A Review of Avian Fatality Data in the Altamont Pass Wind Resource Area

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"There are three kinds of lies: lies, damned lies and statistics." [1]

In the California Energy Commission's 2005 environmental performance report, avian mortality caused by turbine blade strike is given as the primary biological impediment to wind development.[2] Mortality estimates for the Altamont Pass wind resource area (APWRA) are given as 881 – 1,300 raptors and 1,766 – 4,721 total avian deaths annually. The Solano County wind resource area is also listed as having unacceptable avian and bat mortality,[3] and the report indicates that the Tehachapi Pass, San Gorgonio Pass and Pacheco Pass wind resource areas require additional studies using 'more current research protocols' to confirm the low mortality found by previous studies in those areas.[4]

One staff document in support of the environmental performance report discusses turbine-related avian mortality, and states "The numbers of birds killed by other human actions are sufficiently large to conclude that any additional mortality caused by wind turbines qualifies as a considerable environmental impact."[5] Although the implication is that even one avian fatality in a wind park would be too many, the magnitude of the cited numbers for the APWRA are indeed cause for alarm.

The staff findings and policy options for dealing with wind turbine mortality include: development of new wind resources only in areas of low avian risk; bat use, behavior and carcass surveys at all existing parks; industry mitigation of avian impacts; industry mitigation measures in the APWRA to reduce avian mortality; industry research and mitigation measures in the Solano County wind resource area to reduce avian and bat mortality; and additional research in the Tehachapi, San Gorgonio and Pacheco Pass wind resource areas.[6]

The amount of activity that could be generated by the listed policy options would be extensive, costly, and restrict or delay new facilities. Such steps are only justified if the mortality estimates upon which avian concerns are based are accurate. As the mortality estimates given in the environmental performance report are from Smallwood and Thelander[7] their study was reviewed to determine the extent of confidence that should be placed in these numbers.

Most mortality estimates of turbine-related avian impacts are the product of a series of assumptions and numerical extrapolations. The validity of each step of the extrapolation should be examined. This includes the assumption that the baseline data are correct and that the extrapolations include all relevant factors. The turbines monitored need to be representative of the total resource, background

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[1] Quote attributed to Benjamin Disraeli in 'Autobiography of Mark Twain', Albert Bigelow Paine ed., 1924.

[2] California Energy Commission Staff Report, '2005 Environmental Performance Report of California's Electrical System', CEC-700-2005-016, June 2005, p 5.

[3] *Ibid* p 5.

[4] *Ibid* p 6.

[5] California Energy Commission Staff Report, 'Assessment of Avian Mortality from Collisions and Electrocutions', CEC-700-2005-015, June 2005, p 15.

[6] *Ibid* p 3 – 4.

[7] Smallwood K.S. and C.G. Thelander, 'Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area', PIER Final Project Report 500-04-052, August 2004, p 3.

avian mortality needs to be considered, the extrapolation factors need to be defensible, and the time span of the study needs to be adequate. When discussing mitigation or reduction of mortality, the assumption that the cause of mortality has been accurately identified and that the remedy proposed will be efficacious needs to be examined. The steps in mortality extrapolation and the proposed mitigation procedures of Smallwood and Thelander will be demonstrated both generally and for two specific birds: the golden eagle and the ferruginous hawk.

The baseline data were generated by standard carcass searches. Two groups of turbines – the first consisting of 1,525 turbines with a rating of 151 MW and the second 2,548 turbines with a rating of 267 MW – were searched.[8] Turbines in the first group were searched for various periods, ranging from somewhat less than one year to 4.5 years, and the second group was searched twice during approximately a 4-month interval.[9] Evaluation of these data focuses first on the confidence that the mortality was turbine related. Some of the birds attributed as turbine kills were found as far as 220 m (720 ft) from the tower, despite the formal search radius of 50 m.[10] And notwithstanding the prevalence in the APWRA of above-ground electrical lines and guy wires, only 0.8% of the mortalities were identified as electrocution deaths and 0.2% as wire strikes.[11] All carcasses for which the cause of mortality was unknown, nearly 10% of the total, were added to those already attributed to wind turbine blade strike.[12] Of 1,189 carcasses found, all but 27 (2%) were attributed to turbines.

