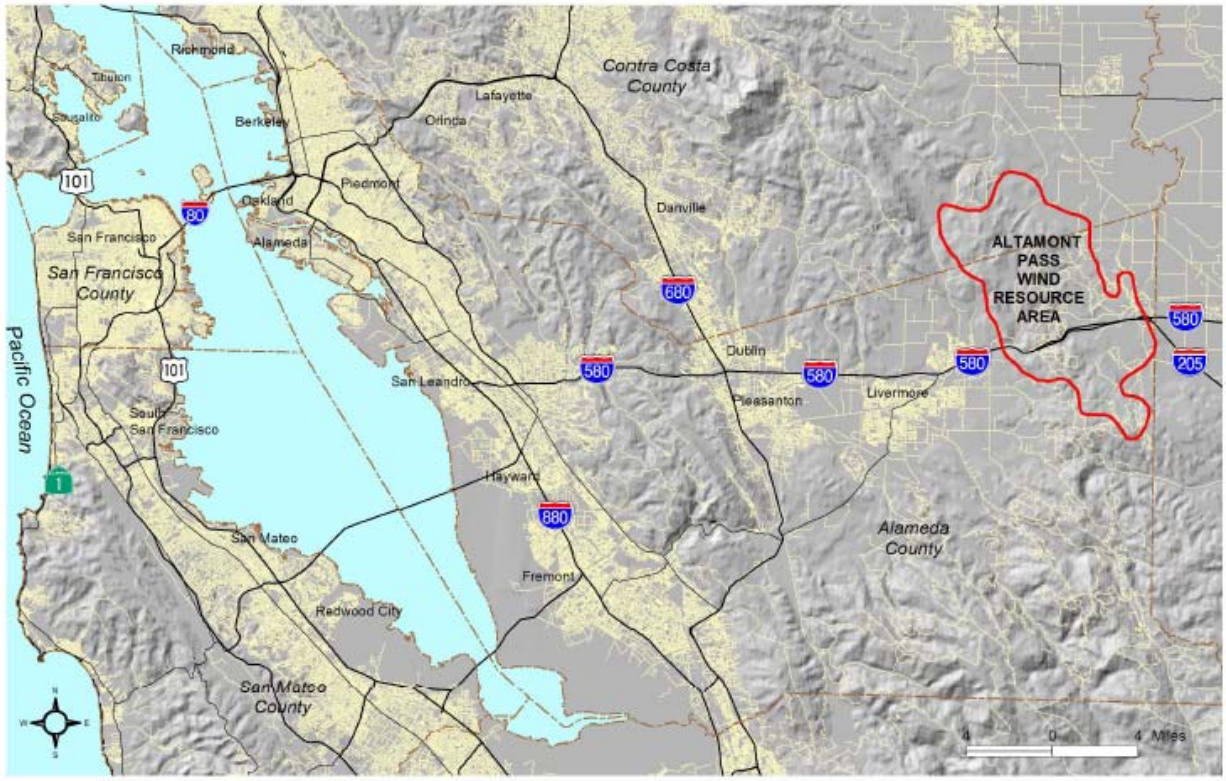
The APWRA supports a broad diversity of bird species, both resident and migratory, that regularly moves through wind turbine area (Orloff and Flannery 1996). Diurnal raptors (eagles and hawks), in particular, use the prevailing winds and updrafts for soaring and gliding during daily movement, foraging and migration. Birds passing through the rotor plane of operating wind turbines are often killed (Howell and DiDonato 1991, Orloff and Flannery 1996, Howell 1997, Smallwood and Thelander 2004). Multiple studies of the bird fatality rates at APWRA show golden eagles, red-tailed hawks, American kestrels, burrowing owls, barn owls and a diverse mix of other non-raptor species are killed each year (Howell and DiDonato 1991, Orloff and Flannery 1996, Howell 1997, Smallwood and Thelander 2004) in turbine-related incidents. Most of these species are protected by both federal and state wildlife legislation.

The current 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 high-impacted raptor species (golden eagle, red-tailed hawk, American kestrel, and burrowing owl) by 50% (of the baseline) by November 2009 through management actions including, but not limited to, a two month shut-down 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 criteria is based on the 2007 Settlement Agreement between the Wind Power Companies, Alameda County, Center for Biological Diversity, Californians for Renewable Energy, and Golden Gate Audubon Society. The management actions are outlined in Exhibit G-1 of the Settlement Agreement.

Study Area

The APWRA is located in central California approximately 56 miles (90 km) east of San Francisco (Figure 1). Permits have been granted for 5400 wind turbines, rated at ca. 580 MW capacity, within the APWRA, distributed over 150 km^2 (50,000 acres) of rolling grassland hills and valleys. The number of functional turbines varies over time due to breakdowns, maintenance shutdowns, seasonal/weather-related shutdowns, and removals for mitigation of avian mortality. The true number of turbines available for power generation during the high-wind season is likely somewhere between 4500-5000. Differential air temperatures between the warmer Central Valley east of Altamont Pass and the cooler marine air from San Francisco Bay cause steady 15 -30 mph (25-45 km/hr) winds to blow across the APWRA during the mid afternoon/evening periods between April and September. This high wind period is when 70-80% of the wind turbine power is generated at the APWRA. Winter wind speeds average 9 – 15 mph (15-25 km/hr).

