Fatality Rates in the Altamont Pass Wind Resource Area 1998-2009

K. Shawn Smallwood

6 January 2010

Abstract: I compared fatality rates between the baseline and current study periods, estimated annual fatalities, monthly fatalities, and examined the data for signs of mitigation effectiveness and differences between repowered and old-generation wind turbines and whether mean fatality rates relate to wind turbine size. I found that fatality rates were not reduced between the baseline and current study periods. APWRA-wide fatality rates were close to those estimated by Smallwood and Karas (2009). Although fatality rates over the current study generally confirmed that relatively hazardous turbines had been identified through rating systems, delays in turbine relocations/removals prevented measuring the effectiveness of removal measures that were required by permits and recommended by the SRC. Similarly, the ability to detect the effectiveness of winter shutdowns was limited because the shutdowns were too brief, inconsistent, and poorly monitored for the first two years. However, I found that mean fatality rates declined substantially with increasing turbine size for most species, though they increased for bats and for golden eagle. Repowering projects generally killed many fewer birds per MW per year than did the old-generation turbines. I also found that fatality rates varied considerably from year to year, and that monthly fatality rates closely corresponded with monthly utilization rates for golden eagle and red-tailed hawk. After more than 8 years of fatality monitoring and the past 4 years of opportunity to implement substantial mitigation measures, I feel that it is time to shut down the old-generation turbines until they are carefully repowered, where care is given to turbine siting, turbine operations, and formulation of additional mitigation measures.

The three year mitigation and assessment period of the Alameda County Avian Wildlife Protection Program (hereafter referred to as program) has ended. The program actually began on 22 September 2005, but the Scientific Review Committee (SRC) and the Avian Monitoring Team – two key elements of the program -- were not activated until a year after the Alameda County Board of Supervisors' Resolution which established the program. The start and end dates of the three year program now ending was established by a settlement agreement arrived at following the filing of a petition for writ of mandate under the California Environmental Quality Act (CEQA). The petitioners were Audubon Society and Californians for Renewable Energy (CARE), the action was the Alameda County Board of Supervisors' Resolution, and the Real Parties in Interest were the wind companies operating in Alameda County.

The primary goal of the program was to achieve a 50% reduction in raptor mortality caused by wind turbines in the Altamont Pass Wind Resource Area (APWRA). This goal was to be achieved by the wind companies implementing mitigation measures required by permit conditions established in the Board Resolution, including measures that were new or modified from the permit conditions as recommended by the SRC. The SRC's role was to work with the monitoring team and analyze data to ensure that the monitoring results are scientifically sound, and the SRC was to provide recommendations to the County throughout the program, as well as to provide confirmed determination of compliance with permit conditions and other duties.

Now that the three year program has ended and the fatality data have been processed, I felt that it is my responsibility as an SRC member to analyze the data and to make my determination of whether raptor fatality rates were reduced by 50% in the APWRA. I felt that my responsibility includes testing hypotheses that can inform my recommendations for next steps and that can help me evaluate the monitoring team's report (the latest draft of document M-21). My analysis does not involve utilization data from the current study, however, as these data have not yet been prepared for analysis. The mapped positions of bird observations were not digitized and the attribute data entered onto spreadsheets were error-laden and a key linking variable between two files was hopelessly corrupted. The utilization data are currently being processed but will not be ready for another few months. In this report, I related monthly fatality rates to monthly utilization rates measured only during the baseline period.

My first objective with this report was to present comparable fatality rate estimates between the baseline period of 1998-2002 and the current study of 2005-2009. My second objective was to test hypotheses that can inform my recommendations as an SRC member on next steps in the APWRA and my assessment of the avian monitoring team's new report, M-21. My specific objectives were to: (1) Compare estimates of fatality rates among all old-generation wind turbines in the APWRA between the baseline period and current study; (2) Compare fatality rates to assess the effectiveness of mitigation measures; (3) Compare fatality rates caused by old-generation turbines to those caused by repowered, modern turbines; and, (4) Test hypotheses relevant to recommending next steps in the APWRA to reduce fatality rates.

METHODS

In July 2009, Alameda County began posting fatality and utilization data collected by the Avian Monitoring Team, but the complexity of the data base required considerable data management and coordination between me and the monitoring team to understand the data and correct errors. Further complicating the situation, the monitoring team repeatedly posted revised tables of data, always without explanation of data fields or how and why the tables had been revised. Most of my questions about the data were answered by monitoring team members after I called or emailed them, but I'm sure that differences emerged between the data set used by the monitoring team and the one I used. By now these differences are relatively minor. Also, most of the assumptions I used in this analysis were debated and finally agreed upon by the Alameda County SRC and Avian Monitoring team.

Study Design

The baseline monitoring period extended from spring 1998 through spring 2003, but the last 6 months involved only two fatality searches. As the monitoring effort progressed from spring 1998, turbine rows were searched according to access granted by wind companies (Carl Thelander, pers. comm.). To the initial ca. 600 turbines, groups of turbines were added to the search rotations as wind companies granted increased access. Monitoring of some groups of turbines ceased for several months or permanently for reasons I do not understand. In the end, I identified three sets of turbines: Set 1 included 1,526 turbines selected by opportunity but were searched 1-4.5 years; Set 2 included 2,548 turbines selected systematically but were searched twice over 6 months; and, Set 3 included about 1,300 turbines that were not searched. Not all of the data collected during the baseline study were directly comparable to the current study and neither were they APWRA-wide in their representation. The most comparable group of turbines included 38 rows searched throughout the monitoring period and current study, and during the baseline period there were various other groups of turbine rows that were searched over smaller time periods, such as three years or two years. Comparisons from these groups were not APWRA-wide, but they can serve as useful indicators of fatality trends.

WEST, Inc. initially designed the current monitoring program, and the monitoring team later implemented modifications that were recommended by the SRC (Table 1). In the initial design, all very small turbines were selected for fatality searches, including all turbines rated 40 KW to 65 KW. All large old-generation turbines (except, inexplicably, for 2 KVS-33 turbines) were also selected for fatality searches, including all turbines rated 250 KW to 400 KW. All of the Vestas V-47 turbines in the Diablo Winds repowering project were searched. The Northwind turbines were excluded from the selection process because Northwind Energy refused to cooperate with the Alameda County Avian Wildlife Protection Program. The Buena Vista turbines (41.6 MW) were also excluded because by 2005 they were already removed in preparation for the Buena Vista repowering project. All of the 38 1-MW turbines in the repowered Buena Vista project were searched by Insignia Environmental since January 2008. The remaining 430.9 MW of old-generation wind turbines in the APWRA were divided into blocks of turbine rows, where the blocks included turbines of similar type and location. The pool of blocks was divided into north and south strata, divided by Old Altamont Pass Road and I-580. Blocks were selected randomly from each stratum, but when estimating fatality rates, I ignored the north-south stratification in the initial design. Fatality rates from the randomly selected turbine blocks were the only rates that required extrapolation to turbines that were not searched, extrapolating from 188.69 MW to 430.9 MW.

At Tres Vaqueros, all Howden turbines were searched beginning in late 2005 and early 2006, but East Bay Regional Park District (EBRPD) took over the searches of 42 of the turbines in June 2006 (Smallwood et al. 2009c). These turbines were on the Souza parcel, which EBRPD obtained title in 2005. The searches were modified from about monthly to about bimonthly and they continued through October 2007. The other Howden turbines at Tres Vaqueros were searched by the Avian Monitoring Team through fall 2009, but turbine operations had ceased after October 2008 so a year of searches was performed at some of the non-operating Howden turbines.

Monitoring gaps occurred amongst the Enertech turbines in the Altech turbine field during late winter each year, due to poor road conditions caused by rainfall. At the repowered Buena Vista project, the fatality search interval was monthly from January through August 2008, switching to bimonthly in September 2008.

Fatality searches

Field methods have been described in multiple reports (Smallwood and Thelander 2004, 2005; Smallwood et al. 2007; Smallwood an Thelander 2008; Smallwood and Karas 2009; Smallwood et al. 2009c; Smallwood et al. in press; Insignia Environmental 2009), so I did not describe them again here.

Estimation and comparison of fatality rates

Fatality rate estimates were based on recorded fatalities determined to have been possibly, probably, or certainly caused by wind turbines, time since death was estimated to have occurred within 90 days of discovery, discovery was within 125 m of a turbine, they were of birds capable of flying (i.e., not a nestling), and they were certainly not counted twice due to body parts that were scattered from the same bird or left behind after being recorded during an earlier fatality search. The fatalities I included were tallied by species per row of turbines, so fatality rates were first calculated by turbine row and then averaged among the rows in the sample group. Fatality rates were represented as means and standard errors among wind turbine rows and only over time periods without gaps of ≥4 month. Excising the gaps between monitoring periods stabilized the mean search intervals and eliminated the need to exclude turbine rows from fatality rate estimates due to being searched for less than a year. All isolated search dates, i.e., those separated from contiguous searches, were excluded from fatality rate estimation.

I calculated fatality rates as weighted means at turbine rows where search intervals differed substantially between series of searches, such as between monthly and bimonthly searches. I adjusted fatality rates for fatalities not found due to scavenger removal and searcher detection errors. For these adjustments I relied on a synthesis of scavenger removal rates and searcher detection rates performed all over the US (Smallwood 2007). I also relied on scavenger removal rates estimated by EBRPD in Vasco Caves Regional Preserve during the 2006-2007 CEC-funded study (Smallwood et al. 2009b, in press). I carried the error terms from the adjustments by using the Delta Method (Goodman 1960).

I would have used the scavenger removal rates from the special 48-hour search intervals directed toward American kestrels and burrowing owls (KB study), but the processing of these data appeared to be unsettled by the time I prepared this report. The monitoring team informed the SRC that data had been re-evaluated and changed in late November and early December (SRC conference call of 3 Dec 2009). The monitoring team agreed to send me the revised data and to post scans of the original data sheets onto the SRC web site, but I did not receive the data and the scanned data sheets were not posted. I could not use the data from the 48-hour search interval study at this time.

To compare fatality rates between the baseline and current study periods, I did not attempt to adjust the rated capacity of operating turbines in the denominator of the fatality rate metric. Making such adjustments would have required accurate data on wind turbine operations, which were not available. The SRC repeatedly recommended that operating data be made available, and I made requests for operating data during the baseline study (Smallwood and Thelander 2004), but the data were not provided. I understand that the Avian Monitoring Team recorded data on turbine status based on the outward appearance of wind turbines over the past four years, but I have not seen those data so I cannot use them. I also understand that the wind companies provided the Avian Monitoring Team with tallies of rated capacity over the past decade. However, after examining these data, I found them to be discrepant from rated capacity data the same companies provided the California Energy Commission, and the discrepancy has increased through time (Figure 1). The SRC recommended fatality rates not be extrapolated to the capacity data that the companies provided the Avian Monitoring Team unless the companies either explain the discrepancy or provide a written assurance to the Avian Monitoring Team and SRC that the data they provided the Monitoring Team are accurate. I have not been given an explanation, nor have I received a written assurance that the companies' data were more accurate than the capacity data they provided the CEC. Therefore, I will not extrapolate fatality rate estimates to the tallies of rated capacities provided by the companies.

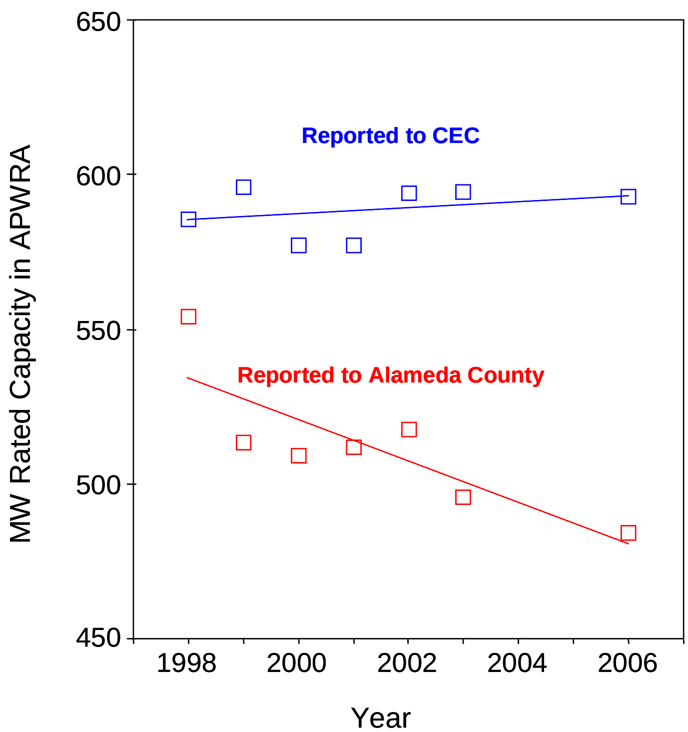


Figure 1. Discrepancies between the APWRA rated capacity data that the wind companies provided to the monitoring team versus those data they provided to the California Energy Commission (Yen et al. 2001; Yen-Nakafuji et al. 2002, 2005, 2006; unpubl. data from CEC).

Instead, I related the number of fatalities to the MW of rated capacity that was originally recorded as each wind turbine row was added to the search rotations of the baseline and current study periods. For example, if 10 100-KW turbines were operational in row A when fatality searches began there in May 1998, then the rated capacity was 1 MW (10 times 100KW = 1 MW). I related the number of fatalities found at row A to 1 MW per year, even if half or all of the turbines had been removed sometime after fatality searches began, or if turbine operations ceased in row A. In this way, any effects of mitigation measures should have been detectable because any changes in fatalities would have been related to a constant rated capacity in the metric's denominator. Resulting fatality rates were then multiplied by the total rated capacity from which the sample was drawn. This approach gets around the problem of extrapolating fatality rates to total rated capacity values that are potentially incorrect or disputed.

For estimating monthly fatality rates, I used the same carcass inclusion rules as described previously, but my calculation of these rates differed from the conventional calculation in two ways. First, I adjusted the fatality counts for scavenger removal and searcher detection rates prior to rather than following the calculation of fatality rates per turbine row. Also, the number of years as a denominator in the fatality rate metric differed. Rather than expressing years as the time span from start to finish of contiguous, periodic fatality searches, I expressed years as the number of times a particular month (e.g., April or September) was covered by the fatality searches. All 12 months would have been covered 4 times for most turbine rows during the current study, Nov 2005 through Oct 2009, though fewer times for those rows added to the search rotation in spring 2007. This approach relied on backdating of carcasses to the time the monitoring team estimated the bird had died.

Baseline Set 2 turbines.--The most important problem with the comparison of fatality rates at mutually surveyed turbines between the baseline and current study periods was the geographic limitations of mutually surveyed turbines. These turbines were located mostly in the central and eastern aspects of the APWRA, and some were in the south. APWRA-wide extrapolations of fatality rates from these turbines will not be entirely satisfactory, in some part due to the geographic clustering of certain turbine models. For this reason, I was still interested in comparing fatality rates among baseline Set 2 turbines. These turbines were searched only twice in 2002-2003 with a search interval of about 90 days, but they numbered 2,548 and occurred throughout the APWRA, encompassing the entire north-south and east-west extents of the APWRA.

However, whereas I previously estimated fatality rates at Set 2 turbines as the number of fatalities/MW/year (Smallwood and Thelander 2004, 2008), I was reluctant to do so again. To compare the fatalities found at these turbines, I calculated a different fatality metric – the number of fatalities/MW/search, where in the denominator of the fatality rate the number of years in the monitoring program was simply replaced by the number of searches. To more directly compare fatality searches in the current monitoring program to the two searches of the baseline monitoring program, I selected the searches at the corresponding turbine strings and on the nearest date to the date of each search during the baseline period. For example, if turbine string 308 was searched on 20 November 2002 and on 25 February 2003, then for the year 2005-2006 of the current program I would have selected for comparison 10 November 2005 and 15 March 2006 if these dates were the closest dates to those when the searches happened during the baseline. For string 308, I would have picked the closest dates to the baseline again, perhaps 1 December 2006 and 20 February 2007 if those were the closest dates. Some strings were not added to the current monitoring program until spring 2007, so these would have been represented by only five comparable fatality searches in the current program (1 in spring 2007, 2 in 2007-2008, and 2 in 2008-2009) instead of the eight for the rest of the turbine strings. The fatality rates expressed as fatalities/MW/search were not adjusted for searcher detection error and scavenger removal rates.

RESULTS

Comparison of baseline to current study fatality rates

Among the 911 wind turbines mutually searched by fatality monitors in both the baseline and current study periods, the fatality rate of target raptors as a group was greater during the current study (Tables 2 and 3). The fatality rate of burrowing owls was also greater during the current study, but those of golden eagles, red-tailed hawks, and American kestrels did not change significantly (Tables 2 and 3). The fatality rate of all birds as a group also increased during the current study, but the fatality rate of al bats as a group did not change significantly (Tables 2 and 3).

Among the turbines that were searched only twice during the baseline period, the fatality rate (fatalities/MW/search) of target raptors as a group increased about 6-fold, and also increased 3-fold for all birds as a group (Table 4). Fatality rates increased about 20-fold for burrowing owls, nearly 6-fold for American kestrels, and 6-fold for red-tailed hawks (Table 4). The mean fatality rate for golden eagles was more than 3-fold greater in the current program compared to the baseline, but the change was not significant (Table 4).

Fatalities per MW per year

Fatality rates mostly decreased with increasing turbine size in the sampled groups of turbines, including for red-tailed hawk, American kestrel, and burrowing owl (Tables 5 and 6, Figure 2). The exceptions were golden eagle fatality rates, which showed no trend with turbine size, and bat fatality rates, which increased with the increased turbine sizes in repowered projects (Figure 2).