The baseline data were not corrected for background mortality – i.e. the number of avian deaths that would occur at the site in the absence of turbines. It would be naïve to expect that birds in the Altamont never die of natural causes. Hunt found that approximately 35% of juvenile golden eagles die in fledging accidents.[13] Lifespan of golden eagles is given as approximately 20 years;[14] ferruginous hawks have a similar lifespan. Of the total population of both species in the APWRA, 5% could be expected to die from aging each year in the absence of turbines. Approximately 8 – 10% of burrowing owls and American kestrels would also reach the ends of their lifespan each year. Hawks, eagles and owls in the APWRA prey upon each other and on other birds present at the site, which would contribute to carcasses with evidence of trauma. Hunt also reported golden eagle deaths from lead and pesticide poisoning and botulism.[15] High avian populations in the APWRA should suggest the possibility of high background mortality, yet this was not considered in the avian mortality calculation. Although there are undeveloped areas of the APWRA with terrain similar to that containing turbines, these areas have not been searched to estimate the site's background mortality.

In Smallwood and Thelander, the baseline data were expressed as deaths/MW/year for each of the two sets of turbines monitored. The fatalities were extrapolated from the specific searched groups of turbines to the Altamont as a whole by calculating a MW-weighted average of the two sets and applying it to the unmonitored turbines.[16] If 151 birds died per year in the first turbine set (with 151 MW) that would yield a value of 1 mortality/MW/year. If 534 birds died per year in the second turbine set (with 267 MW) that would yield a value of 2 mortalities/MW/year. The unmonitored turbines (162 MW) would then be calculated as 1.6 mortalities/MW/year, and all added to arrive at the total APWRA mortality (for this example 950 birds/year).

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[8] *Ibid* p 72.
[9] *Ibid* p 50.
[10] *Ibid* p 39.
[11] *Ibid* p 30.
[12] *Ibid* p 30 & 33.
[13] Hunt G., 'Golden Eagles in a Perilous Landscape: Predicting the Effects of Mitigation for Wind-Turbine Blade-Strike Mortality', PIER Report P500-02-043F, July 2002, p 20.
[14] *Ibid* p 39.
[15] *Ibid* p 20.
[16] Smallwood and Thelander *op. cit.* p 72.

Review of the estimated Altamont mortality total raises a number of questions for the thoughtful reader. Golden eagle deaths in the first turbine set were calculated as 0.038 deaths/MW/year, while 0.14 deaths/MW/year were calculated for the second set, more than three times higher.[17] The second turbine set accounted for 63% of projected total golden eagle mortality. Use of the first turbine set alone would have resulted in a total annual APWRA mortality, before extrapolating for searcher efficiency or scavenging, of approximately 22 eagles/year, while the total with both sets was approximately 59 eagles/year. For ferruginous hawks, no mortalities were found in the first turbine set after searching for up to 4.5 years. The second set, searched for approximately 4 months or less, yielded 2 carcasses[18] and accounted for 100% of the projected APWRA mortality – a number that, before extrapolating for searcher efficiency and scavenging rates, was approximately 13 ferruginous hawks per year as compared to no hawk mortality calculated from the first turbine set.

Smallwood and Thelander speak extensively about the reliability of mortality estimates derived in studies lasting less than one to three years:

"Our new mortality estimates are much larger than those reported in Smallwood and Thelander (in review), but our report to the National Renewable Energy Lab did not include data collected over most of the APWRA where we had not yet been granted access, and it did not include data from the wind turbines because we had not yet completed a full year of fatality searches on these turbines and decided to exclude them from our estimates of mortality. In fact, we had noticed that the mortality estimates representing the Sea West-owned turbines were much larger than observed elsewhere, but we guessed that these larger estimates might be due to time spans consisting of less than a year because the denominator in the mortality estimate would be a fraction and would therefore artificially inflate the mortality estimate, as described in Chapter 3."[19]

"An important point to consider when comparing any standardized measure of mortality between sites is whether the variation in mortality was partly a function of the duration of monitoring used to derive the mortality estimate. Variations in mortality estimates will decline as the monitoring duration increases, and this decline will be most rapid for estimates derived from monitoring that lasts less than a year . . ." [20]

"Mortality estimates based on less than one year of searching are more variable and should be cautiously interpreted when comparing mortality between sites."[21]

"We also found that the variation in mortality estimates is a function of the monitoring period during which carcass searches were performed. Dividing a relatively constant value by a continuous variable will relate to the continuous variable as an inverse power function. . . . Any monitoring duration less than three years is likely to yield unreliable estimates of mortality."[22]