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



Methods

Bird Fatality Monitoring

Survey Design

The numbers and diversity of turbine-related bird fatalities occurring within the APWRA were determined through bird carcass surveys conducted monthly at approximately 2,500 turbines from October 17, 2005 to September 30, 2007. The turbines surveyed comprised a subsample of approximately 4,500 turbines currently operating in the APWRA. The surveyed turbines were distributed in 84 randomly selected plots) stratified by geographic location (north and south monitoring areas) and turbine size (very small – 40-65 kW; small – 100-150 kW; medium ≥ 250 kW). Each plot included 10 to 60 turbines aligned in 1 to 7 turbine strings. Figure 2 also shows the number and distribution of operational turbines that were not surveyed during this study (approximately 2,000). The overall fatality rates for different species throughout the APWRA were estimated based on extrapolation of the results from the 2,500 turbines surveyed adjusted for searcher efficiency and scavenger carcass removal effects.

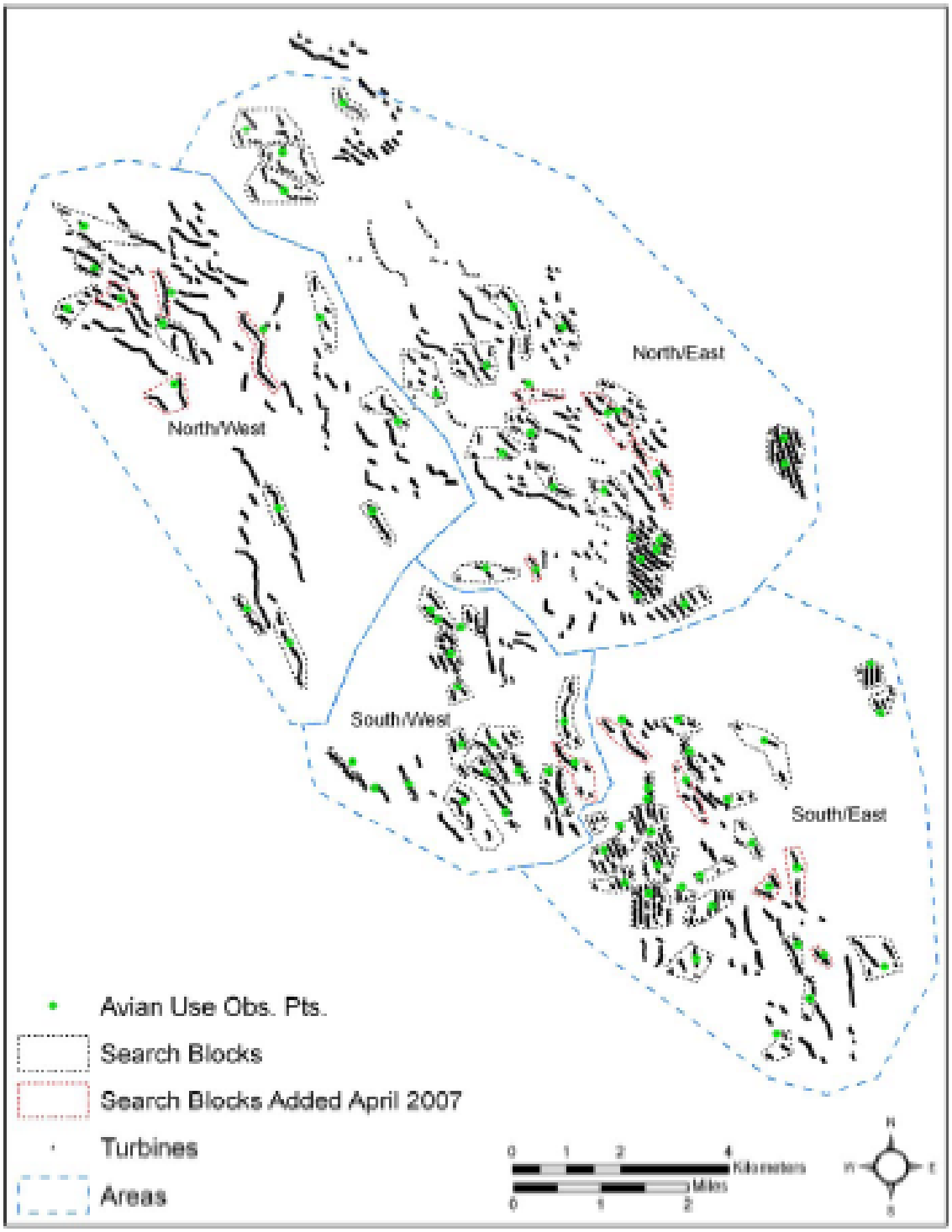


Figure 2. APWRA Bird Fatality Monitoring Locations

Field Survey Methods

The area around each of the 2,500 turbines was systematically searched for bird carcasses approximately once each month. Between October 2005 and March 2007 the average search interval for all turbines in the 291 plots was 44 ± 18.6 days. The average search interval from early April 2007 to October 2007 was 37 ± 4 days. When 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 determination of cause of death is provided in Appendix A.