The relationships suggested in Figure 2 prompted me to relate fatality rates to the sizes of each wind turbine model in the APWRA (Figure 3). Mean fatality rates of all birds as a group declined as an inverse power function with increasing turbine size (Figure 3). At this resolution, bat fatality rates increased with increasing turbine size not just of the repowered turbines, but also with increasing size of the old-generation turbines (Figure 3). Also, golden eagle fatality rates increased with increasing turbine size over two size ranges of turbines, first with turbines ranging in size from 40 KW to 200 KW, and then again with turbines ranging in size from 330 KW to 1 MW (Figure 3).

Monthly fatality rates.—Over the past decade and among all wind turbines monitored, fatality rates of golden eagle increased steadily through spring and summer and declined in fall to a winter-time nadir (Figure 4A). Red-tailed hawk fatality rates decreased through spring and summer and jumped higher over fall and winter (Figure 4A). American kestrel fatality rates were relatively constant throughout the year, but dipped in April and October, and burrowing owl fatality rates peaked in late summer/early fall and during winter (Figure 4A). The monthly trend in fatality rates of all raptors combined resembled those of red-tailed hawks and burrowing owls (Figure 4B), because their rates were among the highest among raptors and paralleled each other. The fatality rates of all birds combined peaked in mid-winter and May, and were lowest in late winter/early spring and early fall (Figure 4B). The monthly fatality rates of all bats as a group peaked in August/September with a secondary peak in March/April (Figure 4B).

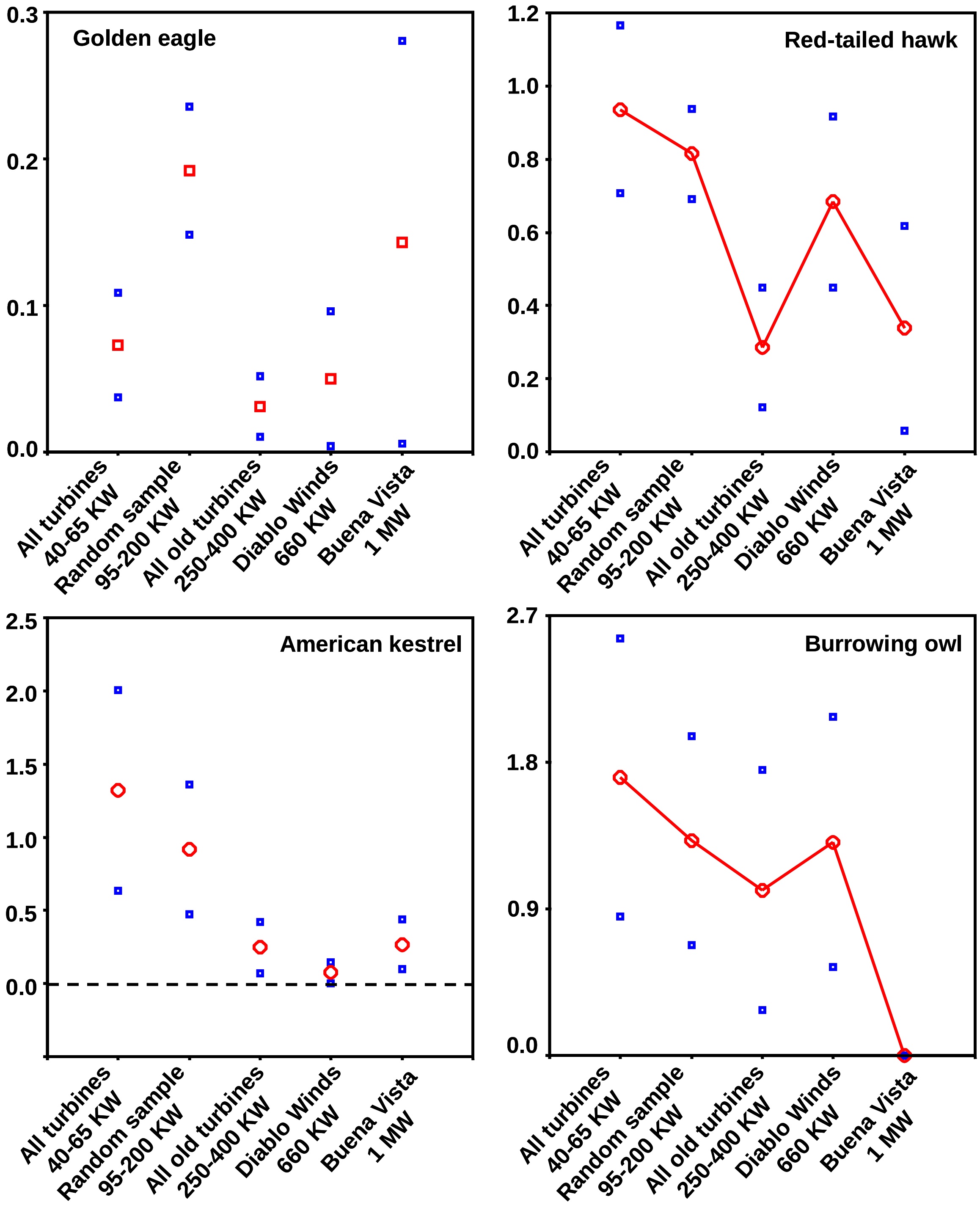


Figure 2A. Mean fatality rates (red circles) and lower and upper bounds of 80% confidence intervals (small blue squares) by size class of wind turbine in the Altamont Pass Wind Resource Area, 2005-2009.

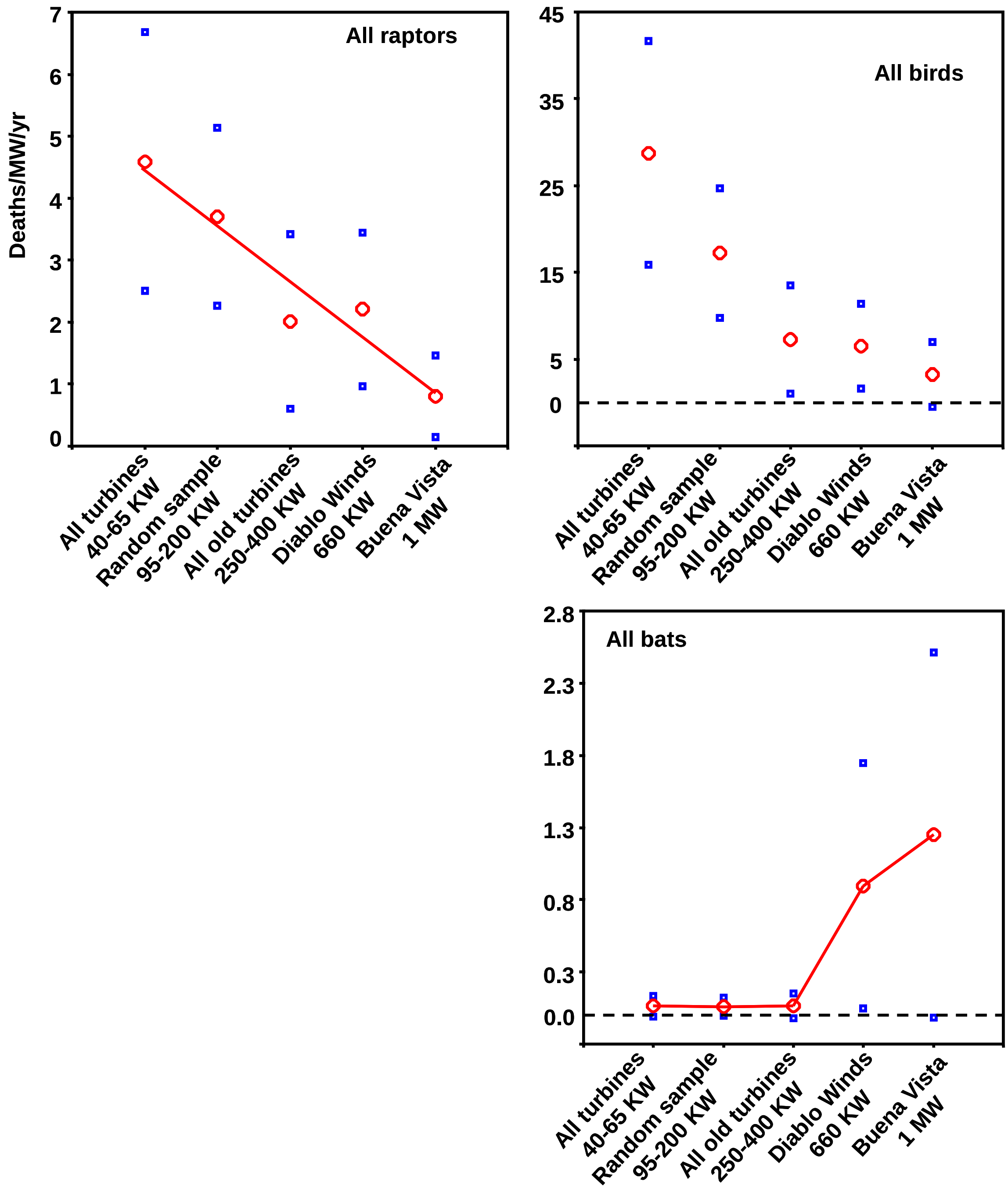


Figure 2B. Mean fatality rates (red circles) and lower and upper bounds of 80% confidence intervals (small blue squares) by size class of wind turbine in the Altamont Pass Wind Resource Area, 2005-2009.

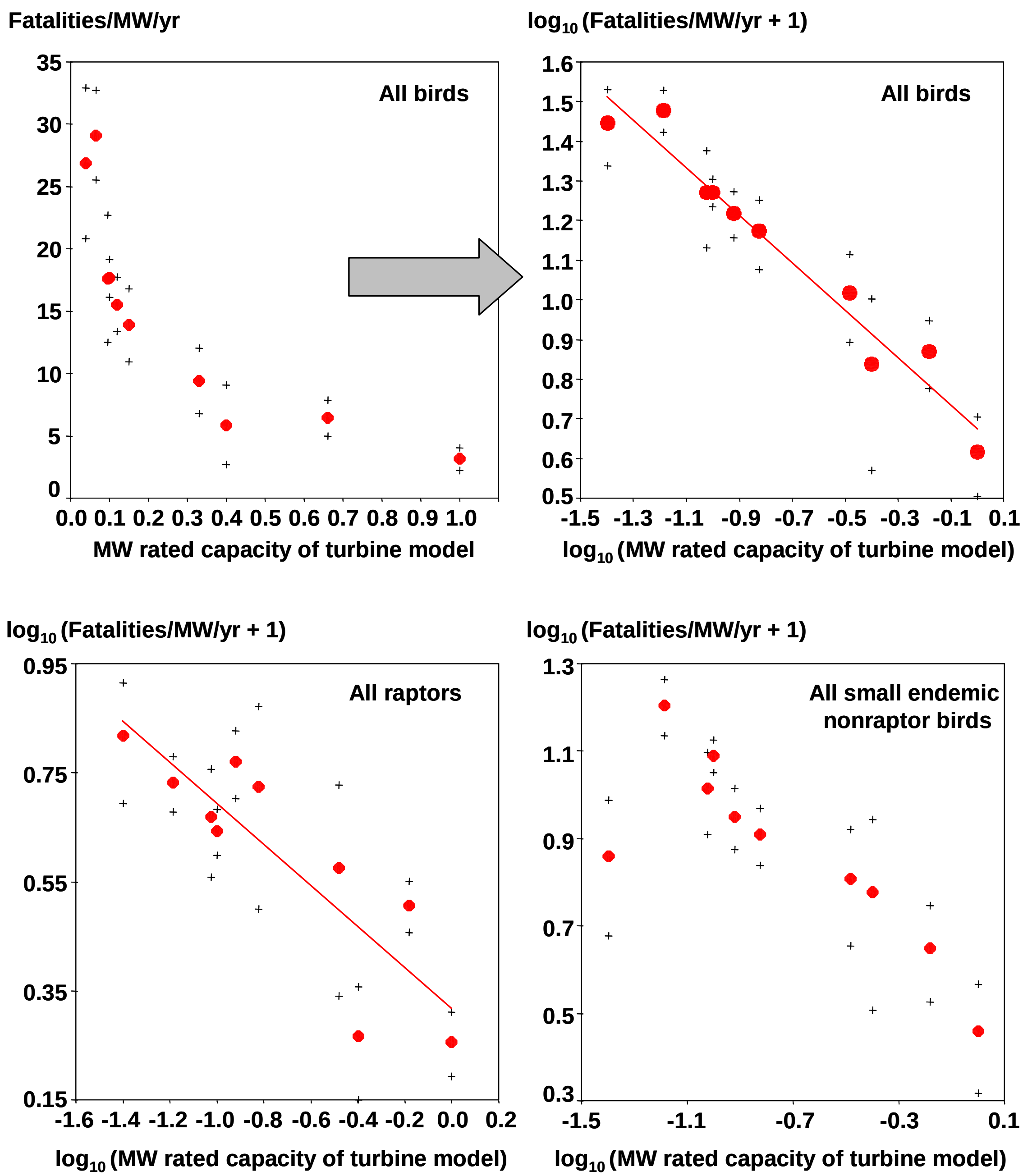


Figure 3A. Mean fatality rates (red circles) and lower and upper bounds of 80% confidence intervals (black crosses) by wind turbine size in the Altamont Pass Wind Resource Area, 2005-2009. Due to small sample size (3 turbine rows), 150-KW turbines were excluded from the comparisons.

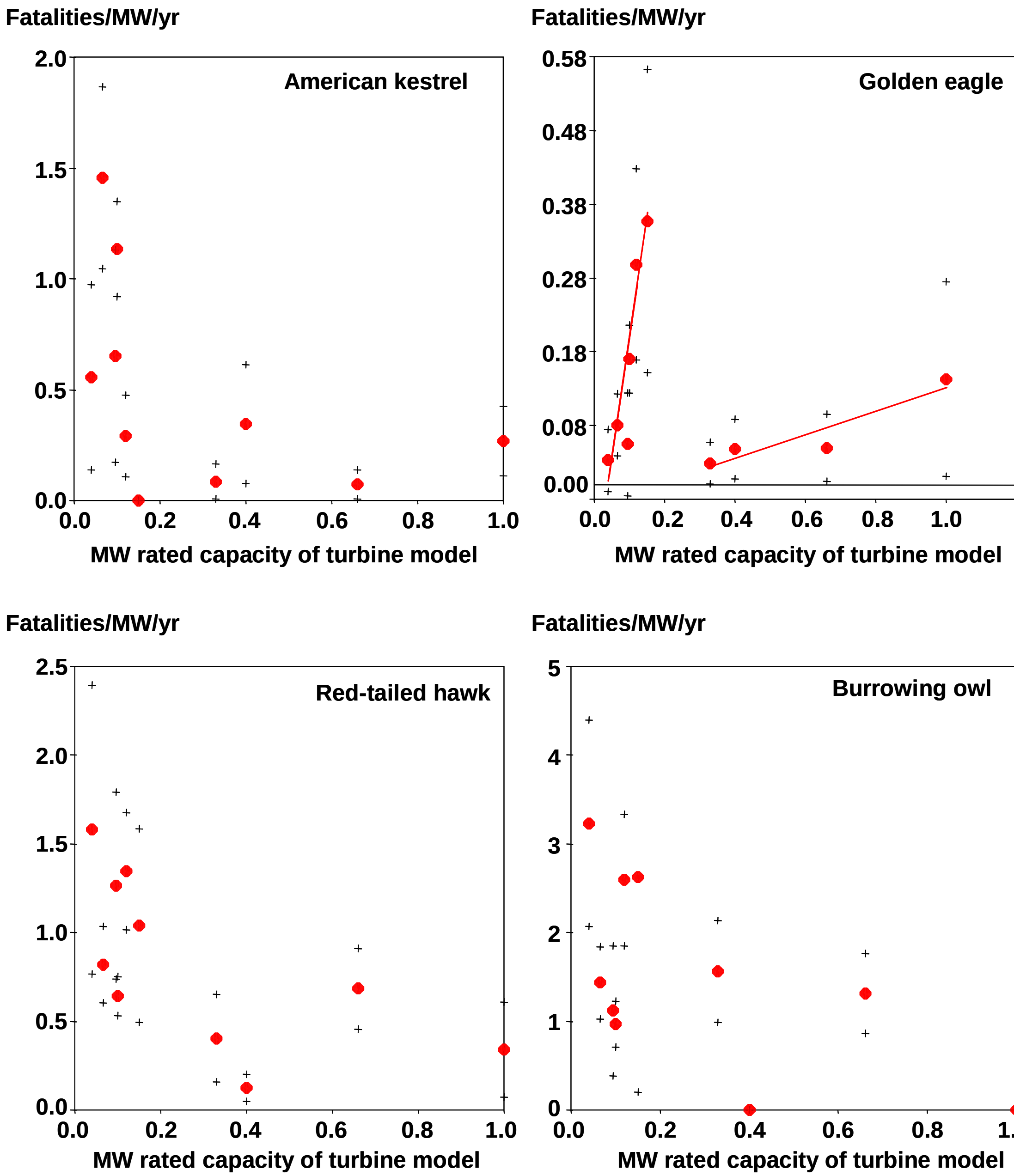


Figure 3B. Mean fatality rates (red circles) and lower and upper bounds of 80% confidence intervals (black crosses) by wind turbine size in the Altamont Pass Wind Resource Area, 2005-2009. Due to small sample size (3 turbine rows), 150-KW turbines were excluded from the comparisons.