One rarely sees authors so thoroughly repudiate the fatality projections of their own report. Smallwood and Thelander had access to the second, larger set of turbines only for the final 6 months of their study.[23] From their graphical presentation,[24] searching of some turbines apparently

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[17] *Ibid* p 70.
[18] *Ibid* p 64.
[19] *Ibid* p 76.
[20] *Ibid* p A-6.
[21] *Ibid* p A-7.
[22] *Ibid* p A-12.
[23] *Ibid* p 47.
[24] *Ibid* p 50.

began approximately 2 months after access was granted and the latest apparently 3.5 months after access. The maximum study duration for the second set of turbines would therefore be 2.5 – 4 months. The first search set also included at least five strings, with an unknown number of turbines, apparently studied for less than one year. The unreliability of data from studies lasting less than one year, and the preference for studies of three year's duration, was reiterated by a commission staff presentation stating "3 years of monitoring necessary to yield reliable results."[25]

The second monitored turbine set had an undue influence on the calculation of total estimated APWRA mortality. First, because it had a larger MW value than the first set, it contributed nearly two thirds of the mortality estimate for the unmonitored turbines and for the resource area as a whole. Second, because the survey period was so short – for some sites apparently less than 2 months – mortalities were multiplied to adjust for the fraction of year searched. These data carried equal significance in the total mortality calculations despite the concern the authors expressed about the reliability of short-term data. To be sure, for several species (such as northern harrier and turkey vulture) this resulted in a lower estimate of total site mortality than would have been the case had the second set been omitted.

In the next step in extrapolation of observed deaths, mortality estimates were first corrected for the efficiency of the searchers in locating carcasses (producing the lower number in the ranges given for APWRA mortality), and then for the proportion of carcasses that may have been present but removed by scavengers (producing the higher number in the ranges). Searcher efficiency is largely related to bird size, and scavenging to interval between searches. The search interval was given as 53 ± 11.6 days for the first turbine set, and 90 days for the second set.[26] Correction factors used were based on numbers reported by other researchers at the APWRA, and ranged from multiplication of observed raptor mortality by 1.2 in both turbine sets to correct for searcher efficiency, to multiplication by 10.2 to correct for scavenging of small non-raptors in the second set of turbines searched.[27] With the corrections for searcher efficiency and scavenging included, the golden eagle mortality contributed by the second turbine set accounted for 71% of the total estimated mortality, with 116 eagles per year using both data sets and 34 eagles per year if the second set is omitted. The latter number is consistent with the estimate of 39 golden eagles per year found by previous researchers.[28] Ferruginous hawk deaths were projected at 24 per year after correction, as compared to no mortalities if the second data set is omitted.

For small non-raptors in the second turbine set, the combined multiplication factor for searcher efficiency and scavenging was 25, indicating that searchers found only 4% of the carcasses and the remaining 96% were missed or removed. In other words, for every 100 small birds hypothesized to have been killed by those turbines, less than two were actually found and counted since the study lasted less than half a year. For small birds in the second turbine set, the variability introduced by the short study duration is thus exacerbated 25-fold by this extrapolation. The magnitude of these 'correction factors' throws serious doubt on the validity of these data. While the extrapolations are less egregious for the larger birds and raptors, small birds constitute a large proportion of the total estimated kill for the APWRA.

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[25] Spiegel L., 'Avian research program wind turbine issues', presentation at the California Energy Commission committee workshop on electricity environmental performance report, June 2005, p 11.

[26] Smallwood and Thelander *op. cit.* p 51.

[27] *Ibid* p 51 – 52.

[28] Orloff F. and A. Flannery, 'A Continued Examination of Avian Mortality in the Altamont Pass Wind Resource Area', CEC 700-96-004CN, October 1996.

The uncertainty introduced by the size of the correction for scavenging, particularly for the second turbine set, is an indication search intervals were too long. Their correction method for scavenging for both turbine sets also contains a logical flaw – it assumes all birds dying during the search interval died on the first day of the interval. If 80.2% of small birds are scavenged in 40 days, and 100 birds died on the first day of a 40-day interval, you would find 20 birds (or, more precisely 19.8 birds) on the 40th day. To find out (from the 19.8 birds found) how many died on the first day, you would multiply by 5.05 and get 100. Smallwood and Thelander divide their small bird carcasses in the first turbine set by 0.198,[29] mathematically the same as multiplying by 5.05. Birds, however, do not all die on the first day of the interval, but should be expected to die roughly evenly throughout the period. During each 10 days of a 40-day interval, approximately 25% of the birds would be expected to die. For a hypothetical 100 birds dying during the interval, 25 carcasses would be there 10 days or less, another 25 there for 10 – 20 days, etc., and 80% of birds are *not* removed in 10 days. Assuming all birds died on the first day of the search interval results in a gross over-correction for scavenging, and other current avian studies do not make that mistake.