Annual Mortality Estimate

Annual mortality estimates for this study, M_a, were determined using the following adjusted mortality estimator (Smallwood 2007):

$$M_a = \frac{M_u}{R \times p} \qquad \text{(Equation 1)}$$

Where M_u is the unadjusted mortality expressed as either the number of fatalities per wind turbine per year or the number of fatalities per megawatt (MW) of rated capacity per year, R is the proportion of carcasses remaining since the last fatality search and is estimated by scavenger removal trials, and p is the proportion of carcasses found by fatality searches during searcher detection trials.

Scavenger Carcass Removal Rate Estimate (R)

Scavenging trials were conducted by WEST three times at APWRA between fall 2005 and fall 2006 (WEST 2007). However, these trials included use of non-native species and/or carcasses of species that the SRC felt did not represent the type or condition of carcasses that would typically be found by scavengers in the search areas. Smallwood (2007) describes the inherent biases of these potential sources of error. For this study, estimates of scavenger carcass removal rates were determined from daily predictions of percentages of carcasses remaining since the last search as described by Smallwood (2007). Following an extensive review of the results of many published and unpublished scavenger removal trials, Smallwood determined that the predicted percentages of bird carcasses remaining each day into a scavenger removal trial could be described best using the following logarithmic model:

$$Rt = (a + b)\ln(t + 1) \qquad \text{(Equation 2)}$$

Where Rt is the percent of carcasses remaining on the *i* th day into the scavenger removal trial, and a and b are fitted parameters derived from fitting the logarithmic model to data gathered from reports of scavenger removal trials performed 1989-2006 throughout the United States. The cumulative carcasses remaining R_c, can then be determined using the following equation:

$$Rc = \frac{\sum_{i=1}^{I} Ri}{I \times 100}$$ (Equation 3)

Where Ri is the percent of carcasses remaining by the *i* th day following the initiation of the scavenger removal trial and I is the duration of the scavenger removal trial corresponding with the fatality search interval used during a mortality monitoring effort.

The mean fatality search intervals for this study were 44 days for the original 291 plots and 37 days for the additional 55 plots started at the end of March/early April, 2007. Based on the above model, the percent carcasses of the different sized birds remaining after 37 and 44 days (R) would be

Search Interval	Small Nonraptors	Large Nonraptors	Small Raptors	Large Raptors	Rock Doves
37 days	29%	53%	26%	92%	79%
44 days	25%	50%	22%	91%	76%

The scavenger removal rates (not R) for these search intervals and different sized birds would then be:

Search Interval	Small Nonraptors	Large Nonraptors	Small Raptors	Large Raptors	Rock Doves
37 days	71%	47%	74%	8%	21%
44 days	75%	50%	78%	9%	24%

In this study golden eagles and red-tailed hawks were considered large raptors; burrowing owls and American kestrels were considered small raptors.

Searcher Detection Efficiency (*p*)

Searcher detection efficiency trials were not conducted for this study. Instead, estimates of detection efficiencies determined in previous bird fatality studies at APWRA were used. Smallwood (2007) analyzed the searcher detection rates from Orloff and Flannery (1992), Johnson et al. (2002), Anderson et al. (2004, 2005) and a series of unpublished reports. Smallwood (2007) determined that the average searcher detection efficiency was 100% for large-bodied raptors, 80% for large nonraptor birds, 79% for medium sized raptors, 78% for medium- sized nonraptor birds, 74% for small raptors, and 51% for small nonraptor birds. Because many of the studies reviewed by Smallwood (2007) were conducted at APWRA, these estimates were used in this report as measures of searcher detection efficiency.

Data Quality Control

Not all of the fatality records compiled during this study were used in the final analyses. Records that provided information indicating that a bird death was not

turbine related (e.g. electrocution), occurred outside the designated survey area or survey period (October 2005 – Sept. 30 2007, when backdated) were excluded. Also, specimens that consisted of old bones (est. time of death >90 days) were excluded. Additionally, records that provided incomplete information the prevented avian group classification or distance to nearest turbine were excluded (some WRRS records).

Results

Bird Fatalities

Unadjusted Mortality Estimates

During the study period we documented 1,596 turbine-related avian fatalities including 7 bats (Table 1). Of these 633 (40%) were raptors, including red-tailed hawks (229), burrowing owls (150), barn owls (95), American kestrels (56), golden eagles (49) and great horned owls (20). Of the remaining 963 non-raptor turbine related fatalities, the majority (70%) were rock pigeons (300), western meadowlarks (194) and European starlings (183). Mourning doves (31), common ravens (23), Loggerhead shrikes (17) horned larks (16) blackbirds (Red-winged and Brewer's – 15 and 13 respectively), mallards (12) comprised and additional 20% of the non-raptor fatalities. These numbers include only those birds found within the survey area (approximately 55% of the number of permitted turbines at APWRA) during the 2 year study period and represent only a portion of the actual number of birds killed at APWRA during that time. Estimates of the total area-wide fatalities, based on mortality rates adjusted for both searcher efficiency and scavenger removal levels are presented below. Table 1 also presents calculated measures of the mean number of fatalities for each species per turbine string, the unit of measure in this analysis.