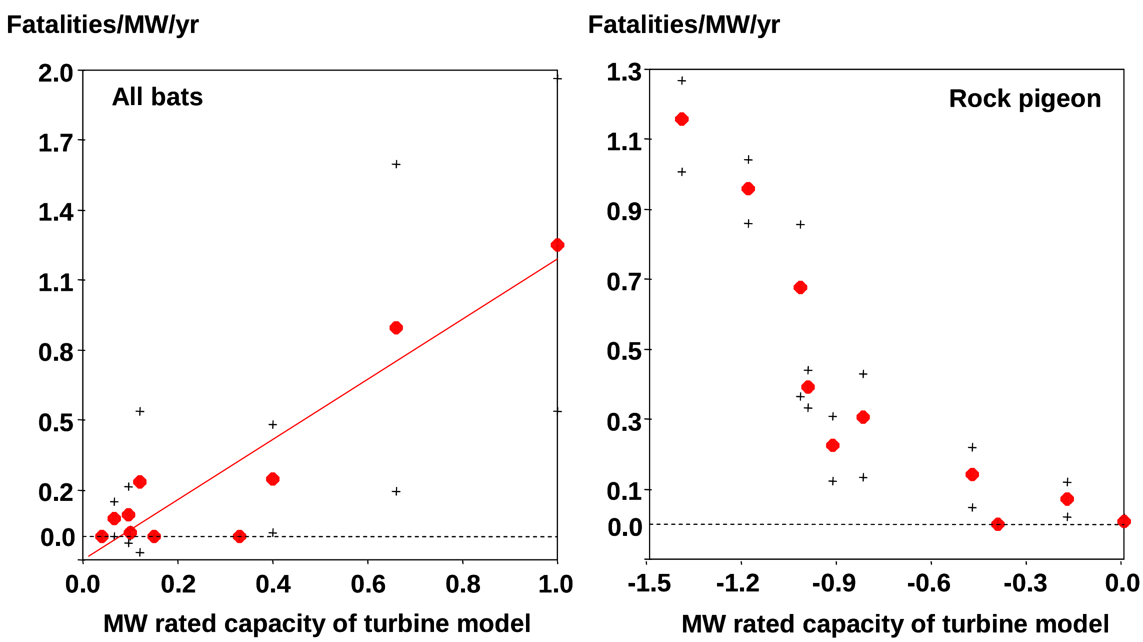


Figure 3C. Mean fatality rates (red circles) and lower and upper bounds of 80% confidence intervals (black crosses) by wind turbine size in the Altamont Pass Wind Resource Area, 2005-2009. Due to small sample size (3 turbine rows), 150-KW turbines were excluded from the comparisons.

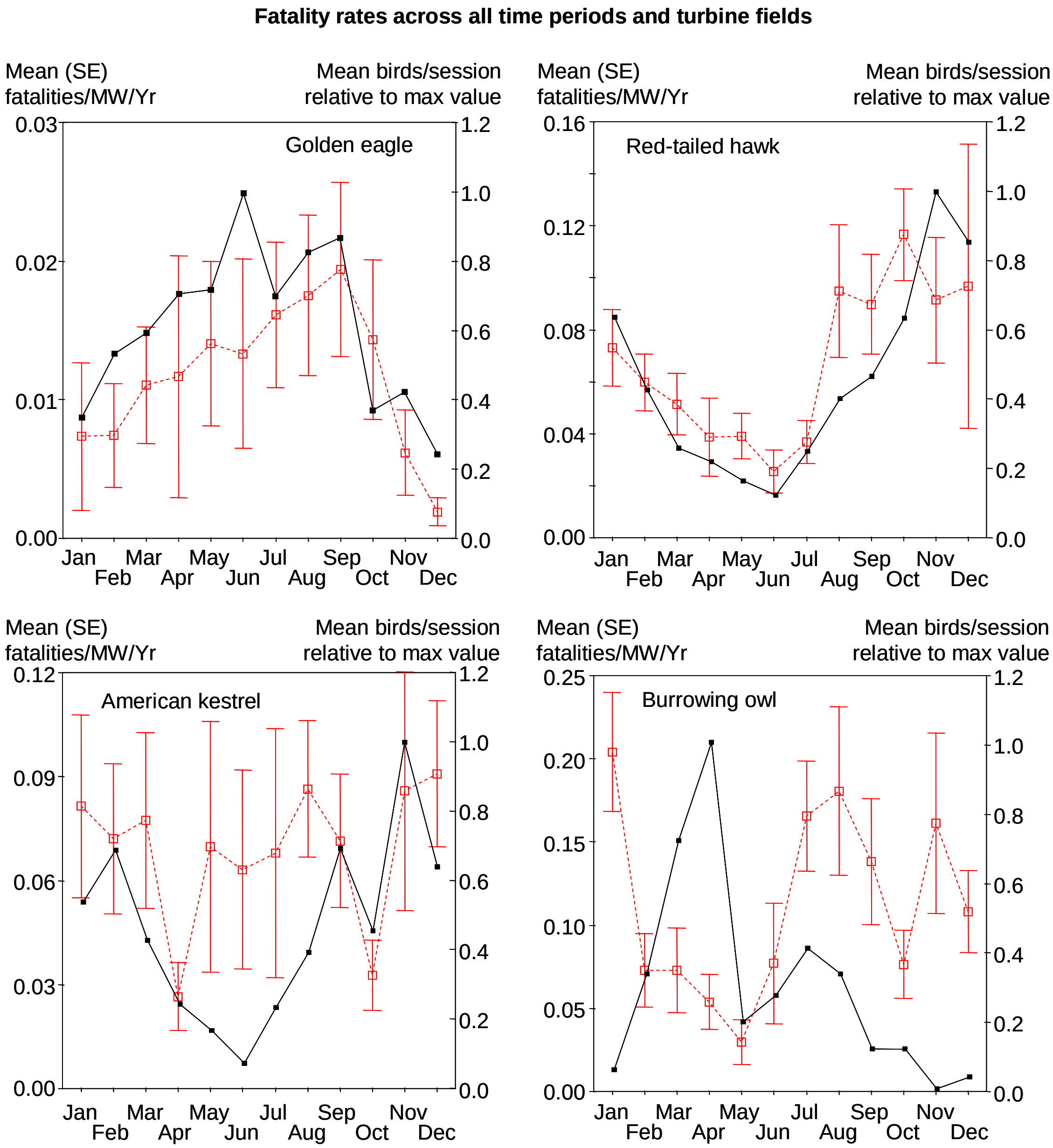


Figure 4A. Mean (and standard error) monthly fatality rates of Golden eagle, red-tailed hawk, American kestrel, and burrowing owl across all time periods and all wind turbines monitored from 1998 through 2009 (red lines and symbols), compared to mean number of individuals observed per session and relative to maximum values (black line and symbols). Utilization data were from Smallwood et al. (2009b).

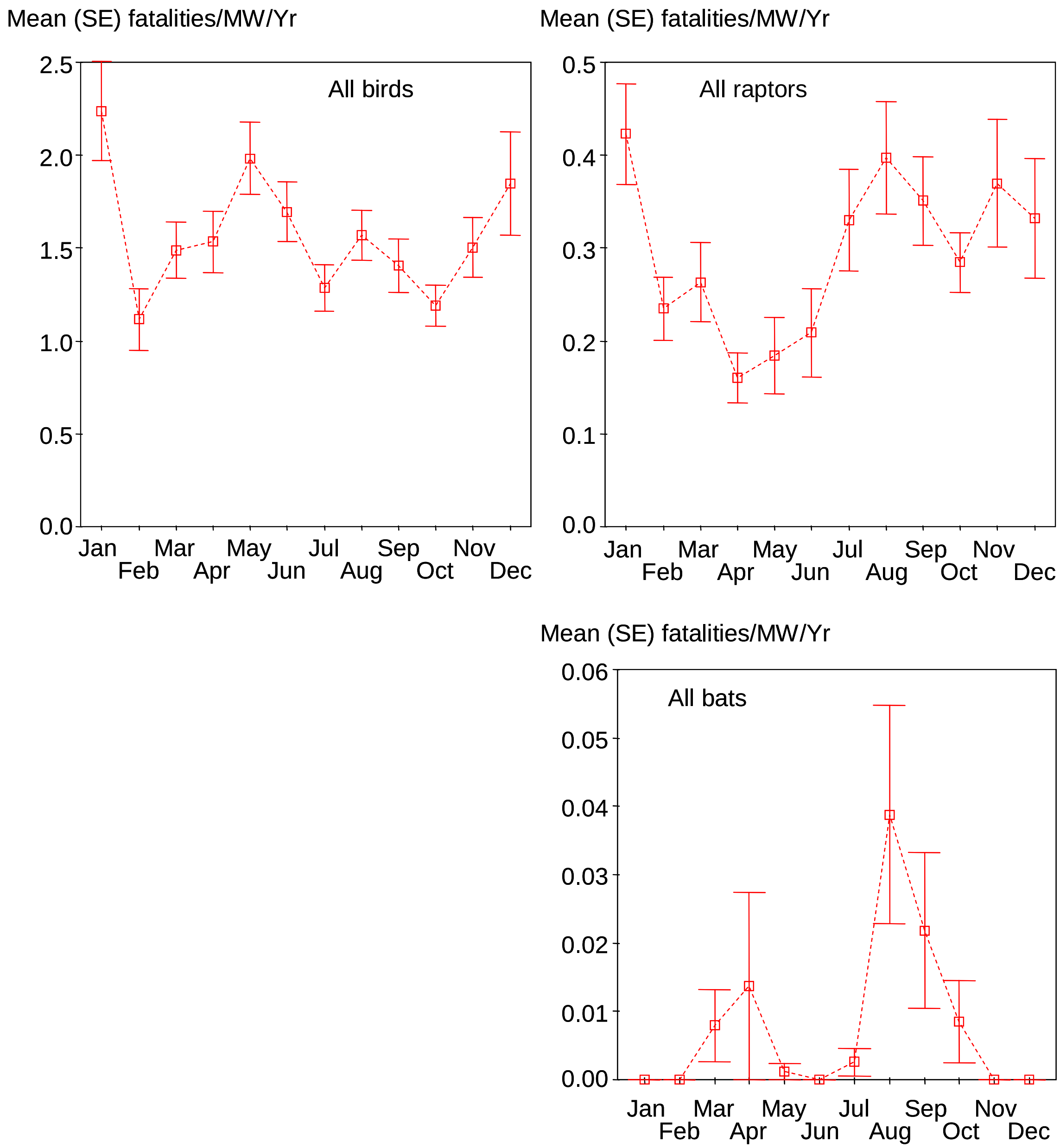


Figure 4B. Mean (and standard error) monthly fatality rates of all birds, all raptors and all bats across all time periods and all wind turbines monitored from 1998 through 2009.

Monthly fatality rates tracked monthly utilization rates measured in 1998-2000 for golden eagle and red-tailed hawk, but not for American kestrel and burrowing owl (Figure 4A). Whereas relative abundance appeared to influence fatality rates of golden eagle and red-tailed hawk, it appears something else is affecting monthly fatality rates of these small raptors, perhaps specific behaviors such as activity shifts to nocturnal hours when observations could not be made, or due to other ecological factors such as interactions with predators.

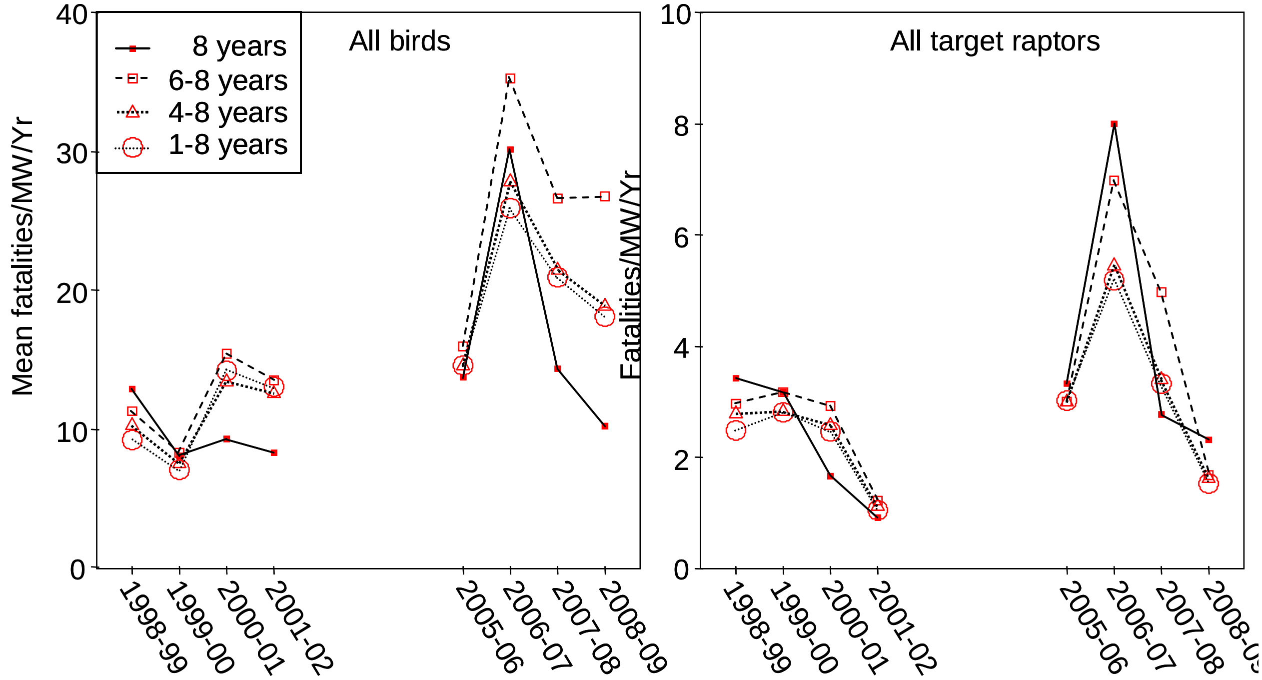
Inter-annual fatality rates.—The most directly comparable group of wind turbines between the baseline and current study periods were among the 35 turbine rows that were searched over all years. This group of turbines indicated that fatality rates of all birds as a group and of all target raptors as a group increased between studies, but were also highly variable inter-annually (Figure 5). Including more turbines in the comparison that were searched fewer years during the baseline period appeared to modify fatality rates in particular years, but did not change the overall conclusion that fatality rates generally increased between the baseline and current study periods.

Among the 35 turbine rows searched over all years of the baseline and current study periods, the inter-annual variation in fatality rates appeared to be potentially cyclic for golden eagle and red-tailed hawk (Figure 6A). American kestrel and burrowing owl fatality rates appeared relatively steady except for occasional peaks, such as the 2006-07 peak in fatality rates for burrowing owls (Figure 6A). The 2006-07 peak in fatality rates appeared to represent all birds as a group and all raptors as a group, as well, and the all raptors comparison indicated raptor fatality rates declined throughout the baseline as well as current study periods (Figure 6B).

For an inter-annual comparison, I singled out the AWI turbines searched all years of the baseline and current study periods because AWI's permits are overdue for review and AWI has recently claimed to have achieved an 85% reduction in fatality rates. However, after adjusting the fatality rates for searcher detection and scavenger removal errors, the fatality rates of the target raptor species appeared to have been highly variable from year to year both during the baseline and current study periods, but on the whole the rates did not decrease between the baseline and current study (Figure 6C).

Effects of mitigation measures

Winter shutdown.—For all birds as a group and all raptors as a group, monthly fatality rates were consistently higher during the current study compared to the baseline period, except for December, which was the only month that at least half of all the old-generation turbines were shut down during the last four years (Figure 7A). The effects of partial shutdowns in November are also apparent, but smaller. The lesser effect in November probably reflects the variable shutdown initiation dates over the last two years. By January there was no sign of a shutdown effect on all birds as a group or all raptors as a group, likely because January and February shutdowns were marginally represented over the last four years. Over the first two years, the crossover design limited shutdowns to half the turbines in January and February. In the third year, turbines were not shut down over most of January. And in the fourth year, groups of turbines were being reactivated over January and early February.



Turbine rows searched:

	1998-99	1999-00	2000-01	2001-02	2005-06	2006-07	2007-08	2008-09	1998-99	1999-00	2000-01	2001-02	2005-06	2006-07	2007-08	2008-09
8 years N =	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
6-8 years N =	56	50	103	111	108	111	111	111	56	50	103	111	108	111	111	111
4-8 years N =	82	76	130	141	286	290	290	290	82	76	130	141	286	290	290	290
1-8 years N =	118	101	143	167	295	335	334	326	118	101	143	167	295	335	334	326

Figure 5. Mean fatality rates among sets of old-generation turbines monitored over several ranges of years between the baseline and current study periods, including all 8 years (N = 35 turbine rows), 6-8 years (N ≥ 50 turbine rows), 4-8 years (N ≥ 76 turbine rows), and 1-8 years (N ≥ 101 turbine rows). Standard errors were not shown to avoid clutter.