An additional potential bias in the second turbine set is related to the difference in seasonal mortality. This portion of the study took place from November 2002 – May 2003.[30] Winter, the season of highest avian mortality found,[31] was considered to be November 16 through the end of February.[32] If the search frequency graph[33] accurately depicts the second turbine set, searches should have taken place between approximately January 1st and mid-March. The vast majority of carcasses found would thus have died during the winter. Two outcomes could arise from this – either the finding of significantly higher winter mortality is an artifact of studying the second set of turbines, or the annual mortality for the second turbines projected from these data are overestimated by concentration of searches covering the winter period.

The matter of search interval for the second turbine string is also puzzling. Although access to the original raw data has not been granted, making data analysis difficult, one assumes that the strings searched for less than 0.5 years on the graph depicting number of searches and searches per year[34] represent the second turbine set. From graph A, it appears as if they were searched twice. From graph B, the lowest number of searches per year for that turbine set was 6, so there must have been about 2 months (61 days) between those two searches. The highest number of searches per year for that set was approximately 9.5, so for those strings the search interval was about 38 days. This implies the search interval was 38 – 61 days for these strings, not the 90 days given for the second set of turbines. A 90-day search interval should show up on graph B around 4 searches per year. There may be several reasons for this discrepancy, including: 1) the second set of turbines was not depicted in these graphs, and there is yet *another* set of turbine strings searched for less than 4 months; 2) the graphs are incorrect; 3) the calculated search interval (and thus the correction for scavenging) is incorrect.

These avian fatality data have not been evaluated for population-level effects either in the original publication[35] or by the California Energy Commission.[36] It is difficult to determine the extent of effort that should be required to mitigate an impact of unknown biological significance, particularly without confidence in the mortality estimates. But, regardless of the number of birds killed or not

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[29] Smallwood and Thelander *op. cit.* p 52.

[30] *Ibid* p 47.

[31] *Ibid* p 36.

[32] *Ibid* p 182.

[33] *Ibid* p 50.

[34] *Ibid* p 50.

[35] *Ibid* p 11, 76, 353 – 354

[36] California Energy Commission staff report on assessment of avian mortality *op. cit.* p 11.

killed, there needs to be certainty that any mandated measures for reduction of mortality will be efficacious, particularly for measures whose implementation is liable to be costly. Many previous efforts in mortality reduction, such as perch guards and blade tip painting, have proven ineffective; there are conflicting opinions on the efficacy of the rodent control program. Although there are predictions of mortality reductions of up to 40% for a suite of measures suggested for the APWRA,[37] few of them have been tested and their effectiveness remains largely hypothetical.

Recommended mortality reduction efforts fall into two areas: modification of the environment and modification of the turbine including turbine operation. Environmental measures include elimination of the debatable rodent control program, removal of rock piles, exclusion of cattle, reduction of vertical and lateral edge in slope cuts and roads, elimination of rodent burrowing under turbine pads, installation of flight diverters, bringing power poles up to APLIC[38] standards and off-site conservation easements.[39] To these are added removal of defunct meteorological towers and moving parts and equipment away from turbines.[40] Of these remedies, meteorological tower removal, particularly of guyed towers, and bringing power poles to APLIC standards are of known efficacy and should be instituted. Although they will reduce avian mortality from wire strikes and electrocutions in the APWRA, they are unlikely to affect turbine-related avian mortality.