Table 1. Total recorded bird fatalities at APWRA between October 2005 and September 2007.

Raptors			Fatalities Per String	
Common name	Total Fatalities	No. Strings w/ Fatalities	Mean	Stdev
Red-tailed hawk	229	124	0.6877	1.0915
Burrowing owl	150	88	0.4505	0.9158
Barn owl	95	66	0.2853	0.7111
American Kestrel	56	45	0.1682	0.4676
Golden eagle	49	39	0.1471	0.4383
Great-horned owl	20	17	0.0601	0.2733
Turkey vulture	8	6	0.0240	0.2039
Unidentified buteo	8	8	0.0240	0.1534
Unidentified raptor	5	5	0.0150	0.1218
Ferruginous hawk	3	3	0.0090	0.0946
Northern harrier	3	3	0.0090	0.0946
Prairie falcon	3	3	0.0090	0.0946
Red-shouldered hawk	1	1	0.0030	0.0548
Swainson's hawk	1	1	0.0030	0.0548
Unidentified owl	1	1	0.0030	0.0548
White-tailed kite	1	1	0.0030	0.0548
Nonraptors			**Fatalities Per String**	
Common name	Total Fatalities	No. Strings w/ Fatalities	Mean	Stdev
Rock pigeon	300	96	0.9009	2.4908
Western meadowlark	194	121	0.5826	0.9678
European Starling	183	112	0.5495	0.9353
Mourning dove	31	24	0.0931	0.3727
Unidentified small bird	27	26	0.0811	0.2842
Common raven	23	19	0.0691	0.2976
Unidentified gull	21	18	0.0631	0.2887
Loggerhead shrike	17	16	0.0511	0.2462
Horned Lark	16	13	0.0480	0.2529
Red-winged blackbird	15	15	0.0450	0.2077
Unidentified blackbird	15	14	0.0450	0.2217
Brewer's blackbird	13	13	0.0390	0.1940
Unidentified medium bird	13	13	0.0390	0.1940
Mallard	12	10	0.0360	0.2165
Unidentified large bird	12	11	0.0360	0.2022
Unidentified passerine	10	10	0.0300	0.1709
American crow	7	6	0.0210	0.1633
Mountain bluebird	7	7	0.0210	0.1437
Unidentified dove	7	7	0.0210	0.1437

Cliff swallow	3	2	0.0090	0.1224
Unidentified bluebird	3	3	0.0090	0.0946
Hammond's flycatcher	2	2	0.0060	0.0774
Killdeer	2	2	0.0060	0.0774
Northern mockingbird	2	2	0.0060	0.0774
Pied-billed grebe	2	2	0.0060	0.0774
Rock wren	2	1	0.0060	0.1096
Unidentified duck	2	2	0.0060	0.0774
White-throated swift	2	2	0.0060	0.0774
Wild turkey	1	1	0.0060	0.1096
American pipit	1	1	0.0030	0.0548
Black-necked stilt	1	1	0.0030	0.0548
Brown-headed cowbird	1	1	0.0030	0.0548
California gull	1	1	0.0030	0.0548
Cockatiel	1	1	0.0030	0.0548
Great blue heron	1	1	0.0030	0.0548
Great egret	1	1	0.0030	0.0548
House Finch	1	1	0.0030	0.0548
House wren	1	1	0.0030	0.0548
Lincoln's sparrow	1	1	0.0030	0.0548
Northern Flicker	1	1	0.0030	0.0548
Sandhill crane	1	1	0.0030	0.0548
Say's phoebe	1	1	0.0030	0.0548
Swainson's thrush	1	1	0.0030	0.0548
Tree swallow	1	1	0.0030	0.0548
Unidentified puddle duck	1	1	0.0030	0.0548
Unidentified sparrow	1	1	0.0030	0.0548
western scrub-jay	1	1	0.0030	0.0548
Western tanager	1	1	0.0030	0.0548

Adjusted Mortality Estimates

Table 2 presents the adjusted annual per turbine mortality estimates for all birds found during the surveys. The mean adjusted mortality rate is used to estimate the total fatalities of each species that would likely occur during the year over the entire APWRA (approx. 4489 turbines). Upper and lower confidence interval values (95% and 80%) are also presented to illustrate the potential range of mortalities for each species. These estimates take into account the birds that are missed by surveyors or are removed by scavengers before the surveyors can find them. For small birds that experience relatively high scavenging rates, the adjusted area wide mortality estimates are generally significantly higher than the unadjusted levels (e.g., 1258 vs. 150 for burrowing owl and 442 vs. 56 for American kestrel). For the larger birds, which are seldom missed during surveys and are not as easily removed by scavengers, the differences between the two mortality estimates are less pronounced (e.g. 57 vs. 49 for golden eagle). It

should be noted however, that these estimates are subject to revision depending on the actual number of turbines actually in operation (4489 is an estimate based on the number of permits issued at APWRA in 2005), but not all turbines may be in place or operative. If fewer turbines are actually in operation, the estimated adjusted mortality values would decrease proportionally. These estimates are likely to be revised pending acquisition of more precise information from the power companies on the actual number of turbines that were operating during the study period, and review of the searcher efficiency and scavenger removal adjustment criteria by the SRC.