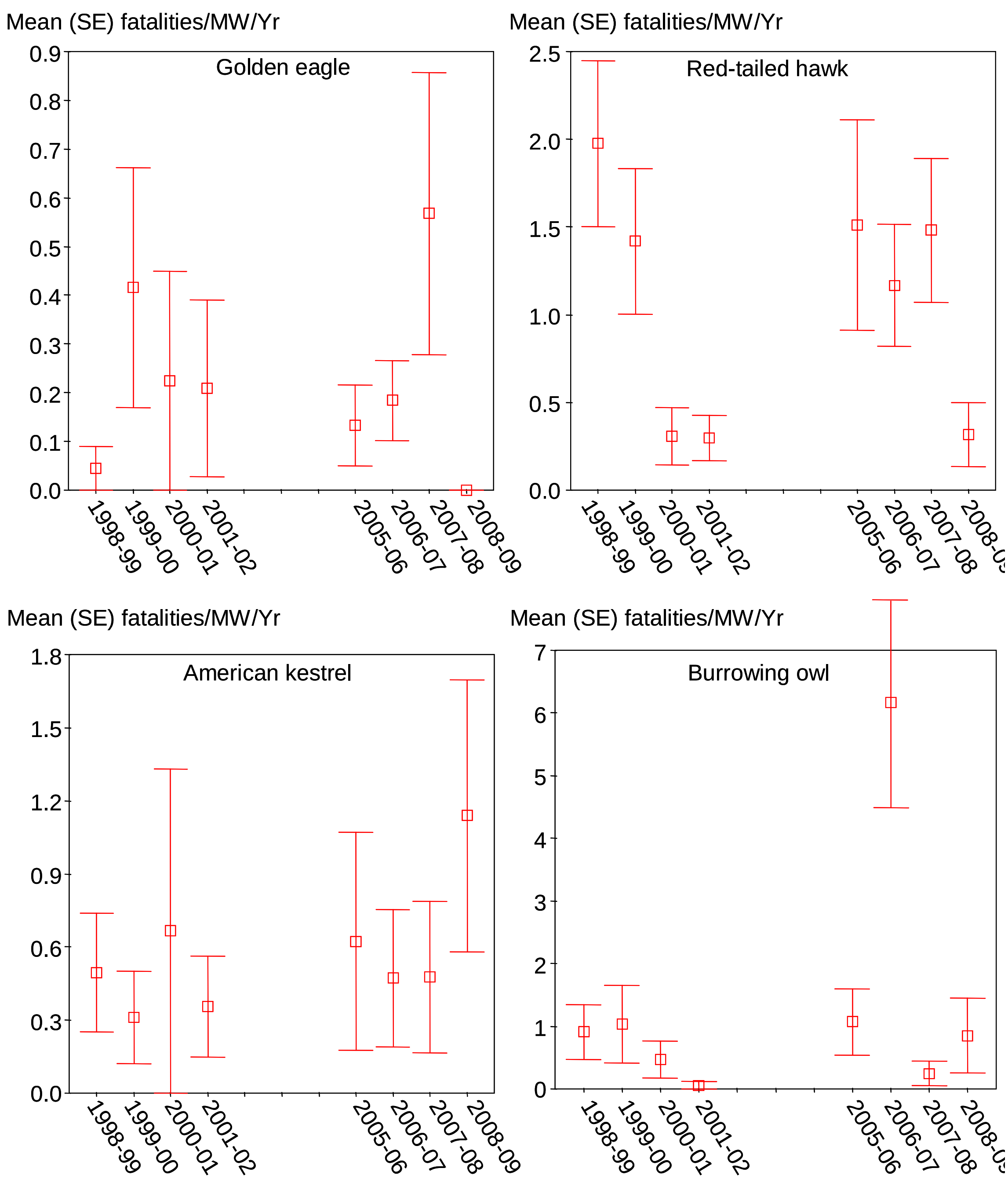


Figure 6A. Mean (SE) annual fatality rates for the target raptor species among 35 turbine rows that were searched all 8 years of the baseline and current study periods.

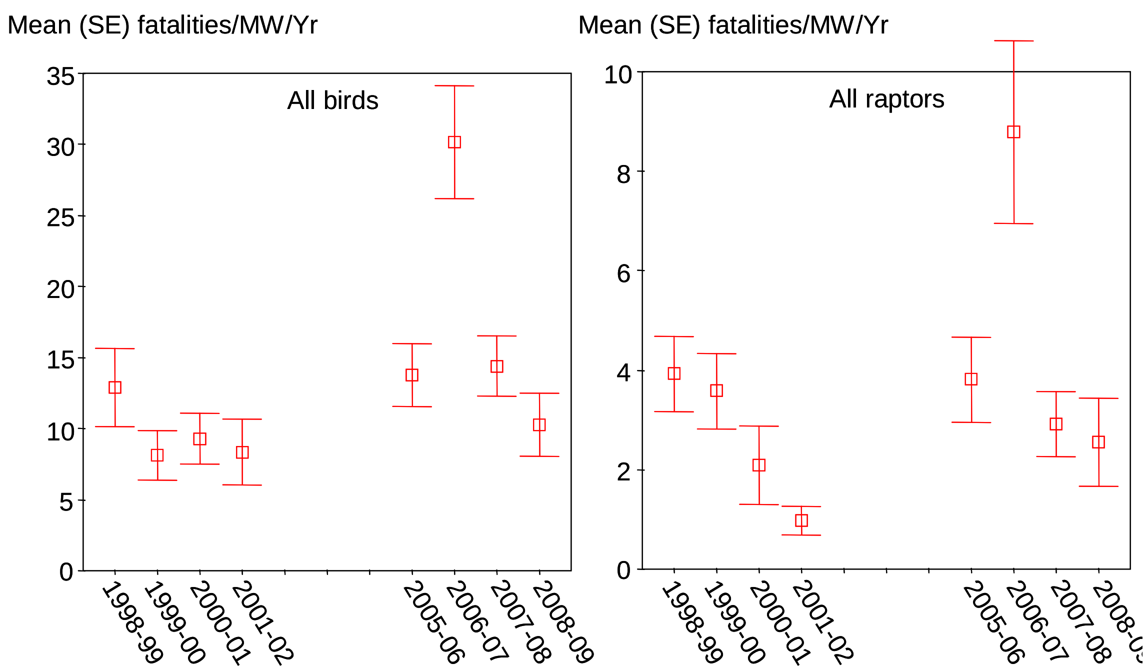


Figure 6B. Mean (SE) annual fatality rates for all raptors and all birds among 35 turbine rows that were searched all 8 years of the baseline and current study periods.

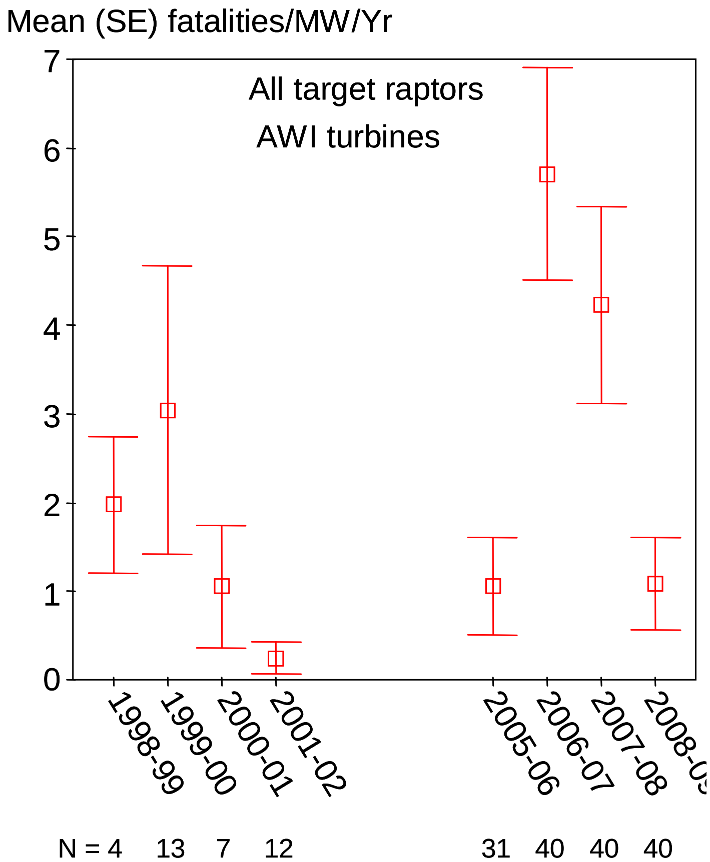


Figure 6C. Mean (SE) annual fatality rates for the target raptor species among AWI turbine rows that were searched all 8 years of the baseline and current study periods.

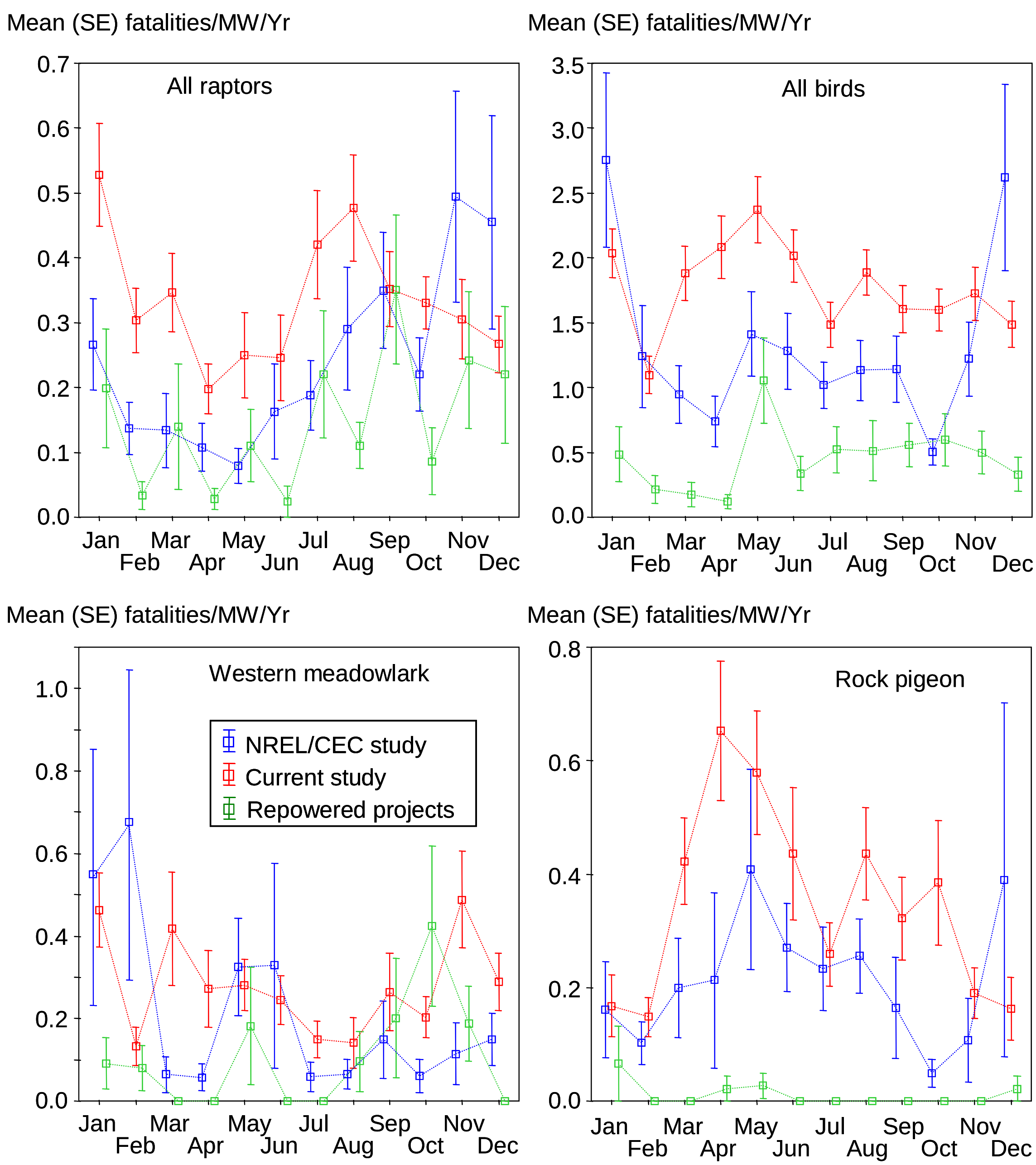


Figure 7A. Comparisons of monthly fatality rates among turbines monitored over the baseline period, over the past 4 years, and for both the Buena Vista and Diablo Winds repowering projects.

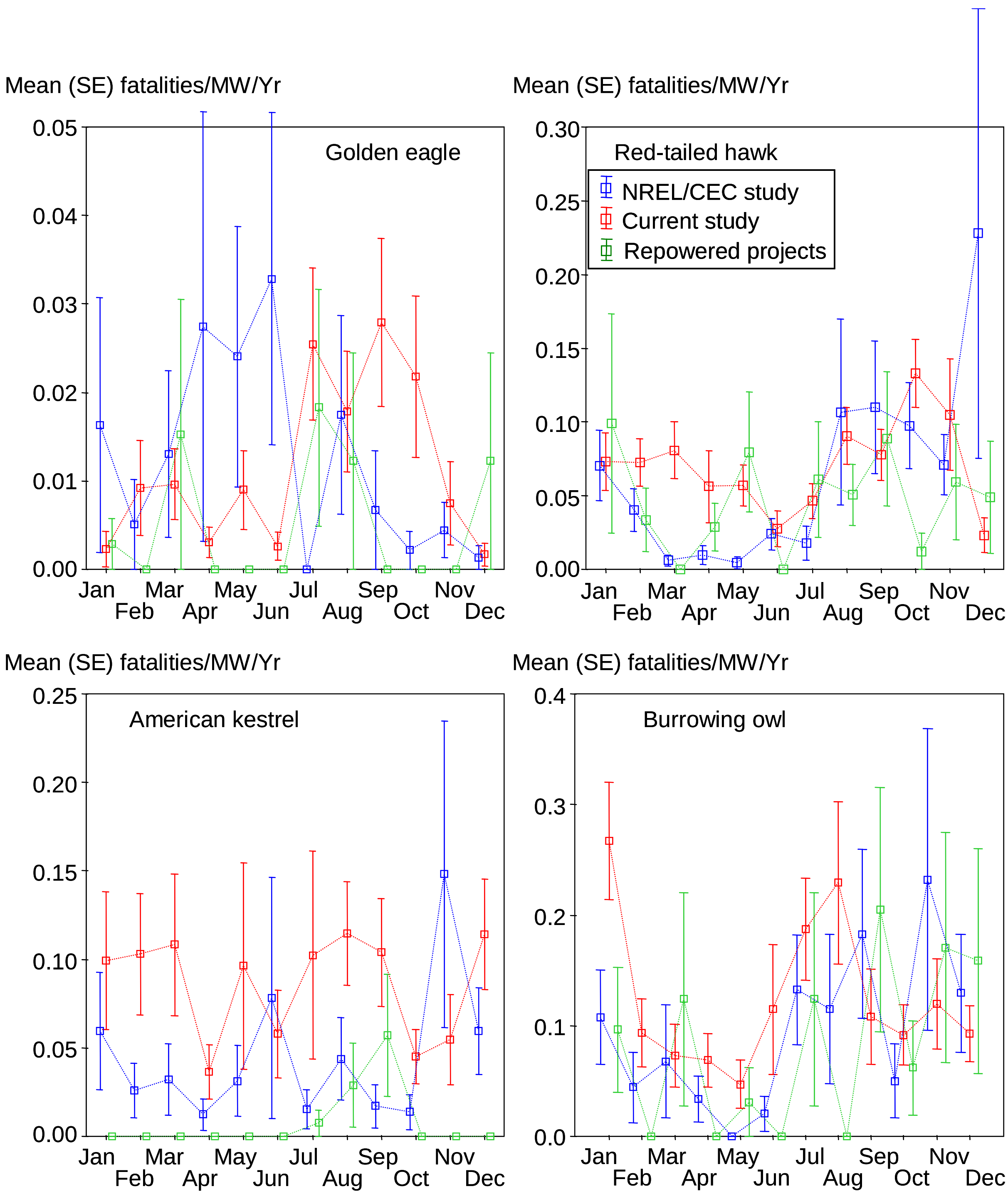


Figure 7B. Comparisons of monthly fatality rates among turbines monitored over the baseline period, over the past 4 years, and for both the Buena Vista and Diablo Winds repowering projects.

Monthly fatality rates among the repowered turbines roughly paralleled those of the old-generation turbines during the current study period (Figures 7A and 7B). Fatality rates at the repowered turbines also declined during the early winter period, though these turbines were not shut down. This similar pattern of fatalities might be explained by birds making greater use of the landscape where old-generation turbines were shut down, thus abandoning the landscape where repowered turbines remained active.

The winter shutdown appeared to protect red-tailed hawks, American kestrels, and burrowing owls during early winter, but not golden eagles (Figure 7B). It must be pointed out, however, that red-tailed hawk fatality rates during the current study increased over those of the baseline period during February, March, April, and May. A possible reason for this spring-time increase in fatalities is that red-tailed hawks having survived the early winter due to the shutdown were later killed when the turbines were re-activated. Red-tailed hawk fatalities were highly responsive to hazardous flight behaviors performed in spring during the baseline period, though relative abundance of red-tailed hawks was considerably lower in spring during the baseline period (Fig. 10 in Smallwood et al. 2009b). With more red-tailed hawks surviving the winter, more would be available to make hazardous flights during spring months of the current study.

American kestrel fatalities declined in November relative to the baseline period, but they were substantially greater during February and March. American kestrel fatalities dropped to zero over most months at repowered turbines, but spiked during late summer/early fall (Figure 7B).

Hazardous turbine removal.—Smallwood and Spiegel (2005c) appeared to have accurately categorized some of the old-generation wind turbines into Tiers of collision hazard (Figure 8). During the first two years of both the baseline and current study periods, fatality rates of target raptor species were greater at turbine rows with these turbines than at those without them (Figure 8). During the second two years of both studies, fatality rates dropped low enough that differences were not noticeable. Fatality rates dropped the most at turbine rows with hazardous turbines.

Similarly, in December 2007 the SRC appeared to have accurately rated turbines as relatively more hazardous to golden eagle and red-tailed hawk (Figure 9). During the first two years of both the baseline and current study periods, turbine rows with one or more of these turbines killed many more golden eagles and red-tailed hawks per MW per year than did the turbine rows composed of turbines that were either not rated by the SRC or rated < 7. Fatality rates at turbine rows with hazardous turbines were also more dynamic, declining through both study periods much faster than the other turbine rows. However, the turbines rated by the SRC did not appear to be more hazardous than other turbines for American kestrel or burrowing owl, though it should be noted that the SRC's ratings were not directed toward burrowing owls.

