ASSESSMENT TO SUPPORT AN ADAPTIVE MANAGEMENT PLAN FOR THE APWRA

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The following mitigation plan for the APWRA is intended to support the early efforts by WEST, Inc to develop viable measures to reduce avian mortality in the APWRA. Herein we provide foundation for the WEST Inc mitigation suggestions with our data based on the NREL/CEC research results published in the CEC final report (Smallwood and Thelander 2004), as well as additional research published by CEC recently (Smallwood and Neher 2005). It also is based on additional analysis and interpretation of data used in these reports, but yet to be published. It is important to note that our assessment is based on 4,074 of the turbines we have necessary information on and does not account for the additional 1,085 turbines that we do not.

The CEC has stated that the mitigation measures in the WEST, Inc December 2004 plan must be justified by scientific information to illustrate that they will in fact result in acceptable levels of reduction in bird fatalities before each can be adopted by the stakeholders. Scientific justification is needed for the ten percent relocation/decommissioning cap, the percentage of turbines shut down seasonally, and the ratios for off-site compensation proposed. These caps appeared to be financially-founded rather than science-founded, and they lacked any relationship to an overall effect. Therefore, the CEC performed preliminary analyses toward using the best science available to quantify and justify the number of turbines that should be removed or seasonally shut down and to estimate more precisely what effect these actions would have on reducing fatalities.

Our assessment indicates that at least 7 to 16% of existing turbines in the APWRA should be permanently shut down and 43 to 100% of them should be seasonally shut down to achieve a desired reduction in bird fatalities. We predict that a permanent shut down of 7% of the turbines could lead to fatality reductions of the four targeted raptor species from 17% to 29% depending on the species, whereas a 16% shut down could lead to 28% to 64% reductions. A winter-time shutdown of all turbines could lead to a 29% to 47% decrease in total fatalities or a 20 % to 45% decrease in fatalities per kWh/year for targeted species, and a fall and winter shutdown could lead to a 44% to 59% decrease in total fatalities or a 17 % to 39% decrease in fatalities per kWh/year for targeted species. Though not entirely additive, implementing both of these measures would lead to a greater reduction in fatality than what is predicted for each measure individually. Permanent shut down of 16% of the 4,074 turbines would remove 89 MW of rated capacity. Seasonal shut down of all turbines during fall and winter would amount to a loss of about 32% of annual power output, whereas shut down during winter only would result in a loss of about 16.4% of annual output.

We also propose that more effort be dedicated to measures that reduce the potential to attract raptors close to the turbines, and we provide a contingency plan that recommends measures to be taken immediately and others to be taken in the event acceptable levels in bird fatalities are not achieved in 3 years. Finally, we provide a recommendation for off-site mitigation to compensate for the level of bird loss that can not be mitigated while providing incentive to the operators to continue their efforts to reduce these losses and maintain mitigation commensurate with the actual loss of bird lives.

It is our assessment that a combination of these measures, following our science-founded guidelines, is most appropriate to mitigate the existing conditions while taking into consideration the turbine operators' potential capacity losses. We strongly urge, however, that those members of the scientific community, who expressed their deep concerns and willingness to participate, be involved and agreeable to adopting our proposed plan (e.g., Pete Bloom, Grainger Hunt, Hans Peeters and Robert Risebrough, who authored a comment letter to the Alameda County Board of Supervisors on November 4, 2004).

ADAPTIVE MANAGEMENT

The ultimate strategy should be an adaptive management plan, meaning that it should include the following steps (Haney and Power 1996, and see Smallwood et al. 1999):

(1) Compile all existing data;
(2) Develop project goals;
(3) Develop working hypotheses;
(4) Implement the prescriptions;
(5) Monitor results;
(6) Evaluate and test monitoring data, and
(7) Return to step #3.

A common misbelieve is that adaptive management is a trial and error approach. It is not (see Holling 1978 and Walters 1986 for original concepts). It includes the steps listed above, or some variation on this scheme that ensures adequate scale, replication and interspersion of control and prescribed treatments are in place (Smallwood et al. 1999). Adaptive management is ideally suited to an applied conservation problem in which the conservation measures needed take precedence over experimental designs typical of basic research science, including classical experimental block designs. An example of a working adaptive management plan can be found in Smallwood and Morrison (2004).