Table 2. Adjusted per turbine mortality estimates for all bird species recovered at APWRA during the study period between October 2005 and September 2007.

Raptors	**Adjusted Fatalities Per Turbine**		**Estimated APWRA Fatalities (for 4489 Turbines)**				
common name	**Mean**	**Stdev**	**Total**	**.95LCI**	**.95UCI**	**.80LCI**	**.80UCI**
Burrowing owl	0.28019	0.73729	1258	902	1613	1025	1490
American Kestrel	0.09848	0.56183	442	171	713	265	619
Red-tailed hawk	0.07295	0.14632	327	257	398	281	374
Barn owl	0.05722	0.18813	257	166	348	198	316
Golden eagle	0.01261	0.05127	57	32	81	40	73
Great-horned owl	0.00646	0.03857	29	10	48	17	41
Unidentified buteo	0.00373	0.03253	17	1	32	6	27
Turkey vulture	0.00235	0.02878	11	-3	24	1	20
Ferruginous hawk	0.00161	0.02002	7	-2	17	1	14
Unidentified raptor	0.00087	0.00775	4	0	8	1	6
Northern harrier	0.00082	0.00957	4	-1	8	1	7
Prairie falcon	0.00058	0.00656	3	-1	6	1	5
Swainson's hawk	0.00040	0.00737	2	-2	5	-1	4
Unidentified owl	0.00023	0.00418	1	-1	3	0	2
White-tailed kite	0.00017	0.00302	1	-1	2	0	2
Red-shouldered hawk	0.00015	0.00274	1	-1	2	0	2
Nonraptors	**Adjusted Fatalities Per Turbine**		**Estimated APWRA Fatalities (for 4489 Turbines)**				
common name	**Mean**	**Stdev**	**Total**	**.95LCI**	**.95UCI**	**.80LCI**	**.80UCI**
Western meadowlark	0.46359	1.09268	2081	1554	2608	1737	2426
European Starling	0.42947	1.01777	1928	1437	2419	1607	2249
Rock pigeon	0.18646	0.65680	837	520	1154	630	1044
Unidentified small bird	0.05457	0.23754	245	130	360	170	320
Horned Lark	0.04308	0.26617	193	65	322	109	277
Loggerhead shrike	0.04053	0.25255	182	60	304	102	262
Unidentified blackbird	0.03564	0.24167	160	43	276	84	236

Red-winged blackbird	0.02689	0.15539	121	46	196	72	170
Brewer's blackbird	0.02269	0.14812	102	30	173	55	149
Unidentified gull	0.02081	0.11048	93	40	147	59	128
Mourning dove	0.01884	0.08606	85	43	126	57	112
Unidentified passerine	0.01798	0.11838	81	24	138	43	118
Common raven	0.01696	0.11398	76	21	131	40	112
Mallard	0.01253	0.10427	56	6	107	23	89
Unidentified bluebird	0.01166	0.13195	52	-11	116	11	94
Unidentified medium bird	0.00956	0.07083	43	9	77	21	65
Unidentified large bird	0.00947	0.05819	43	14	71	24	61
Cliff swallow	0.00761	0.12441	34	-26	94	-5	73
Mountain bluebird	0.00546	0.04216	24	4	45	11	38
American crow	0.00531	0.04338	24	3	45	10	38
Rock wren	0.00471	0.08596	21	-20	63	-6	48
Hammond's flycatcher	0.00443	0.07220	20	-15	55	-3	43
Unidentified dove	0.00415	0.03516	19	2	36	8	30
Pied-billed grebe	0.00396	0.06653	18	-14	50	-3	39
Brown-headed cowbird	0.00393	0.07163	18	-17	52	-5	40
Great egret	0.00375	0.06850	17	-16	50	-5	38
House Finch	0.00338	0.06175	15	-15	45	-4	35
Northern mockingbird	0.00253	0.03444	11	-5	28	1	22
Say's phoebe	0.00203	0.03705	9	-9	27	-3	21
Black-necked stilt	0.00193	0.03513	9	-8	26	-2	20
Swainson's thrush	0.00174	0.03176	8	-7	23	-2	18
White-throated swift	0.00172	0.02319	8	-3	19	0	15
western scrub-jay	0.00142	0.02600	6	-6	19	-2	15
Killdeer	0.00136	0.01846	6	-3	15	0	12
Unidentified duck	0.00129	0.01681	6	-2	14	0	11
California gull	0.00125	0.02283	6	-5	17	-2	13
Northern Flicker	0.00121	0.02209	5	-5	16	-2	12
Unidentified sparrow	0.00107	0.01954	5	-5	14	-1	11
House wren	0.00085	0.01544	4	-4	11	-1	9
Sandhill crane	0.00075	0.01370	3	-3	10	-1	8
American pipit	0.00074	0.01343	3	-3	10	-1	8
Unidentified puddle duck	0.00064	0.01174	3	-3	9	-1	7
Cockatiel	0.00054	0.00979	2	-2	7	-1	5
Lincoln's sparrow	0.00051	0.00926	2	-2	7	-1	5
Western tanager	0.00045	0.00827	2	-2	6	-1	5
Tree swallow	0.00033	0.00597	1	-1	4	0	3
Wild turkey	0.00017	0.00319	1	-1	2	0	2
Great blue heron	0.00010	0.00176	0	0	1	0	1