The graphs in Figures 7 and 8 provided no evidence that removal of Tier 1-3 turbines or SRC-rated turbines had any effect on fatality rates of target species. This lack of effect could have been due to (1) many of the identified hazardous turbines having not been removed until after December 2007, which would have limited the time when an effect could be measured to less than two years, or (2) an unfortunate coincidence of timing, when turbine removals would have corresponded with ongoing reductions in fatalities that had nothing to do with mitigation. The

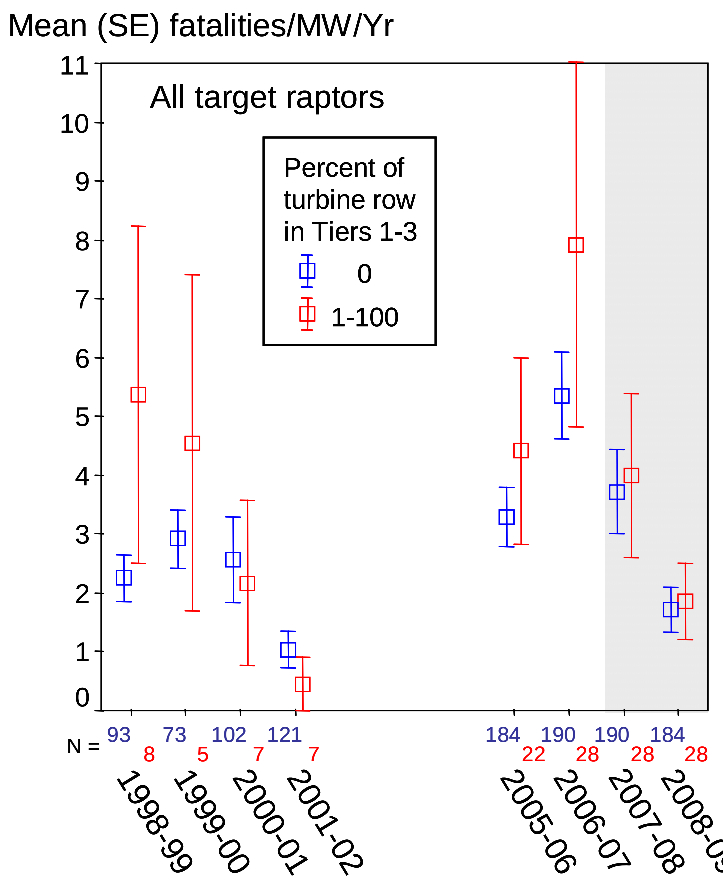


Figure 8. Comparisons of mean (SE) annual fatality rates among turbine rows numbering 12 or fewer turbines and between rows with and without turbines in Tiers 1 through 3 (Smallwood and Spiegel 2005c). I do not know how many turbines in Tiers 1-3 were removed or relocated, but I suspect most were moved during the last two years, indicated by the gray shade.

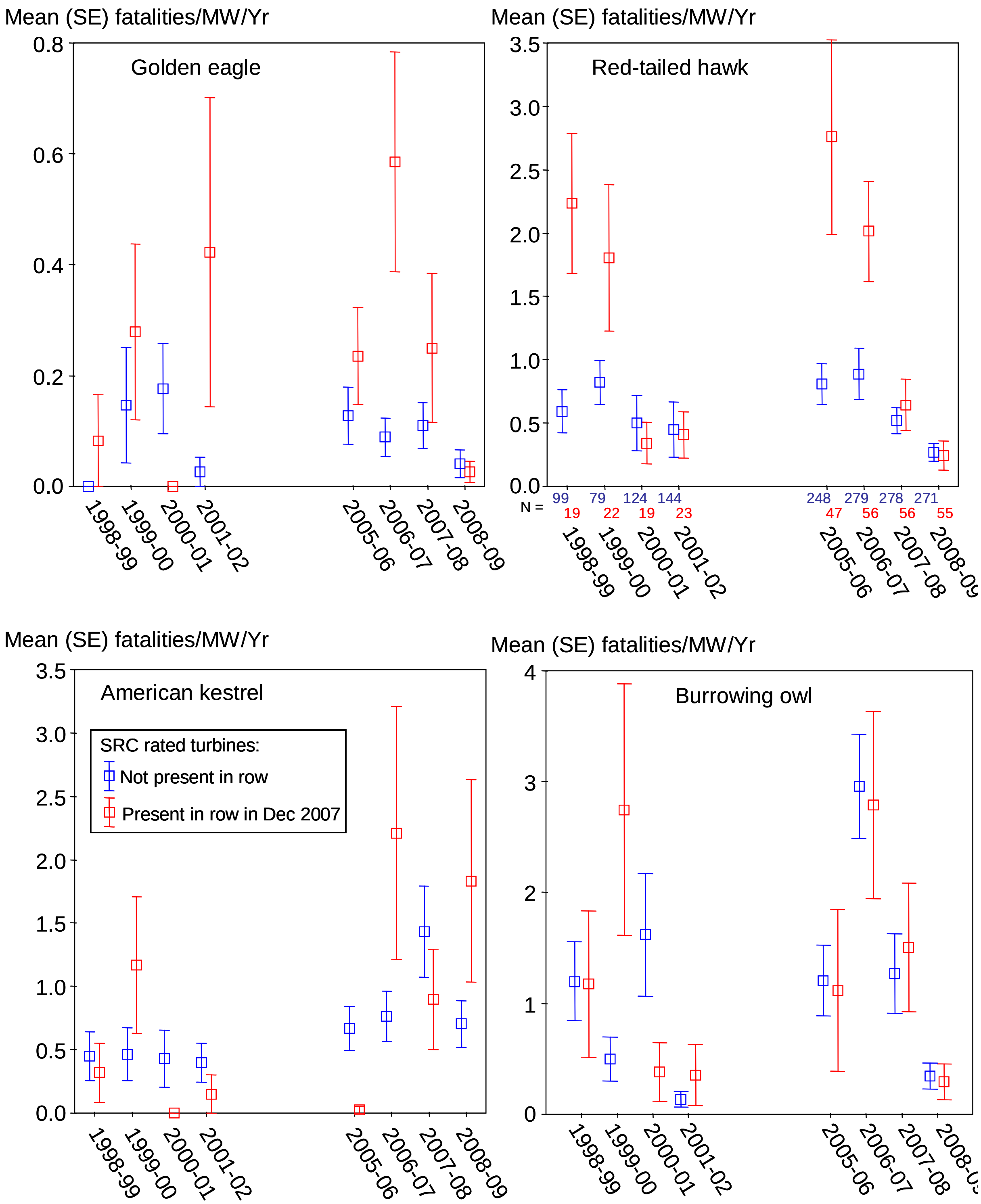


Figure 9. Comparisons of mean (SE) annual fatality rates between turbine rows with and without wind turbines that were rated 7 to 10 by the SRC in December 2007. Whether turbines rated 7 to 10 were removed after December 2007 remains undetermined, but I assume most were not removed.

SRC has been unable to verify that turbines in Tiers 1-3 or rated 7-10 were removed, and it does not know how many were moved or when they were moved. As for the second possible reason for a lack of effect, the four-year declines during both the baseline and current study periods, separated by several years of unknown fatality rates, resemble trends in fatality rates that one might expect of an inter-annual cycle linked to a cycle in abundance. Unfortunately, until I have adequately processed utilization data to compare to the fatality rates, I will be unable to determine whether the fatality rates of golden eagle and red-tailed hawk are cyclic.

Derelict, non-productive, or vacant tower removals.—I had no means of testing the effectiveness of derelict tower removal because I had no reliable information of where or how many derelict towers were removed or put back into service. As of April 2007, when I surveyed about 67% of the old-generation turbines, I noted no reduction in the number of derelict towers. I observed no evidence of any of these towers being removed until the last year of the Avian Wildlife Protection Program.

Effects of repowering

Compared to small turbines (i.e., 60 to 65 KW), the fatality rate at Buena Vista was 89% lower for all birds, 81% lower for target raptors, 64% lower for red-tailed hawk, 80% lower for American kestrel, 100% lower for burrowing owl, but nearly twice as great for golden eagle and nearly 20 times greater for all bats as a group. However, the Buena Vista turbines were not monitored during the high fatality year of 2007, so the differences might be less if fatality rates are compared over the same time spans (I have not done this yet). Diablo Winds turbines were monitored over the same time spans as the small old-generation turbines. Compared to small turbines, the fatality rate at Diablo Winds was 77% lower for all birds, 48% lower for target raptors, 32% lower for golden eagle, 27% lower for red-tailed hawk, 94% lower for American kestrel, 23% lower for burrowing owl, but nearly 14 times greater for all bats as a group. Of course, as shown in Figure 3, the differences in fatality rates between repowering and old-generation turbines tend to lessen as the repowered turbines are compared to larger old-generation turbines. Compared to medium-sized old-generation turbines (most of the wind turbines in the APWRA), the fatality rate at Buena Vista was 77% lower for target species and 81% lower for all birds, and the fatality rate at Diablo Winds was 35% lower for target raptors and 62% lower for all birds.

Total fatalities

By adding total estimated fatalities among groups of wind turbines defined by how they were selected for monitoring (i.e., all small turbines, all large old-generation turbines, all Diablo Winds turbines, all Buena Vista turbines, and medium-sized turbines based on extrapolation from a random sample), I estimated that the APWRA killed on average at least 7,643-9,298 birds per year over the past four years, including 1,645-,1967 raptors, 55-94 golden eagles, 475-477 American kestrels, 253-433 red-tailed hawks, and 714-718 burrowing owls.

DISCUSSION

Estimates of fatality rates tended to be greater during the current study compared to the baseline; they did not support a conclusion of a 50% reduction in raptor fatalities since the baseline period, nor did they support a conclusion of any reduction at all. This result should be of no surprise to anyone familiar with the Avian Wildlife Protection Program. The SRC warned of this result on 21 December 2006, pointing out that to achieve the reduction goal, the companies would need to implement the measures required by their operating permits. After learning of the new measures agreed upon in the settlement agreement, the SRC warned that those measures collectively would not achieve a 50% reduction, i.e., more commitment would be needed from the companies. Later the SRC warned that the measures being implemented to date would unlikely achieve a reduction any greater than 27%. On 13 March 2007, the SRC expressed concern over the companies' ability to achieve the goal. And on 27 December 2007, the SRC warned that the later the wind companies implement mitigation measures, the less likely sufficiently precise estimates of mortality will be obtained to assess effectiveness, and the less likely the goal will be reached. Also, none of the SRC's recommended mitigation measures were implemented adequately. The wind companies did not initiate repowering, they did not shut down turbines for 4 months over the winter, they did not remove end-of-row derelict towers, they did not begin removing mid-row derelict, vacant, or nonproductive towers until the very last year of the program, they did not quickly enough remove Tier 1-3 turbines or the turbines the SRC rated as hazardous in late 2007, they did not provide operating data to the SRC, they did not remove artificial rock piles, and they did nothing else that the SRC recommended except for continued monitoring of the Diablo Winds turbines. Finally, the SRC was not given the means to perform its job effectively, such as not being able to provide confirmed determinations of permit compliance, and the monitoring team has struggled to produce results in progress reports that could have better informed the Program.

The goal of 50% reduction in raptor fatalities was not achieved, and there is no legitimate alternative analytical methodology that can change this result. In fact, the results suggest fatality rates increased substantially. It may be true that fatality rates increased, but I suspect that they did not increase as much as indicated. The monitoring team may be more experienced at finding carcasses than the fatality monitors who worked during the baseline period, so they may have found more carcasses per search, though I doubt that their skill levels had improved enough to explain all of the differences in fatality rates. Also, Julie Yee quantified a potential bias in comparing fatality rates derived from different average search intervals, though this bias appears to be in the 5% to 10% range. High inter-annual variability may also have influenced the comparison as the 2006-2007 bird year experienced very high fatality rates. It is possible that such a year of high fatality rates might have been 1997 or 2003, just before or after the baseline monitoring period, and if such a year happened to have been monitored, then the fatality rates would have been about equal between the baseline and current study periods. However, none of these possible explanations, if true, could have resulted in conclusions that fatality rates were reduced between the baseline and current study periods.

Mean fatality rates reported herein were close to the fatality rates reported in Smallwood and Karas (2009). I regard the estimates as conservative because I still cannot account for the effects of crippling bias (Smallwood 2007, Smallwood et al. in press), and I suspect that scavenger removal rates have been faster than characterized so far. My suspicion was supported by the 48-hour search interval directed to detect American kestrel and burrowing owls carcasses, when the more intensive searches detected 1.4 times the number of small raptors and 2.4 times the number of small nonraptor birds than predicted by national averages of scavenger removal rates (Smallwood 2007, 2009). My estimates of bat fatality rates were especially conservative because I used small birds as the surrogate species group when calculating scavenger removal and searcher detection rates, but I am aware that bats are removed faster than small birds and are more often missed by searchers when carcasses are present. The bat fatality rate estimates herein will be revised once average removal rates and searcher detection rates are developed for bats.

Effectiveness of mitigation measures

The first two years of winter shutdown clouded tests of winter-time shutdown effectiveness. The cross-over design was poorly planned and executed, and was an idea I disagreed with since its inception. It might have killed more red-tailed hawks than it saved. However, even the universal shutdowns were unsatisfactory, perhaps because they were too brief, but also because relative to the baseline period, red-tailed hawk fatalities spiked during spring as if the hawks spared over the winter shutdown were later killed in spring. Of course, if red-tailed hawk fatalities were indeed simply delayed by the shutdown, then this result would indicate that many red-tailed hawks stay longer in the APWRA than I previously believed, but it also might mean that red-tailed hawks in the APWRA experience high rates of recruitment. It might be possible that the spring-time spike in red-tailed hawk fatalities might lessen if the winter shutdown was implemented as recommended by the SRC, but I suspect it will only lessen slightly. A winter-time shutdown may not result in a net reduction of red-tailed hawk fatalities. Also, because monthly patterns of fatality rates vary among species, no particular seasonal shutdown of turbines will uniformly benefit all species. However, August and September is when wind turbines in the APWRA kill larger numbers of bats and most raptors. An August/September shutdown would probably be much more effective than a winter shutdown. (A winter shutdown was suggested in 2005 as a tradeoff between saving birds and minimizing loss of power generation, as winter contributed only 14% of annual generation. The wind companies first proposed the winter shutdown and Smallwood and Spiegel 2005a assessed it potential effectiveness.)

Although the data collected during the current study verified that Smallwood and Spiegel (2005c) classified appropriate turbines into Tiers 1-3 and the SRC ranked appropriate turbines as relatively more hazardous, the data did not detect any effect of hazardous turbine relocation or removal. The opportunity to measure the effect of hazardous turbine relocation was missed, however, because most of the relocated turbines were not relocated until the last year of the current study, when fatality rates had already declined for no reason that I can attribute to mitigation or wind turbine attrition (because the decline in fatality rates also occurred during the baseline period when no mitigation was implemented). Had the hazardous turbines been relocated immediately, as recommended by Smallwood and Spiegel (2005c), the large differences in fatality rates between Tier 1-3 turbines and Tier 4-6 turbines during 2005-06 and 2006-07 might have been eliminated, and overall fatality rates reduced. Overall, however, this measure was never projected to reduce APWRA-wide fatality rates by more than about 10%.

I had no means to test for the effectives of any other recommended or permit-required mitigation measures, such as removal of derelict towers. Worse, the wind companies began using vacant towers as end-of-row flight diverters in 2005, contrary to my recommendations (Smallwood and Thelander 2004) and contrary to SRC recommendations. The SRC repeatedly recommended immediate removal of these towers, the presence of which might have contributed to more rather than fewer raptor fatalities.

Effectiveness of repowering

The only clearly effective means of reducing fatality rates of most birds was repowering to larger wind turbines. Wind turbine size related strongly to fatality rates, which declined with increasing turbine size for most species. The exceptions to this trend were for golden eagle and bats, which increased with turbine size. Thus, repowering may pose equal or greater threats to golden eagles and bats, unless effective mitigation measures can be formulated. For golden eagles, a scientific basis exists to more safely site the wind turbines by avoiding favored golden eagle flight paths. For bats, however, scientific bases exist to mitigate the impacts by shutting down turbines during August and September and by increasing cut-in speeds.

The first nearly two years of fatality monitoring at Buena Vista Wind Energy project revealed ridge saddles and notches to be most hazardous turbine locations for golden eagle and most raptors (Smallwood unpubl. report to East Bay Regional Park District). On the other hand, bats were more vulnerable to modern turbines on ridgelines and ridge saddles. It appears that no siting guidelines will uniformly benefit all bird and bat species, so tradeoffs will be necessary when making siting decisions for repowering projects in the APWRA. Siting of repowered turbines to reduce raptor fatalities can be informed by analysis of utilization data and landscape and wind conditions (Smallwood and Neher 2004, 2009; Smallwood et al. 2009a, b, c).

The overall reduction in fatality rates due to the two small repowering projects in the APWRA indicates that all the old-generation wind turbines in the APWRA should be repowered as soon as possible. In the meantime I recommend shutting down all the old-generation wind turbines rather than continuing to experiment with mitigation measures. The Avian Wildlife Protection Program proved that the wind companies are unwilling to cooperate with effective mitigation experiments in the APWRA, so continuing to deliberate over such experiments is pointless.

Acknowledgments

I thank Brian Karas and Levin Nason for answering my many questions about the fatality data collected by the Alameda County Avian Monitoring Team, for being very patient with my suggested corrections of data base errors, and for discussing ideas about what the data mean.

REFERENCES

Goodman, L. A. 1960. On the exact variance of products. Journal American Statistical Association 55:708-713.

Insignia Environmental. 2009. 2008/2009 Annual Report for the Buena Vista Avian and Bat Fatality Monitoring Project. Unpublished report prepared for County of Contra Costa, Martinez, California.

Smallwood, K .S. 2007. Estimating wind turbine-caused bird mortality. Journal of Wildlife Management 71:2781-2791.

Smallwood, K. S. 2009. Smallwood's review of M32. Alameda County SRC document P-111. 6 pp. http://www.altamontsrc.org/alt_doc/p111_smallwoods_review_of_m32.pdf

Smallwood, K. S. and B. Karas. 2009. Avian and Bat Fatality Rates at Old-Generation and Repowered Wind Turbines in California. Journal of Wildlife Management 73:1062-1071.