Proposed flight diverters are described as either poles placed beyond the end turbine in a string or removal of the turbine from the end tower in a string. This could serve to divert birds around the end turbine, identified as more hazardous to birds than interior turbines.[41] A cautious approach to the installation of flight diverters is justified, as improper placement could divert birds into rather than away from the turbine. In addition, it has been suggested that active turbines next to derelict turbines have higher avian mortality;[42] this effect may also apply to bird diverters whether they are poles or turbine towers, increasing rather than decreasing mortality at end-of-string turbines. The remaining environmental alterations are assessed as having medium to low impact on the mortality of selected species, except for high estimated mortality reduction for burrowing owls from movement of equipment and grazing management.[43]

Modification of the turbine or its management to reduce mortality includes: removal of derelict turbines, relocation of turbines identified as dangerous, movement of turbines to form 'wind walls' and blade painting.[44] Although not expected to have a direct impact on avian mortality, installation of monitoring equipment to record when each turbine is operating, compilation of these operational data, and installation of accelerometers to detect turbine blade strikes are also suggested to improve mortality investigations.[45] To these measures are added permanent shutdown of some turbines,[46] seasonal shutdown of all turbines and repowering of the APWRA.[47]

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[37] Smallwood and Thelander *op. cit.* p 354.
[38] Avian Power Line Interaction Committee
[39] Smallwood and Thelander *op. cit.* p 350.
[40] Smallwood S. and L. Spiegel, 'Assessment to Support an Adaptive Management Plan for the APWRA', California Energy Commission, January 2005, p 18.
[41] Smallwood and Thelander *op. cit.* p 344.
[42] Smallwood and Spiegel *op. cit.* p 12.
[43] *Ibid* p 18.
[44] Smallwood and Thelander *op. cit.* p 350.
[45] *Ibid* p 346 – 347.
[46] Smallwood and Spiegel *op. cit.* p 7.
[47] *Ibid* p 18.

Blade painting, as described by Hodos,[48] would be investigative in nature, as would be installation of monitoring equipment and accelerometers. These are of uncertain utility, practicality, and/or effectiveness for mortality reduction, and should be neither mandated nor discouraged.

Shutting all turbines down in the fall and winter is projected to reduce mortality for selected species by 44 – 59%, while a winter-only shutdown is projected to reduce avian mortality by 29 – 47%.[49] This proposal arises because studies have found that seasonal avian mortality is not correlated with wind or power production. Smallwood and Thelander found the season of highest avian mortality (approximately 35%) to be winter,[50] and Hunt found golden eagle mortality to be 36% in fall and winter combined, rather than the 20% predicted from seasonal power production data.[51] The projected reductions in mortality assume that *no* birds are killed by non-operating turbines.[52] Therefore, 100% of turbine-related fatalities are presumed to be caused by blade strikes, despite the lack of scientific evidence to support this conclusion and the extensive literature on avian mortality caused by collision with buildings, communication towers, smokestacks, telephone poles, fence posts and other impediments. Neither Smallwood and Thelander nor Smallwood and Spiegel comments on potential causes for this unanticipated winter mortality; Hunt provides some thoughts while acknowledging that they are speculative. Since this significant and unexpected difference in seasonal mortality is not understood, one would hope that the hypothesis that non-operating turbines have no associated avian mortality is thoroughly tested before prescribing it as a mitigation measure for the entire APWRA or for other resource areas.

Removal of derelict turbines reduces opportunities for avian collision, and should be supported. For permanent shut down of turbines without removal, the possibility of collision mortality remains. Both permanent shutdown and movement of 'dangerous' turbines would be costly, but perhaps justified if high confidence was placed in the model identifying them and in the underlying mortality data used to produce the model.

There should be concern about the assumption that repowering of the APWRA will result in significantly reduced avian mortality. Previous assumptions about tubular vs. lattice towers, upwind vs. downwind rotors, and elimination of perching on nacelles have since been disproved and should be cautionary. Smallwood and Thelander reported that raptor mortality estimates in the APWRA, with its older turbines, were equivalent to those of modern parks when mortality was adjusted for relative raptor abundance.[53] The unexpected avian and bat mortality estimated to occur at the Solano County wind resource area, populated with modern turbines, provides additional evidence that repowering may not solve the problems in the Altamont.

In considering enacting recommendations or policy decisions for the Altamont Pass or for other wind resource areas, one should consider what is and particularly what is *not* known about avian interactions with wind turbines, and recall that in the APWRA a 71% reduction in estimated golden eagle mortality and a 100% reduction in estimated ferruginous hawk mortality could be achieved simply by omitting the second, flawed, turbine set.

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[48] Hodos, W., 'Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines', NREL/SR-500-33249, August 2003.

[49] Smallwood and Spiegel *op. cit.* p 9 – 10.

[50] Smallwood and Thelander *op. cit.* p 36.

[51] Hunt *op. cit.* p 22.

[52] Smallwood and Spiegel *op. cit.* p 9.

[53] Smallwood and Thelander *op. cit.* p 80.