Table 3 presents the adjusted annual mortality estimates (capacity rated MW/yr) for all birds found during the surveys. The estimated area-wide mortality levels are very similar to those presented in Table 2 (fatalities per turbine). However, in this analysis a base value of 580 MW/yr is used as the rated output capacity for the entire APWRA, pending a more accurate accounting of actual capacity during the study period. While this value is the best available metric, which allows for the many differences among the various turbine types, it is not a measure of power output, which is a closer measure of actual turbine operating time and blade speed, critical parameters needed to precisely determine the periods of operation and real-time levels of impact risk to birds. It is well documented that all the turbines at APWRA are not operating at full capacity all year due to seasonal differences in wind patterns, breakdowns, required down time for maintenance, etc. Accordingly, the actual output capacity of the APWRA is likely to be less, potentially significantly less, than the 580 MW/yr rated capacity. However, until more precise information on the actual MW output, or preferably actual power output of the turbines at APWRA are made available by the power companies, the full rated MW/yr capacity value is the only suitable measure on which to base area-wide bird mortality estimates.

Table 3. Adjusted MW/yr mortality estimates for all bird species recovered during the study period between October 2005 and September 2007.

Raptors	**Adjusted Fatalities Per MW/Yr**		**Estimated APWRA Fatalities (for 580 MW)**				
common name	**Mean**	**Stdev**	**Total**	**.95LCI**	**.95UCI**	**.80LCI**	**.80UCI**
Burrowing owl	2.26476	5.34608	1314	981	1647	1096	1531
American Kestrel	0.96190	5.58697	558	210	906	330	785
Red-tailed hawk	0.74252	1.65961	431	327	534	363	498
Barn owl	0.67350	2.48033	391	236	545	290	492
Golden eagle	0.12249	0.51534	71	39	103	50	92
Great-horned owl	0.06335	0.38584	37	13	61	21	52
Unidentified buteo	0.03771	0.32220	22	2	42	9	35
Turkey vulture	0.02238	0.28662	13	-5	31	1	25
Unidentified raptor	0.00953	0.08376	6	0	11	2	9
Northern harrier	0.00751	0.08617	4	-1	10	1	8
Prairie falcon	0.00583	0.06556	3	-1	7	1	6
Ferruginous hawk	0.00546	0.06225	3	-1	7	1	6
Swainson's hawk	0.00404	0.07374	2	-2	7	-1	5
White-tailed kite	0.00165	0.03016	1	-1	3	0	2
Unidentified owl	0.00069	0.01267	0	0	1	0	1
Red-shouldered hawk	0.00060	0.01095	0	0	1	0	1

Nonraptors	Adjusted Fatalities Per MW/Yr		Estimated APWRA Fatalities (for 580 MW)				
common name	Mean	Stdev	Total	.95LCI	.95UCI	.80LCI	.80UCI
European Starling	4.29540	9.99513	2491	1869	3114	2084	2898
Western meadowlark	3.88423	8.38185	2253	1731	2775	1911	2594
Rock pigeon	2.57377	9.99506	1493	870	2115	1086	1900
Unidentified small bird	0.58516	2.73438	339	169	510	228	451
Horned Lark	0.47450	2.93413	275	92	458	156	395
Unidentified blackbird	0.43602	3.30246	253	47	459	118	387
Loggerhead shrike	0.42513	2.59741	247	85	408	141	352
Brewer's blackbird	0.32433	2.20382	188	51	325	98	278
Red-winged blackbird	0.30984	1.80414	180	67	292	106	253
Mourning dove	0.20578	1.00265	119	57	182	79	160
Common raven	0.18216	1.38330	106	19	192	49	162
Unidentified passerine	0.15583	1.10552	90	22	159	45	135
Unidentified gull	0.15482	0.85789	90	36	143	55	125
Unidentified bluebird	0.14827	1.61615	86	-15	187	20	152
Mallard	0.13764	1.25852	80	1	158	29	131
Unidentified large bird	0.09269	0.64766	54	13	94	27	80
Unidentified medium bird	0.09195	0.68270	53	11	96	26	81
Rock wren	0.07247	1.32247	42	-40	124	-12	96
Mountain bluebird	0.06303	0.48224	37	7	67	17	56
Brown-headed cowbird	0.06039	1.10205	35	-34	104	-10	80
Great egret	0.05775	1.05384	33	-32	99	-9	76
American crow	0.05646	0.45352	33	4	61	14	51
Unidentified dove	0.04221	0.36750	24	2	47	10	39
Cliff swallow	0.03345	0.44194	19	-8	47	1	37
Northern mockingbird	0.02533	0.34440	15	-7	36	1	29
Say's phoebe	0.02030	0.37052	12	-11	35	-3	27
Swainson's thrush	0.01740	0.31759	10	-10	30	-3	23
Unidentified sparrow	0.01647	0.30056	10	-9	28	-3	22
Black-necked stilt	0.01604	0.29273	9	-9	28	-3	21
White-throated swift	0.01529	0.20214	9	-4	21	1	17
Killdeer	0.01359	0.18460	8	-4	19	0	15
Unidentified duck	0.01287	0.16812	7	-3	18	1	14
California gull	0.01251	0.22833	7	-7	21	-2	17
Sandhill crane	0.01155	0.21077	7	-6	20	-2	15
Hammond's flycatcher	0.01102	0.14248	6	-2	15	1	12
Northern Flicker	0.01009	0.18411	6	-6	17	-2	13
House wren	0.00846	0.15438	5	-5	15	-1	11
Cockatiel	0.00825	0.15055	5	-5	14	-1	11
American pipit	0.00736	0.13431	4	-4	13	-1	10
Pied-billed grebe	0.00682	0.10320	4	-2	10	0	8
Unidentified puddle duck	0.00644	0.11743	4	-4	11	-1	9
House Finch	0.00513	0.09357	3	-3	9	-1	7