Smallwood, K. S. and L. Neher. 2004. Repowering the APWRA: Forecasting and minimizing avian mortality without significant loss of power generation. California Energy Commission, Public Interest Energy Research – Environmental Area Report CEC-500-2005-005, Sacramento, California, USA.

Smallwood, K. S., and L. Neher. 2009. Map-Based Repowering of the Altamont Pass Wind Resource Area Based on Burrowing Owl Burrows, Raptor Flights, and Collisions with Wind Turbines. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. CEC-500-2009-065. Sacramento, California. 63 pp. http://www.energy.ca.gov/2009publications/CEC-500-2009-065/CEC-500-2009-065.PDF

Smallwood, K. S. and L. Spiegel. 2005a. Assessment To Support An Adaptive Management Plan For The APWRA. Unpublished CEC staff report, January 19. 19 pp.

Smallwood, K. S. and L. Spiegel. 2005c. Combining biology-based and policy-based tiers of priority for determining wind turbine relocation/shutdown to reduce bird fatalities in the APWRA. Unpublished CEC staff report, June 1. 9 pp.

Smallwood, K. S. and C. Thelander. 2004. Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. 500-01-019. Sacramento, California, USA.

Smallwood, K. S. and C. Thelander. 2005. Bird mortality in the Altamont Pass Wind Resource Area, March 1998 – September 2001 Final Report. National Renewable Energy Laboratory, NREL/SR-500-36973. Golden, Colorado, USA.

Smallwood, K. S., C. G. Thelander. 2008. Bird Mortality in the Altamont Pass Wind Resource Area, California. Journal of Wildlife Management 72:215-223.

Smallwood, K. S., L. Neher, and D. A. Bell. 2009a. Map-based repowering and reorganization of a wind resource area to minimize burrowing owl and other bird fatalities. Energies 2009(2):915-943. http://www.mdpi.com/1996-1073/2/4/915

Smallwood, K. S., L. Rugge, and M. L. Morrison. 2009b. Influence of Behavior on Bird Mortality in Wind Energy Developments: The Altamont Pass Wind Resource Area, California. Journal of Wildlife Management 73:1082-1098.

Smallwood, K. S., D. A. Bell, S. A. Snyder, and J. E. DiDonato. In press. Novel scavenger removal trials increase estimates of wind turbine-caused avian fatality rates. Journal of Wildlife Management (In press).

Smallwood, K. S., C. G. Thelander, M. L. Morrison, and L. M. Rugge. 2007. Burrowing owl mortality in the Altamont Pass Wind Resource Area. Journal of Wildlife Management 71:1513-1524.

Smallwood, K. S., L. Neher, D. Bell, J. DiDonato, B. Karas, S. Snyder, and S. Lopez. 2009c. Range Management Practices to Reduce Wind Turbine Impacts on Burrowing Owls and Other Raptors in the Altamont Pass Wind Resource Area, California. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. CEC-500-2008-080. Sacramento, California. 183 pp. http://www.energy.ca.gov/2008publications/CEC-500-2008-080/CEC-500-2008-080.PDF

Yen, D., J. Guzman, and A. Nasim. 2001. Wind performance reporting summary 1996-1999. California Energy Commission Staff Report P500-01-018.

Yen-Nakafuji, D., J. Guzman, and G. Herrejon. 2002. Wind performance reporting summary 2000-2001. California Energy Commission Staff Report P500-02-034F.

Yen-Nakafuji, D. 2005. California wind resources. California Energy Commission Staff Report P500-2005-071D.

Yen-Nakafuji, D., M. Kane, J. S. Kahlon, and P. Spaulding. 2006. Wind performance reporting summary 2002-2003. California Energy Commission Staff Report P500-2006-060.

Table 1. Summary of fatality searches in the APWRA, including searches by Alameda County Avian Monitoring Team (Alameda), Insignia Environmental (Insignia), and East Bay Regional Park District (EBRPD).

Sample	Searched	Search team	No. towers	MW of rated capacity	Search radius (m)	Mean search interval (days)	Mean years	Dates
Diablo Winds	All	Alameda	31	20.46	75	32.08	4.33	Apr 2005 to Oct 2009
Buena Vista	All	Insignia	38	38.00	75	15 / 30	1.92[a]	Jan 2008 – Nov 2009
Old-generation turbines, Current Study								
Medium, 95-200 KW	Random blocks	Alameda	1,869	188.69	50	34.75	3.72	Nov 2005 – Oct 2009[b]
Very small, 40-65 KW	All	Alameda	759	45.10	50	35.91	3.90	Nov 2005 – Oct 2009
Large, 250-400 KW	All	Alameda/ EBRPD	135	45.54	50-60	34.63	3.08	Nov 2005 – Oct 2009
-- Tres Vaqueros	All off Souza	Alameda	41	13.53	60	35.70	3.88	Nov 2005 – Oct 2009
-- Tres Vaqueros	All on Souza	EBRPD	34	11.22	60	15.90	1.31	Jun 2006 – Sep 2007
Northwind	All on Souza	EBRPD	20	1.30	50	18.22	0.98	Oct 2006 – Sep 2007
Old-generation turbines, Baseline comparison								
Mutually surveyed core	Mutual	NREL/CEC	911	81.59	50	49.7	2.58	Nov 1998 – Oct 2002
Current study core	Mutual	Alameda	908	81.29	50	35.7	4.00	Oct 2005 – Oct 2009
Twice-searched in baseline and directly comparable to current study	Systematic Varied	NREL/CEC and Alameda	1,282 1,282	141.80 141.80	50 50-60	>90 >90	--- ---	Oct 2002 – Apr 2003 Oct 2005 – Apr 2009

[a] Monthly searches were performed for 8 months, then bimonthly searches performed over following 15 months.
[b] Added 536 turbines to the search rotation in March 2007, increasing turbine sample from 1,233 to 1,869.

Table 2. Comparisons of mean and SE of estimated fatalities per MW per year of birds and bats in the Altamont Pass Wind Resource Area among mutually searched turbines during baseline and current study periods, adjusted for searcher detection and scavenger removal rates based on Smallwood (2007). For select comparisons, I used 2-tailed Independent Samples *t*-tests (df = 229).

	Fatalities/MW/year at mutually surveyed turbines				Independent	
	Baseline, 1998-2002		**Current study, 2005-2009**		samples	
Species	**Mean**	**SE**	**Mean**	**SE**	*t*-value	*P*
Mallard	0.203	0.075	0.081	0.047	1.491[b]	0.137
Ring-necked duck	0.000	0.000	0.000	0.000		
Puddle duck	0.000	0.000	0.000	0.000		
Duck spp.	0.000	0.000	0.004	0.004		
Wild turkey	0.014	0.013	0.000	0.000		
Pied-billed grebe	0.000	0.000	0.000	0.000		
Brown pelican	0.000	0.000	0.138	0.078		
Double-crested cormorant	0.017	0.016	0.000	0.000		
Great blue heron	0.000	0.000	0.003	0.003		
Great egret	0.000	0.000	0.077	0.078		
Cattle egret	0.000	0.000	0.000	0.000		
Black-crowned night-heron	0.000	0.000	0.000	0.000		
Turkey vulture	0.011	0.011	0.006	0.004	0.462[a]	0.645
White-tailed kite	0.000	0.000	0.000	0.000		
Northern harrier	0.006	0.003	0.010	0.006	0.674[a]	0.501
Red-shouldered hawk	0.000	0.000	0.000	0.000		
Swainson's hawk	0.000	0.000	0.000	0.000		
Red-tailed hawk	0.482	0.128	0.597	0.103	0.774[a]	0.440
Ferruginous hawk	0.000	0.000	0.001	0.001		
Buteo spp.	0.000	0.000	0.023	0.010		
Hawk spp.	0.000	0.000	0.000	0.000		
Golden eagle	0.068	0.024	0.084	0.022	0.522[a]	0.602
American kestrel	0.548	0.135	0.821	0.259	1.059[a]	0.291
Peregrine falcon	0.000	0.000	0.000	0.000		
Prairie falcon	0.002	0.002	0.002	0.002	0.052[a]	0.958
Falcon spp.	0.000	0.000	0.000	0.000		

Species	Fatalities/MW/year at mutually surveyed turbines				Independent samples t-value	P
	Baseline, 1998-2002		Current study, 2005-2009			
	Mean	SE	Mean	SE		
Raptor	0.006	0.006	0.008	0.006		
Large raptor	0.000	0.000	0.000	0.000		
Small raptor	0.000	0.000	0.015	0.015		
American coot	0.000	0.000	0.000	0.000		
Sandhill crane	0.000	0.000	0.000	0.000		
Killdeer	0.000	0.000	0.024	0.021		
Black-necked stilt	0.000	0.000	0.021	0.021		
American avocet	0.141	0.040	0.005	0.003		
Lesser yellowlegs	0.000	0.000	0.000	0.000		
Bonaparte's gull	0.000	0.000	0.000	0.000		
Ring-billed gull	0.029	0.023	0.003	0.003		
Western gull	0.000	0.000	0.004	0.004		
California gull	0.027	0.015	0.048	0.026		
Herring gull	0.000	0.000	0.004	0.004		
Gull spp.	0.041	0.022	0.192	0.080		
Rock pigeon	1.525	0.339	4.623	0.816	4.145[b]	0.000
Mourning dove	2.215	1.043	0.803	0.461	1.685[b]	0.095
Dove spp.	0.000	0.000	0.226	0.137		
Cockatiel	0.000	0.000	0.031	0.034		
Barn owl	0.091	0.031	0.184	0.040	1.991[b]	0.048
Great-horned owl	0.048	0.026	0.030	0.011	0.657[a]	0.512
Burrowing owl	1.469	0.301	2.407	0.571	1.984[a]	0.049
Common poorwill	0.000	0.000	0.024	0.026		
White-throated swift	0.000	0.000	0.013	0.015		
Northern flicker	0.247	0.167	0.039	0.043		
Hammond's flycatcher	0.000	0.000	0.000	0.000		
Pacific-slope flycatcher	0.055	0.046	0.000	0.000		
Say's phoebe	0.018	0.017	0.000	0.000		
Western kingbird	0.018	0.017	0.000	0.000		
Flycatcher spp.	0.000	0.000	0.031	0.035		

Species	Fatalities/MW/year at mutually surveyed turbines				Independent samples *t*-value	*P*
	Baseline, 1998-2002		Current study, 2005-2009			
	Mean	**SE**	**Mean**	**SE**		
Loggerhead shrike	0.063	0.048	0.246	0.157	1.760[b]	0.080
Warbling vireo	0.000	0.000	0.000	0.000		
Vireo spp.	0.000	0.000	0.000	0.000		
Western scrub-jay	0.000	0.000	0.000	0.000		
American crow	0.162	0.049	0.054	0.022		
Common raven	0.094	0.069	0.215	0.073		
Horned lark	0.418	0.201	0.339	0.234	0.345[a]	0.727
Corvid spp.	0.000	0.000	0.000	0.000		
Tree swallow	0.000	0.000	0.011	0.012		
Violet-green swallow	0.000	0.000	0.000	0.000		
Cliff swallow	0.060	0.047	0.044	0.035		
Barn swallow	0.000	0.000	0.039	0.044		
Swallow spp.	0.000	0.000	0.000	0.000		
Rock wren	0.000	0.000	0.000	0.000		
House wren	0.000	0.000	0.008	0.009		
Western bluebird	0.000	0.000	0.000	0.000		
Mountain bluebird	0.000	0.000	0.042	0.034		
Bluebird spp.	0.000	0.000	0.005	0.006		
Swainson's thrush	0.000	0.000	0.000	0.000		
Northern mockingbird	0.086	0.077	0.010	0.012		
European starling	1.850	0.730	3.268	1.832	1.845[a]	0.066
American pipit	0.000	0.000	0.000	0.000		
Yellow warbler	0.000	0.000	0.000	0.000		
Black-throated gray warbler	0.000	0.000	0.000	0.000		
Wilson's warbler	0.000	0.000	0.021	0.024		
Western tanager	0.000	0.000	0.023	0.026		
Spotted towhee	0.000	0.000	0.000	0.000		
Savannah sparrow	0.066	0.062	0.014	0.015		
Fox sparrow	0.000	0.000	0.000	0.000		
Lincoln sparrow	0.000	0.000	0.000	0.000		

Species	Fatalities/MW/year at mutually surveyed turbines				Independent samples *t*-value	*P*
	Baseline, 1998-2002		Current study, 2005-2009			
	Mean	**SE**	**Mean**	**SE**		
Golden-crowned sparrow	0.000	0.000	0.031	0.034		
Sparrow spp.	0.000	0.000	0.020	0.022		
Red-winged blackbird	0.492	0.216	0.232	0.147	1.113[a]	0.268
Tricolored blackbird	0.029	0.025	0.053	0.059		
Western meadowlark	2.561	1.258	2.891	1.616	0.325[a]	0.745
Brewer's blackbird	0.278	0.184	0.156	0.103	0.403[a]	0.687
Brown-headed cowbird	0.055	0.046	0.000	0.000		
Blackbird spp.	0.000	0.000	0.463	0.333		
House finch	0.728	0.328	0.000	0.000	2.268[b]	0.025
Lesser goldfinch	0.000	0.000	0.000	0.000		
House sparrow	0.000	0.000	0.008	0.009		
Unknown bird	1.234	0.572	2.620	1.325		
Mexican free-tailed bat	0.000	0.000	0.040	0.035		
Hoary bat	0.115	0.070	0.010	0.011		
Western red bat	0.000	0.000	0.095	0.081		
Unknown bat	0.000	0.000	0.000	0.000		
All bats	0.115	0.070	0.145	0.128	0.292[a]	0.771
All native small birds	8.621	4.352	7.803	4.775	0.310[a]	0.757
All native medium/large birds	0.715	0.308	1.473	0.659		
All native nonraptors	9.335	4.660	9.276	5.434		
All exotic birds	3.388	1.082	7.930	2.692		
All target raptors	2.566	0.588	3.908	0.954	2.546[a]	0.012
All raptors	2.730	0.668	4.188	1.050	2.740[a]	0.007
All birds	15.454	6.410	21.394	9.176	2.500[a]	0.013

[a] Assumed equal variances, because $P > 0.05$ in Levene's Test for Equality of Variances.
[b] Assumed unequal variances, because $P \leq 0.05$ in Levene's Test for Equality of Variances.

Table 3. Comparisons of mean and SE of estimated fatalities per MW per year of birds and bats in the Altamont Pass Wind Resource Area among mutually searched turbines during baseline and current study periods, adjusted for searcher detection and scavenger removal rates based on Smallwood et al. (in press). For select comparisons, I used 2-tailed Independent Samples *t*-tests (df = 229)

	Fatalities/MW/year at mutually surveyed turbines				**Independent samples**	
	Baseline, 1998-2002		**Current study, 2005-2009**			
Species	**Mean**	**SE**	**Mean**	**SE**	***t*-value**	***P***
Mallard	0.298	0.094	0.119	0.065	1.500[b]	0.135
Ring-necked duck	0.000	0.000	0.000	0.000		
Puddle duck	0.000	0.000	0.000	0.000		
Duck spp.	0.000	0.000	0.006	0.006		
Wild turkey	0.020	0.019	0.000	0.000		
Pied-billed grebe	0.000	0.000	0.000	0.000		
Brown pelican	0.000	0.000	0.113	0.113		
Double-crested cormorant	0.025	0.023	0.000	0.000		
Great blue heron	0.000	0.000	0.004	0.004		
Great egret	0.000	0.000	0.113	0.113		
Cattle egret	0.000	0.000	0.000	0.000		
Black-crowned night-heron	0.000	0.000	0.000	0.000		
Turkey vulture	0.020	0.019	0.010	0.006	0.463[a]	0.644
White-tailed kite	0.000	0.000	0.000	0.000		
Northern harrier	0.010	0.006	0.018	0.011	0.672[a]	0.502
Red-shouldered hawk	0.000	0.000	0.000	0.000		
Swainson's hawk	0.000	0.000	0.000	0.000		
Red-tailed hawk	0.827	0.208	1.022	0.156	0.767[a]	0.444
Ferruginous hawk	0.000	0.000	0.002	0.002		
Buteo spp.	0.000	0.000	0.040	0.017		
Hawk spp.	0.000	0.000	0.000	0.000		
Golden eagle	0.116	0.041	0.144	0.036	0.517[a]	0.606
American kestrel	0.455	0.176	0.809	0.345	1.483[b]	0.140
Peregrine falcon	0.000	0.000	0.000	0.000		
Prairie falcon	0.004	0.004	0.004	0.003	0.054[a]	0.957
Falcon spp.	0.000	0.000	0.000	0.000		

Species	Fatalities/MW/year at mutually surveyed turbines				Independent samples t-value	P
	Baseline, 1998-2002		Current study, 2005-2009			
	Mean	SE	Mean	SE		
Raptor	0.010	0.010	0.014	0.011		
Large raptor	0.000	0.000	0.000	0.000		
Small raptor	0.000	0.000	0.015	0.015		
American coot	0.000	0.000	0.000	0.000		
Sandhill crane	0.000	0.000	0.000	0.000		
Killdeer	0.000	0.000	0.027	0.021		
Black-necked stilt	0.000	0.000	0.030	0.030		
American avocet	0.081	0.057	0.004	0.004		
Lesser yellowlegs	0.000	0.000	0.000	0.000		
Bonaparte's gull	0.000	0.000	0.000	0.000		
Ring-billed gull	0.042	0.032	0.004	0.004		
Western gull	0.000	0.000	0.006	0.006		
California gull	0.040	0.021	0.070	0.036		
Herring gull	0.000	0.000	0.006	0.006		
Gull spp.	0.061	0.030	0.280	0.102		
Rock pigeon	3.355	0.751	10.133	1.835	4.135[b]	0.000
Mourning dove	2.062	0.876	0.879	0.352	1.492[b]	0.138
Dove spp.	0.000	0.000	0.248	0.110		
Cockatiel	0.000	0.000	0.034	0.035		
Barn owl	0.155	0.052	0.316	0.064	1.986[b]	0.048
Great-horned owl	0.082	0.043	0.051	0.018	0.659[a]	0.511
Burrowing owl	1.179	0.416	2.374	0.885	2.827[b]	0.005
Common poorwill	0.000	0.000	0.026	0.027		
White-throated swift	0.000	0.000	0.014	0.015		
Northern flicker	0.245	0.158	0.042	0.044		
Hammond's flycatcher	0.000	0.000	0.000	0.000		
Pacific-slope flycatcher	0.052	0.047	0.000	0.000		
Say's phoebe	0.018	0.017	0.000	0.000		
Western kingbird	0.018	0.017	0.000	0.000		
Flycatcher spp.	0.000	0.000	0.034	0.035		