Lincoln's sparrow	0.00508	0.09263	3	-3	9	-1	7
Tree swallow	0.00503	0.09184	3	-3	9	-1	7
Western tanager	0.00453	0.08265	3	-3	8	-1	6
western scrub-jay	0.00432	0.07879	3	-2	7	-1	6
Wild turkey	0.00175	0.03186	1	-1	3	0	2
Great blue heron	0.00148	0.02702	1	-1	3	0	2

Table 4 shows the seasonal pattern of fatalities for all raptors (incl. the 4 target raptor species) and non raptors over the 2 year study period. The most obvious result of this analysis is the marked increase in fatalities for all species and species groups during the second year. It is unknown at this time whether these results are simply stochastic and correlated with a proportional increase in local bird abundance (bird use data analysis results pending) or whether they are due to some as yet unknown turbine operation related causes. However, the results notably contrast with the hoped for reduction in bird fatalities at APWRA, particularly in light of the fact that half the turbines where systematically shut down to achieve that end during both winter periods .

Table 4. Seasonal Fatality Data for October 2005 to September 2007 at APWRA.

Species	Fall 2005	Winter 05/06	Spring 2006	Summer 2006	Total 05/06	Fall 2006	Winter 06/07	Spring 2007	Summer 2007	Total 06/07
Non Raptors	120	69	163	200	**552**	211	331	349	204	**1095**
All Raptors	78	38	115	104	**335**	95	196	248	166	**705**
RTHA	25	16	21	30	**92**	51	46	31	15	**143**
GOEA	2	1	8	6	**17**	6	6	7	14	**33**
BUOW	0	2	4	26	**32**	27	38	25	2	**92**
AMKE	0	2	2	13	**17**	7	12	6	11	**36**
4 Raptors	30	21	35	75	**161**	91	102	69	42	**304**
Bats				2	**2**	1	1	2		**4**
Unid. Bird						1		7	14	**22**
Total Birds & Bats	**198**	**107**	**278**	**306**	**889**	**307**	**528**	**599**	**370**	**1804**

Fall = Oct, Nov, Dec; **Winter**= Jan, Feb, Mar; **Spring** = April, May, June; **Summer** = July, Aug, Sept.

Discussion

The results of this study show an apparent continued trend of high bird fatalities, both raptors and non-raptors at APWRA. The number of annual fatalities does not appear to be decreasing despite implementation of specific conservations measures including the cross-over winter shutdown program, high risk turbine removal and blade-painting. Indeed, the number of fatalities across most species increased in 2006-2007 over the previous year. The reasons for this recent trend are not yet known, but could potentially be due to the effects of stochastic ecological events on local bird abundance and movement patterns. Only continued long-term monitoring at APWRA will provide the necessary data on bird population changes required for fully understanding the causation of bird fatalities at the site.

Within the scope of the present study, as noted in the results section, there are also a variety of problems associated with this study that may affect the precision and quality of the mortality rate and fatality estimates presented in this report, some of which we will try to deal with during the report revision.

First, there is a lack of an accurate metric by which to reliably measure mortality. Estimating fatalities per turbine or megawatt (MW) for the entire AWPRA is confounded by the extreme variability in the number of functional turbines and, consequently the rated capacity, year to year and season to season (or even daily) throughout the study. Some sites in the AWPRA have vastly different operation times when compared to other sites. As a case in point, the entire Santa Clara site was shutdown for a whole year between January 2006 and February 2007. Similarly, Enertech turbines are shutdown for the rainy season independent of mitigation winter shutdowns.