Species	Fatalities/MW/year at mutually surveyed turbines				Independent samples *t*-value	***P***
	Baseline, 1998-2002		Current study, 2005-2009			
	Mean	SE	Mean	SE		
Loggerhead shrike	0.062	0.047	0.269	0.131	1.879[b]	0.062
Warbling vireo	0.000	0.000	0.000	0.000		
Vireo spp.	0.000	0.000	0.000	0.000		
Western scrub-jay	0.000	0.000	0.000	0.000		
American crow	0.115	0.068	0.044	0.031		
Common raven	0.139	0.098	0.314	0.085		
Horned lark	0.390	0.171	0.375	0.202	0.066[a]	0.947
Corvid spp.	0.000	0.000	0.000	0.000		
Tree swallow	0.000	0.000	0.012	0.012		
Violet-green swallow	0.000	0.000	0.000	0.000		
Cliff swallow	0.054	0.047	0.048	0.032		
Barn swallow	0.000	0.000	0.043	0.045		
Swallow spp.	0.000	0.000	0.000	0.000		
Rock wren	0.000	0.000	0.000	0.000		
House wren	0.000	0.000	0.009	0.009		
Western bluebird	0.000	0.000	0.000	0.000		
Mountain bluebird	0.000	0.000	0.046	0.032		
Bluebird spp.	0.000	0.000	0.006	0.006		
Swainson's thrush	0.000	0.000	0.000	0.000		
Northern mockingbird	0.084	0.078	0.012	0.012		
European starling	1.655	0.561	3.594	1.346	2.215[b]	0.013
American pipit	0.000	0.000	0.000	0.000		
Yellow warbler	0.000	0.000	0.000	0.000		
Black-throated gray warbler	0.000	0.000	0.000	0.000		
Wilson's warbler	0.000	0.000	0.023	0.024		
Western tanager	0.000	0.000	0.025	0.026		
Spotted towhee	0.000	0.000	0.000	0.000		
Savannah sparrow	0.066	0.063	0.015	0.015		
Fox sparrow	0.000	0.000	0.000	0.000		
Lincoln sparrow	0.000	0.000	0.000	0.000		

Species	Fatalities/MW/year at mutually surveyed turbines				Independent samples *t*-value	***P***
	Baseline, 1998-2002		Current study, 2005-2009			
	Mean	SE	Mean	SE		
Golden-crowned sparrow	0.000	0.000	0.034	0.035		
Sparrow spp.	0.000	0.000	0.021	0.022		
Red-winged blackbird	0.428	0.186	0.254	0.123	0.842[a]	0.400
Tricolored blackbird	0.027	0.025	0.058	0.060	0.476[a]	0.635
Western meadowlark	2.493	1.029	3.169	1.193	0.661[a]	0.510
Brewer's blackbird	0.276	0.172	0.171	0.088		
Brown-headed cowbird	0.052	0.047	0.000	0.000		
Blackbird spp.	0.000	0.000	0.506	0.298		
House finch	0.641	0.285	0.000	0.000	2.291[b]	0.024
Lesser goldfinch	0.000	0.000	0.000	0.000		
House sparrow	0.000	0.000	0.009	0.010		
Unknown bird	1.165	0.466	3.098	1.063		
Mexican free-tailed bat	0.000	0.000	0.044	0.034		
Hoary bat	0.110	0.066	0.011	0.011		
Western red bat	0.000	0.000	0.104	0.078		
Unknown bat	0.000	0.000	0.000	0.000		
All bats	0.110	0.066	0.159	0.123	0.452[a]	0.652
All native small birds	8.133	3.732	8.551	3.792		
All native medium/large birds	0.800	0.424	2.026	0.850		
All native nonraptors	8.933	4.156	10.577	4.641		
All exotic birds	5.030	1.330	13.770	3.225		
All target raptors	2.577	0.842	4.349	1.421	3.436[a]	0.001
All raptors	2.859	0.976	4.817	1.569	3.665[a]	0.000
All birds	16.821	6.463	29.164	9.435	0.409[b]	0.000

[a] Assumed equal variances, because P > 0.05 in Levene's Test for Equality of Variances.
[b] Assumed unequal variances, because P ≤ 0.05 in Levene's Test for Equality of Variances.

Table 4. Comparison of APWRA-wide fatality rates (i.e., fatalities/MW/search) among 153 turbine strings (1,282 turbines, 141.8 MW) searched twice each during the baseline study (306 total searches in 2002-2003) and again to the nearest corresponding date each subsequent year during the current study (1,167 searches in 2005-2009), using 2-tailed Independent Samples *t*-tests (df = 304).

	Adjusted fatality rate, deaths/MW/search					
	Baseline period		Current study		Independent samples	
Species	**Mean**	**SE**	**Mean**	**SE**	***t*-value**	***P***
Golden eagle	0.0075	0.0043	0.0242	0.0175	-0.927 [a]	0.355
Red-tailed hawk	0.0240	0.0100	0.1493	0.0424	-2.875 [b]	0.005
American kestrel	0.0226	0.0130	0.1299	0.0441	-2.335 [b]	0.021
Burrowing owl	0.0047	0.0047	0.0919	0.0356	-2.430 [b]	0.016
Target species	0.0588	0.0175	0.3953	0.0692	-4.718 [b]	0.000
Total raptors	0.0770	0.0222	0.5136	0.0783	-5.365 [b]	0.000
Total birds	0.3509	0.0739	1.1066	0.1196	-5.374 [b]	0.000

[a] Assumed equal variances, because P > 0.05 in Levene's Test for Equality of Variances.
[b] Assumed unequal variances, because P ≤ 0.05 in Levene's Test for Equality of Variances.

Table 5. Mean (SE) fatality rates of birds and bats in the Altamont Pass Wind Resource Area, adjusted for searcher detection and scavenger removal errors based on national averages (Smallwood 2007).

	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood (2007)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
Species	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Mallard	0.164	0.116	0.069	0.034	0.000	0.000	0.041	0.043	0.000	0.000
Ring-necked duck	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Puddle duck	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Duck spp.	0.000	0.000	0.011	0.008	0.000	0.000	0.000	0.000	0.000	0.000
Wild turkey	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Pied-billed grebe	0.000	0.000	0.000	0.000	0.000	0.000	0.164	0.200	0.000	0.000
Brown pelican	0.127	0.072	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Double-crested cormorant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Great blue heron	0.003	0.003	0.000	0.000	0.000	0.000	0.020	0.021	0.000	0.000
Great egret	0.071	0.072	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cattle egret	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Black-crowned night-heron	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Turkey vulture	0.001	0.001	0.019	0.009	0.004	0.004	0.029	0.030	0.000	0.000
White-tailed kite	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Northern harrier	0.009	0.007	0.011	0.005	0.000	0.000	0.000	0.000	0.000	0.000
Red-shouldered hawk	0.003	0.003	0.000	0.000	0.004	0.004	0.000	0.000	0.000	0.000
Swainson's hawk	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Red-tailed hawk	0.547	0.114	0.477	0.068	0.168	0.076	0.400	0.111	0.200	0.126
Ferruginous hawk	0.011	0.011	0.001	0.001	0.035	0.033	0.010	0.010	0.000	0.000
Buteo spp.	0.016	0.014	0.037	0.011	0.004	0.004	0.000	0.000	0.000	0.000
Hawk spp.	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Golden eagle	0.043	0.017	0.112	0.022	0.018	0.009	0.029	0.021	0.084	0.063
American kestrel	1.340	0.380	0.913	0.224	0.249	0.119	0.069	0.055	0.228	0.112
Peregrine falcon	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000

Species	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood (2007)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Prairie falcon	0.000	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.006	0.006
Falcon spp.	0.000	0.000	0.018	0.021	0.000	0.000	0.000	0.000	0.000	0.000
Raptor	0.000	0.000	0.021	0.007	0.000	0.000	0.000	0.000	0.000	0.000
Large raptor	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Small raptor	0.014	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
American coot	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.013	0.000	0.000
Sandhill crane	0.009	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Killdeer	0.012	0.014	0.021	0.017	0.000	0.000	0.000	0.000	0.000	0.000
Black-necked stilt	0.000	0.000	0.013	0.013	0.000	0.000	0.000	0.000	0.000	0.000
American avocet	0.000	0.000	0.007	0.003	0.000	0.000	0.000	0.000	0.000	0.000
Lesser yellowlegs	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bonaparte's gull	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Ring-billed gull	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Western gull	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
California gull	0.004	0.005	0.085	0.042	0.000	0.000	0.021	0.022	0.180	0.185
Herring gull	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
Gull spp.	0.028	0.021	0.253	0.086	0.071	0.056	0.130	0.065	0.000	0.000
Rock pigeon	4.067	0.749	0.661	0.121	0.118	0.072	0.084	0.051	0.008	0.008
Mourning dove	0.752	0.435	0.327	0.191	0.185	0.182	0.178	0.147	0.000	0.000
Dove spp.	0.131	0.088	0.180	0.114	0.080	0.076	0.000	0.000	0.000	0.000
Cockatiel	0.028	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Barn owl	0.227	0.065	0.123	0.023	0.174	0.078	0.014	0.015	0.026	0.026
Great-horned owl	0.047	0.021	0.036	0.010	0.033	0.019	0.000	0.000	0.000	0.000
Burrowing owl	1.734	0.455	1.322	0.328	0.891	0.465	1.247	0.457	0.000	0.000
Common poorwill	0.022	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
White-throated swift	0.050	0.056	0.012	0.011	0.000	0.000	0.000	0.000	0.000	0.000
Northern flicker	0.018	0.021	0.040	0.034	0.000	0.000	0.000	0.000	0.000	0.000

Species	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood (2007)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Hammond's flycatcher	0.000	0.000	0.002	0.002	0.000	0.000	0.055	0.067	0.000	0.000
Pacific-slope flycatcher	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Say's phoebe	0.000	0.000	0.017	0.020	0.000	0.000	0.055	0.067	0.000	0.000
Western kingbird	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Flycatcher spp.	0.000	0.000	0.023	0.023	0.000	0.000	0.000	0.000	0.000	0.000
Loggerhead shrike	0.199	0.136	0.189	0.120	0.037	0.042	0.109	0.101	0.000	0.000
Warbling vireo	0.000	0.000	0.000	0.000	0.147	0.168	0.000	0.000	0.000	0.000
Vireo spp.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.035
Western scrub-jay	0.000	0.000	0.000	0.000	0.091	0.109	0.000	0.000	0.000	0.000
American crow	0.074	0.027	0.072	0.018	0.000	0.000	0.000	0.000	0.120	0.123
Common raven	0.224	0.088	0.186	0.058	0.062	0.053	0.123	0.090	0.000	0.000
Horned lark	0.618	0.371	0.396	0.242	0.000	0.000	0.109	0.101	0.642	0.472
Corvid spp.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Tree swallow	0.010	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Violet-green swallow	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cliff swallow	0.041	0.032	0.000	0.000	0.128	0.226	0.054	0.066	0.000	0.000
Barn swallow	0.036	0.040	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Swallow spp.	0.000	0.000	0.006	0.007	0.000	0.000	0.000	0.000	0.000	0.000
Rock wren	0.135	0.151	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
House wren	0.000	0.000	0.012	0.011	0.000	0.000	0.000	0.000	0.000	0.000
Western bluebird	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mountain bluebird	0.018	0.020	0.044	0.031	0.000	0.000	0.000	0.000	0.000	0.000
Bluebird spp.	0.101	0.092	0.042	0.035	0.074	0.085	0.000	0.000	0.000	0.000
Swainson's thrush	0.000	0.000	0.006	0.007	0.000	0.000	0.033	0.039	0.000	0.000
Northern mockingbird	0.000	0.000	0.021	0.019	0.000	0.000	0.000	0.000	0.000	0.000
European starling	3.855	2.132	3.527	1.963	0.829	0.594	0.534	0.487	0.000	0.000
American pipit	0.033	0.037	0.022	0.022	0.000	0.000	0.000	0.000	0.000	0.000

Species	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood (2007)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Yellow warbler	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.072	0.079
Black-throated gray warbler	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.035
Wilson's warbler	0.000	0.000	0.013	0.015	0.000	0.000	0.000	0.000	0.000	0.000
Western tanager	0.000	0.000	0.020	0.018	0.000	0.000	0.000	0.000	0.250	0.276
Spotted towhee	0.000	0.000	0.000	0.000	0.000	0.000	0.033	0.039	0.000	0.000
Savannah sparrow	0.012	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fox sparrow	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lincoln sparrow	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Golden-crowned sparrow	0.028	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.053	0.058
Sparrow spp.	0.018	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.072	0.079
Red-winged blackbird	0.310	0.200	0.096	0.062	0.123	0.137	0.000	0.000	0.000	0.000
Tricolored blackbird	0.049	0.055	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
Western meadowlark	3.401	1.905	2.682	1.462	1.509	0.910	1.485	0.943	0.107	0.116
Brewer's blackbird	0.380	0.240	0.070	0.052	0.000	0.000	0.000	0.000	0.122	0.132
Brown-headed cowbird	0.066	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blackbird spp.	0.406	0.300	0.287	0.173	0.150	0.162	0.000	0.000	0.000	0.000
House finch	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.067	0.000	0.000
Lesser goldfinch	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.031	0.035
House sparrow	0.008	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Unknown bird	2.219	1.177	1.807	0.908	0.980	0.909	0.298	0.278	0.244	0.265
Mexican free-tailed bat	0.037	0.033	0.000	0.000	0.000	0.000	0.479	0.448	0.176	0.143
Hoary bat	0.000	0.000	0.000	0.000	0.042	0.048	0.312	0.255	0.872	0.636
Western red bat	0.022	0.024	0.045	0.044	0.016	0.019	0.000	0.000	0.000	0.000
Unknown bat	0.000	0.000	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.000
All bats	0.059	0.057	0.053	0.051	0.058	0.067	0.791	0.703	1.048	0.779
All native small birds	8.586	5.368	5.925	3.470	3.210	2.730	2.525	2.044	1.656	1.580
All native medium and large birds	1.183	0.589	1.122	0.402	0.426	0.385	0.458	0.323	0.301	0.308

Species	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood (2007)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
All native nonraptors	9.769	5.957	7.047	3.872	3.636	3.115	2.983	2.367	1.957	1.888
All exotic birds	7.958	2.922	4.190	2.086	0.946	0.666	0.618	0.537	0.008	0.008
All target raptors	3.664	0.965	2.824	0.641	1.326	0.669	1.745	0.645	0.512	0.301
All raptors	3.994	1.103	3.098	0.735	1.579	0.811	1.798	0.699	0.544	0.333
All birds	21.721	9.982	14.335	6.693	6.162	4.592	5.399	3.603	2.509	2.230

Table 6. Mean (SE) fatality rates of birds and bats in the Altamont Pass Wind Resource Area, adjusted for searcher detection and scavenger removal errors based on a camera-trap study at Vasco Caves Regional Preserve (Smallwood et al. in press).

	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood et al. (in press)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
Species	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
Mallard	0.239	0.163	0.101	0.046	0.000	0.000	0.059	0.061	0.000	0.000
Ring-necked duck	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Puddle duck	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
Duck spp.	0.000	0.000	0.016	0.011	0.000	0.000	0.000	0.000	0.000	0.000
Wild turkey	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Pied-billed grebe	0.000	0.000	0.000	0.000	0.000	0.000	0.186	0.203	0.000	0.000
Brown pelican	0.104	0.104	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Double-crested cormorant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Great blue heron	0.004	0.004	0.000	0.000	0.000	0.000	0.030	0.031	0.000	0.000
Great egret	0.104	0.104	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cattle egret	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Black-crowned night-heron	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Turkey vulture	0.002	0.002	0.032	0.015	0.006	0.006	0.050	0.050	0.000	0.000
White-tailed kite	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Northern harrier	0.016	0.011	0.018	0.008	0.000	0.000	0.000	0.000	0.000	0.000
Red-shouldered hawk	0.004	0.004	0.000	0.000	0.006	0.006	0.000	0.000	0.000	0.000
Swainson's hawk	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Red-tailed hawk	0.936	0.179	0.815	0.096	0.286	0.127	0.683	0.182	0.338	0.218
Ferruginous hawk	0.019	0.019	0.002	0.001	0.059	0.057	0.016	0.017	0.000	0.000
Buteo spp.	0.028	0.023	0.063	0.019	0.007	0.007	0.000	0.000	0.000	0.000
Hawk spp.	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Golden eagle	0.073	0.028	0.192	0.034	0.031	0.016	0.050	0.036	0.143	0.107
American kestrel	1.320	0.533	0.916	0.346	0.248	0.137	0.073	0.058	0.267	0.133
Peregrine falcon	0.000	0.000	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000

Species	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood et al. (in press)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Prairie falcon	0.000	0.000	0.004	0.002	0.000	0.000	0.000	0.000	0.010	0.010
Falcon spp.	0.000	0.000	0.019	0.021	0.000	0.000	0.000	0.000	0.000	0.000
Raptor	0.000	0.000	0.036	0.011	0.000	0.000	0.000	0.000	0.000	0.000
Large raptor	0.000	0.000	0.004	0.003	0.000	0.000	0.000	0.000	0.000	0.000
Small raptor	0.013	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
American coot	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.018	0.000	0.000
Sandhill crane	0.013	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Killdeer	0.014	0.014	0.023	0.015	0.000	0.000	0.000	0.000	0.000	0.000
Black-necked stilt	0.000	0.000	0.019	0.019	0.000	0.000	0.000	0.000	0.000	0.000
American avocet	0.000	0.000	0.006	0.004	0.000	0.000	0.000	0.000	0.000	0.000
Lesser yellowlegs	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Bonaparte's gull	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Ring-billed gull	0.000	0.000	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
Western gull	0.000	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000
California gull	0.007	0.007	0.124	0.057	0.000	0.000	0.030	0.031	0.259	0.272
Herring gull	0.000	0.000	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000
Gull spp.	0.041	0.030	0.369	0.099	0.103	0.079	0.189	0.086	0.000	0.000
Rock pigeon	8.916	1.681	1.444	0.272	0.243	0.158	0.183	0.111	0.018	0.019
Mourning dove	0.822	0.335	0.362	0.145	0.204	0.180	0.201	0.135	0.000	0.000
Dove spp.	0.143	0.076	0.200	0.092	0.087	0.074	0.000	0.000	0.000	0.000
Cockatiel	0.031	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Barn owl	0.388	0.107	0.211	0.035	0.296	0.131	0.025	0.025	0.044	0.045
Great-horned owl	0.080	0.035	0.061	0.017	0.057	0.032	0.000	0.000	0.000	0.000
Burrowing owl	1.707	0.664	1.319	0.501	1.014	0.575	1.311	0.598	0.000	0.000
Common poorwill	0.024	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
White-throated swift	0.054	0.056	0.014	0.011	0.000	0.000	0.000	0.000	0.000	0.000
Northern flicker	0.020	0.021	0.044	0.032	0.000	0.000	0.000	0.000	0.000	0.000

Species	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood et al. (in press)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Hammond's flycatcher	0.000	0.000	0.002	0.002	0.000	0.000	0.062	0.068	0.000	0.000
Pacific-slope flycatcher	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Say's phoebe	0.000	0.000	0.019	0.020	0.000	0.000	0.062	0.068	0.000	0.000
Western kingbird	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Flycatcher spp.	0.000	0.000	0.026	0.023	0.000	0.000	0.000	0.000	0.000	0.000
Loggerhead shrike	0.217	0.119	0.210	0.098	0.041	0.043	0.123	0.097	0.000	0.000
Warbling vireo	0.000	0.000	0.000	0.000	0.162	0.171	0.000	0.000	0.000	0.000
Vireo spp.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036	0.041
Western scrub-jay	0.000	0.000	0.000	0.000	0.102	0.110	0.000	0.000	0.000	0.000
American crow	0.061	0.038	0.059	0.023	0.000	0.000	0.000	0.000	0.173	0.181
Common raven	0.327	0.110	0.271	0.062	0.091	0.075	0.179	0.126	0.000	0.000
Horned lark	0.677	0.295	0.439	0.190	0.000	0.000	0.123	0.096	0.760	0.596
Corvid spp.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Tree swallow	0.011	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Violet-green swallow	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cliff swallow	0.045	0.030	0.000	0.000	0.109	0.230	0.061	0.067	0.000	0.000
Barn swallow	0.039	0.041	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Swallow spp.	0.000	0.000	0.006	0.007	0.000	0.000	0.000	0.000	0.000	0.000
Rock wren	0.147	0.153	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
House wren	0.000	0.000	0.013	0.010	0.000	0.000	0.000	0.000	0.000	0.000
Western bluebird	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mountain bluebird	0.019	0.020	0.048	0.027	0.000	0.000	0.000	0.000	0.000	0.000
Bluebird spp.	0.111	0.089	0.047	0.032	0.082	0.086	0.000	0.000	0.000	0.000
Swainson's thrush	0.000	0.000	0.006	0.007	0.000	0.000	0.037	0.040	0.000	0.000
Northern mockingbird	0.000	0.000	0.023	0.019	0.000	0.000	0.000	0.000	0.000	0.000
European starling	4.214	1.567	3.923	1.377	0.902	0.516	0.604	0.463	0.000	0.000
American pipit	0.036	0.038	0.025	0.021	0.000	0.000	0.000	0.000	0.000	0.000

Species	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood et al. (in press)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Yellow warbler	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.083	0.094
Black-throated gray warbler	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036	0.041
Wilson's warbler	0.000	0.000	0.014	0.015	0.000	0.000	0.000	0.000	0.000	0.000
Western tanager	0.000	0.000	0.022	0.018	0.000	0.000	0.000	0.000	0.290	0.330
Spotted towhee	0.000	0.000	0.000	0.000	0.000	0.000	0.037	0.040	0.000	0.000
Savannah sparrow	0.014	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fox sparrow	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Lincoln sparrow	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Golden-crowned sparrow	0.031	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.064	0.071
Sparrow spp.	0.020	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.083	0.094
Red-winged blackbird	0.339	0.169	0.105	0.051	0.134	0.140	0.000	0.000	0.000	0.000
Tricolored blackbird	0.053	0.055	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000
Western meadowlark	3.726	1.412	2.964	1.019	1.639	0.710	1.680	0.735	0.128	0.143
Brewer's blackbird	0.416	0.199	0.077	0.047	0.000	0.000	0.000	0.000	0.146	0.163
Brown-headed cowbird	0.072	0.075	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Blackbird spp.	0.444	0.272	0.318	0.135	0.168	0.162	0.000	0.000	0.000	0.000
House finch	0.000	0.000	0.000	0.000	0.000	0.000	0.062	0.068	0.000	0.000
Lesser goldfinch	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036	0.041
House sparrow	0.008	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Unknown bird	2.604	0.971	2.147	0.698	1.188	1.007	0.371	0.304	0.293	0.326
Mexican free-tailed bat	0.041	0.032	0.000	0.000	0.000	0.000	0.541	0.430	0.211	0.180
Hoary bat	0.000	0.000	0.000	0.000	0.046	0.049	0.354	0.233	1.039	0.805
Western red bat	0.024	0.025	0.050	0.044	0.018	0.019	0.000	0.000	0.000	0.000
Unknown bat	0.000	0.000	0.008	0.007	0.000	0.000	0.000	0.000	0.000	0.000
All bats	0.064	0.056	0.058	0.050	0.064	0.068	0.895	0.663	1.249	0.985
All native small birds	9.400	4.331	6.551	2.601	3.489	2.515	2.857	1.823	1.957	1.942
All native medium and large birds	1.601	0.786	1.589	0.475	0.621	0.552	0.655	0.452	0.432	0.453

Species	Fatalities/MW/year, 2005-2009, adjusted based on Smallwood et al. (in press)									
	All small turbines, 40-65 KW		Randomly selected turbines, 95-200 KW		All large old-generation turbines, 250-400 KW		Diablo Winds, 660 KW		Buena Vista, 1 MW	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
All native nonraptors	11.000	5.117	8.140	3.077	4.111	3.067	3.512	2.275	2.389	2.395
All exotic birds	13.169	3.289	5.369	1.651	1.145	0.674	0.788	0.575	0.018	0.019
All target raptors	4.035	1.404	3.243	0.977	1.579	0.855	2.117	0.875	0.748	0.459
All raptors	4.591	1.625	3.700	1.117	2.010	1.095	2.208	0.967	0.803	0.513
All birds	28.760	10.032	17.209	5.845	7.266	4.835	6.507	3.816	3.210	2.927

Table 7. Mean and lower and upper bounds of 80% confidence interval (LB, UB) of estimated fatalities per year of birds and bats in the Altamont Pass Wind Resource Area, adjusted for searcher detection and scavenger removal rates based on national averages (Smallwood 2007) and a camera-trap study at Vasco Caves Regional Preserve (Smallwood et al. in press).

	APWRA-wide fatalities/year and 80% CI, 2005-2009					
	Adjusted by Smallwood (2007)			Adjusted by Smallwood et al. (in press)		
Species	**Mean**	**LB**	**UB**	**Mean**	**LB**	**UB**
Mallard	37.9	11.2	64.6	55.3	19.0	91.6
Ring-necked duck	0.0	0.0	0.0	0.0	0.0	0.0
Puddle duck	0.9	-0.3	2.1	1.3	-0.4	3.1
Duck spp.	4.8	0.6	9.0	7.0	1.1	12.8
Wild turkey	0.6	-0.2	1.5	0.9	-0.3	2.1
Pied-billed grebe	3.4	-1.9	8.6	3.8	-1.5	9.1
Brown pelican	5.7	1.6	9.9	4.7	-1.3	10.7
Double-crested cormorant	0.0	0.0	0.0	0.0	0.0	0.0
Great blue heron	0.5	-0.2	1.3	0.8	-0.2	1.8
Great egret	3.2	-1.0	7.4	4.7	-1.3	10.7
Cattle egret	0.0	0.0	0.0	0.0	0.0	0.0
Black-crowned night-heron	0.0	0.0	0.0	0.0	0.0	0.0
Turkey vulture	8.9	2.8	14.9	15.2	5.0	25.4
White-tailed kite	0.3	-0.1	0.6	0.5	-0.1	1.0
Northern harrier	5.0	2.0	8.1	8.6	3.4	13.7
Red-shouldered hawk	0.3	-0.1	0.6	0.5	-0.1	1.1
Swainson's hawk	0.4	-0.1	0.9	0.7	-0.2	1.6
Red-tailed hawk	253.4	195.9	310.9	433.4	347.4	519.4
Ferruginous hawk	2.8	-0.6	6.1	4.7	-1.0	10.3
Buteo spp.	16.8	9.5	24.1	28.7	16.6	40.7
Hawk spp.	0.1	0.0	0.3	0.2	-0.1	0.5
Golden eagle	55.0	37.8	72.2	94.0	66.5	121.5
American kestrel	475.3	315.8	634.9	477.2	239.0	715.3
Peregrine falcon	1.2	-0.4	2.8	2.1	-0.6	4.8
Prairie falcon	1.3	0.3	2.2	2.2	0.5	3.8
Falcon spp.	7.9	-3.6	19.3	8.3	-3.4	20.0

Species	APWRA-wide fatalities/year and 80% CI, 2005-2009					
	Adjusted by Smallwood (2007)			Adjusted by Smallwood et al. (in press)		
	Mean	LB	UB	Mean	LB	UB
Raptor	9.0	5.3	12.8	15.4	9.2	21.6
Large raptor	1.0	0.1	1.9	1.6	0.1	3.2
Small raptor	0.6	-0.2	1.4	0.6	-0.2	1.4
American coot	0.4	0.1	0.8	0.4	-0.1	0.8
Sandhill crane	0.4	-0.1	0.9	0.6	-0.2	1.4
Killdeer	9.7	-0.3	19.7	10.6	1.3	20.0
Black-necked stilt	5.5	-1.6	12.7	8.1	-2.3	18.5
American avocet	2.9	1.4	4.5	2.4	0.2	4.6
Lesser yellowlegs	0.0	0.0	0.0	0.0	0.0	0.0
Bonaparte's gull	0.4	-0.1	0.9	0.6	-0.2	1.4
Ring-billed gull	0.8	-0.2	1.7	1.1	-0.3	2.5
Western gull	1.2	-0.4	2.7	1.7	-0.5	3.9
California gull	44.2	10.9	77.4	64.2	18.6	109.9
Herring gull	1.2	-0.4	2.7	1.7	-0.5	3.9
Gull spp.	116.1	62.5	169.8	169.5	106.3	232.8
Rock pigeon	475.6	359.3	591.8	1,039.7	779.0	1,300.3
Mourning dove	186.9	41.6	332.3	206.4	92.7	320.0
Dove spp.	87.1	14.8	159.4	96.4	36.8	156.1
Cockatiel	1.3	-0.6	3.1	1.4	-0.5	3.3
Barn owl	72.6	50.0	95.2	124.1	88.0	160.2
Great-horned owl	19.0	11.1	26.9	32.5	19.5	45.6
Burrowing owl	713.9	467.4	960.3	718.3	354.0	1,082.6
Common poorwill	1.0	-0.4	2.4	1.1	-0.4	2.5
White-throated swift	7.5	-1.9	16.9	8.3	-1.0	17.6
Northern flicker	18.2	-1.8	38.2	19.9	0.8	39.1
Hammond's flycatcher	1.8	-0.9	4.6	2.1	-0.8	4.9
Pacific-slope flycatcher	0.0	0.0	0.0	0.0	0.0	0.0
Say's phoebe	8.5	-4.1	21.1	9.4	-3.4	22.2
Western kingbird	0.0	0.0	0.0	0.0	0.0	0.0
Flycatcher spp.	10.1	-2.7	22.8	11.1	-1.6	23.7

Species	APWRA-wide fatalities/year and 80% CI, 2005-2009					
	Adjusted by Smallwood (2007)			Adjusted by Smallwood et al. (in press)		
	Mean	**LB**	**UB**	**Mean**	**LB**	**UB**
Loggerhead shrike	94.5	15.2	173.7	104.5	38.6	170.4
Warbling vireo	6.7	-3.1	16.5	7.4	-2.6	17.4
Vireo spp.	1.2	-0.5	2.9	1.4	-0.6	3.4
Western scrub-jay	4.1	-2.2	10.5	4.7	-1.8	11.1
American crow	38.9	21.4	56.3	34.9	11.1	58.7
Common raven	95.4	53.1	137.7	139.4	91.0	187.8
Horned lark	225.1	44.5	405.7	251.0	97.4	404.7
Corvid spp.	0.0	0.0	0.0	0.0	0.0	0.0
Tree swallow	0.5	-0.2	1.1	0.5	-0.2	1.2
Violet-green swallow	0.0	0.0	0.0	0.0	0.0	0.0
Cliff swallow	8.8	-8.0	25.6	8.2	-8.6	25.1
Barn swallow	2.3	-1.0	5.7	2.6	-0.9	6.0
Swallow spp.	2.5	-1.1	6.1	2.7	-0.9	6.4
Rock wren	6.1	-2.7	14.8	6.6	-2.2	15.5
House wren	5.2	-0.8	11.1	5.7	-0.1	11.4
Western bluebird	0.0	0.0	0.0	0.0	0.0	0.0
Mountain bluebird	19.6	1.5	37.7	21.6	5.5	37.7
Bluebird spp.	26.1	-3.4	55.6	29.0	0.9	57.1
Swainson's thrush	3.2	-1.6	8.0	3.6	-1.3	8.4
Northern mockingbird	9.1	-1.6	19.7	9.9	-0.5	20.3
European starling	1,742.5	487.5	2,997.5	1,933.9	1,040.4	2,827.4
American pipit	11.1	-3.1	25.3	12.4	-1.6	26.3
Yellow warbler	2.7	-1.1	6.6	3.2	-1.4	7.8
Black-throated gray warbler	1.2	-0.5	2.9	1.4	-0.6	3.4
Wilson's warbler	5.6	-2.6	13.8	6.2	-2.2	14.5
Western tanager	18.3	-5.3	41.9	20.7	-5.3	46.6
Spotted towhee	0.7	-0.4	1.7	0.8	-0.3	1.8
Savannah sparrow	0.6	-0.2	1.4	0.6	-0.2	1.4
Fox sparrow	0.0	0.0	0.0	0.0	0.0	0.0
Lincoln sparrow	0.7	-0.3	1.8	0.8	-0.3	1.8

Species	APWRA-wide fatalities/year and 80% CI, 2005-2009					
	Adjusted by Smallwood (2007)			Adjusted by Smallwood et al. (in press)		
	Mean	LB	UB	Mean	LB	UB
Golden-crowned sparrow	3.3	-1.3	8.0	3.8	-1.5	9.2
Sparrow spp.	3.5	-1.5	8.5	4.0	-1.7	9.8
Red-winged blackbird	60.8	7.2	114.5	66.7	20.4	113.1
Tricolored blackbird	3.4	-1.5	8.2	3.7	-1.2	8.6
Western meadowlark	1,412.1	410.5	2,413.6	1,559.0	847.0	2,271.0
Brewer's blackbird	51.9	3.1	100.7	57.4	12.2	102.5
Brown-headed cowbird	3.0	-1.3	7.3	3.3	-1.1	7.6
Blackbird spp.	148.7	26.3	271.2	164.7	65.0	264.4
House finch	1.1	-0.6	2.9	1.3	-0.5	3.0
Lesser goldfinch	1.2	-0.5	2.9	1.4	-0.6	3.4
House sparrow	0.3	-0.2	0.8	0.4	-0.1	0.9
Unknown bird	938.9	296.2	1,581.6	1,115.4	591.0	1,639.7
Mexican free-tailed bat	18.1	-2.5	38.7	20.9	-1.0	42.8
Hoary bat	41.4	0.9	81.9	48.8	0.6	97.0
Western red bat	21.2	-5.7	48.1	23.2	-3.4	49.9
Unknown bat	3.1	-0.6	6.8	3.5	-0.1	7.1
All bats	83.9	-7.8	175.6	96.5	-3.9	196.8
All native small birds	3,201.1	683.7	5,718.5	3,538.7	1,562.2	5,515.2
All native medium/large birds	577.0	275.0	879.0	814.8	440.6	1,189.0
All native nonraptors	3,778.1	958.7	6,597.6	4,353.5	2,002.8	6,704.2
All exotic birds	2,220.3	845.9	3,594.7	2,976.3	1,818.5	4,134.1
All target raptors	1,497.6	1,016.9	1,978.3	1,722.9	1,006.9	2,438.8
All raptors	1,644.6	1,092.9	2,196.4	1,968.6	1,143.5	2,793.7
All birds	7,643.1	2,897.5	12,388.7	9,298.4	4,964.8	13,632.0