Without an accurate accounting of the number of functional turbines or capacity per month or quarter, we have had to employ a static number of turbines or MWs as a metric that does not truly represent variability or dynamics of power generation as it relates to avian mortality over time. A better and more precise estimate could be gained by employing power output (kilowatt hours) as the standard metric. The seasonal or annual variability in power output may be a major factor in the observed seasonal and annual variation in avian mortality. Calculating the number fatalities or mortality rate per KW hour will give a clearer and more precise picture of the true avian cost of power production as well as enable a more accurate cost/benefit analysis of the mitigation measures employed in the field. This revised analysis would provide the SRC with a more powerful and precise tool to maximize the effects of turbine removal or shutdown mitigation while minimizing the reduction in power production across the AWPRA.

Second, the implementation of the monitoring program during the early part of the study resulted in some gaps in fatality and bird use data collection and longer fatality search intervals than in the latter portion of the study. These anomalies may confound the analysis of the inter-annual and seasonal variability in avian mortality. Additionally, minor changes were made to the data collection sheets and a cause of death

protocol was instituted during the course of the study that may require conversion of the earlier data to maintain consistency.

Third, at the beginning of the study wind smiths removed all of the carcasses they found. They were documented and reported to the WRRS independent of the monitoring survey. This protocol was changed in 2006 after which all birds/bats found by wind technicians in monitored plots, with the exception of Golden Eagles, were marked and left in the field for the monitoring crews to find.

Fourth, there was a lack of randomization associated with the study design. For example all Enertech turbines are in monitored plots, as well as all of Enxco Patterson Pass site. We suggest boot strap analysis to mitigate this issue. Some sites (North Wind and Buena Vista) that were sampled in the Baseline study were not available (restricted) for selection in our plot randomization process. Because no plots were searched in these areas during this study fatality records from those sites will have to be excised from the Baseline mortality estimate to make it comparable to our estimates.

Lastly, we propose running a sensitivity analysis on the scavenger rate and other scaling factors that appear to have a large influence on our estimates for the revised report.

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Appendix A: Field Methods

Altamont Bird Fatality Field Survey Methods

Each of the 2,500 turbines was searched for bird carcasses approximately once each month. The overall average time between searches for all turbines in the original 291 plots was 44 ± 18.6 days. The average search interval for the additional 55 plots started at the end of March/early April 2007 was 37 ± 4 days. 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 are 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.

1. 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)

2. 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)

3. 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).

4. 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.

5. 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

6. 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 C)

B. Predation underlined:

- *Scavenged/predated* carcass of *non-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)	Unknown	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)	Unknown	Blade Strike
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

Glossary of Terms:

Rarely-predated species: eagles, large buteos, and great-horned owls.

Any other species: any bird or bat species other than non-predated species.

Intact: no evidence of scavenging or predation by vertebrates.

Scavenged/predated: carcass shows signs of being eaten by vertebrate scavengers or predators (i.e., feather spot, gnaw marks on bones or feathers, plucked feathers)

Active BUOW burrow: ground squirrel burrows with presence of whitewash and castings.

Threatened or Endangered Species. If a State or Federally Threatened or Endangered species was found (i.e., golden eagle), data was collected on the find and it was then flagged to mark its location. This information was then reported to the Livermore Operations office (925-245-5555) at the end of the day. The find was then collected and processed by a designated Florida Power and Light (FPL) employee. If a non-native species such as rock pigeon, European starling, or house sparrow was found, data on the fatality was collected, and the searchers removed and disposed of the carcass off-site. All other species were placed in separate specimen bags and labeled with the following information: incident number, site, turbine number, species, and date found, and then preserved in the Monitoring Team freezer at the field house. If the species found could not be identified in the field, the carcass was opportunistically taken by a TEAM member to the UCD Wildlife Museum to attempt identification. When the freezer was full, carcasses were taken to the U.S. Fish & Wildlife office in Sacramento for disposal. This was coordinated with Tara Happy, the biologist at FPL.

Electrocutions. All suspected electrocutions were fully documented in the field, marked with an orange pin flag and left in the field. These fatalities are also reported to Livermore Operations Office at the end of the day they were subsequently removed by an FPL employee.

Specimens found by Maintenance Personnel. Fatalities found by turbine field maintenance personnel within designated search areas were documented by Renee Culver, marked with black electrical tape on the legs, and left in place for Monitoring Team searchers to find. When these marked remains were found by

the searchers during their next survey period, all standard data was collected on it and it was documented like any other remains.

Injured Birds. If an injured bird or bat was found on site, the Operations Office was contacted immediately and a designated FPL employee took the bird to a local rehabilitation facility for treatment.

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

Bats. All bats found during the bird fatality surveys were also documented and recorded in the database.

Diablo Winds Fatality Searches. Mortality searches of each of the 31 turbines in the Diablo Winds monitoring area are conducted monthly using the APWRA Monitoring study protocol, with the exception of the search radius. Because the Diablo Winds turbines are much larger than all other turbines in the APWRA, the search radius for each turbine was extended out to 75 meters to ensure adequate coverage.