In the case of the APWRA, the existing data have been compiled and working hypotheses developed. Needed are steps 2 and 4 through 7 of the Haney and Power (1996) adaptive management approach. As steps 3, 4 and 7 are implemented, it will be at least as important to consider the consequences of committing Type II errors in statistical hypothesis testing as considering the consequences of committing Type I error (National Research Council 1986, Shrader-Frechette 1992).[a] A principal need, and one that has been raised repeatedly in comments to previous management plans and in meetings, is the goal statement.

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[a] A Type I error is the rejection of the null hypothesis when in fact it is true, and a Type II error is not rejecting the null hypothesis when in fact it is false. As an example, if a null hypothesis was that rock piles located nearby wind turbines have no effect on raptor mortality, then a Type I error would be rejecting it and concluding incorrectly that

THE GOAL

The goal of the Migratory Bird Treaty Act is no take of any birds protected by this act. The U.S. Fish and Wildlife Service stated its goal for the APWRA is (1) a substantial reduction in bird mortality; and (2) a demonstrated declining trajectory of bird mortality though time. The appellants in litigation directed toward the wind turbine owners identified a short-term (2-year) or interim goal of 40% reduction of mortality and a long-term goal of much greater mortality reduction, although they have not identified a specific percentage reduction to be achieved over the long term. The turbine owners have not identified a specific goal.

The CEC suggests that the **50%** reduction based on the mortality levels reported in Smallwood and Thelander (2004, Table 3-10) should be achieved within three years,[b] using the following recommended prescriptions. At that time the efficacy of the prescriptions should be assessed, and if necessary alternative prescriptions should be implemented to achieve an **85%** reduction in mortality within the next three years (over a total time span of six years of treatments). Because a realistic scenario cannot account for 100% reduction in mortality, compensation shall be required to off-set the remainder of losses. This plan incorporates measures to be taken immediately, as well as contingency measures in the event that the stated goal of 50% reduction is not accomplished in three years, and a phased approach to off-site compensation in the event that the goals are exceeded. One prescription, which would initiate an entirely new set of environmental review documents pursuant to CEQA, would be the decommissioning and shutting down of all existing wind turbines of older design and the initiation of repowering projects.

Determining the success of this plan relies on the implementation of a rigorous monitoring effort that should be peer-reviewed by qualified scientists. Should alternative prescriptions other than repowering be implemented three years from now, only to fail to achieve an 85% reduction within six years from now, more aggressive measures such as the removal of all the wind turbines of older design should be considered.

RECOMMENDED PRESCRIPTIONS

<u>Immediate Implementation</u>

Selective relocation/shutdown of operating turbines

As a first step toward determining the appropriate number of turbines to shut down or relocate, we modified Smallwood and Thelander's (2004) ratings of collision threat posed by each turbine

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relocating rock piles will reduce raptor mortality. The resulting management action would be the removal of rock piles from nearby wind turbines, costing the turbine owners money but not affecting raptors at all. A Type II error would be incorrectly not rejecting the null hypothesis, and as a result deciding not to remove the rock piles even though they are indeed related to increased raptor mortality. The National Research Council (1986) advocated erring on the side of caution, and biasing management actions toward avoiding the consequences of Type II error in hypothesis-testing.

[b] This timeframe is to correspond with the time needed to reliably detect an effect of the treatments applied.

for golden eagle, American kestrel and burrowing owl. In Smallwood and Thelander, rating values ≤0 represented lesser levels of collision threat, whereas values >0 represented greater levels of threat – a very simple breakdown. We examined the frequency distributions of collision threat and added a third level in support of a management plan in the APWRA. The new scoring values are listed in Table 1.

Table 1. Crosswalk between collision threat ratings in Smallwood and Thelander (2004) and the levels used in this assessment.

American kestrel ratings		**Burrowing owl ratings**		**Golden eagle ratings**	
CEC report	**This exercise**	**CEC report**	**This exercise**	**CEC report**	**This exercise**
≤0	0	≤0	0	≤0	0
1 to 13	1	1 to 13	1	1 to 31	1
≥14	2	≥14	2	≥32	2

Smallwood and Thelander's (2004) ratings of collision threat to red-tailed hawk resulted in a low percentage correct classification of reported fatalities, so we abandoned that rating system and developed another scoring system based on the landscape attributes that associated more strongly with red-tailed hawk fatalities and that were relatively orthogonal in their inter-relationships. We scored wind turbines for their threat to red-tailed hawks according to the following conditions:

Condition	**Score**
At the end of a turbine string	1
In a canyon	1
On steep slopes, ≥10˚	1
Fewer than 13 other turbines within 300 meters	1
At the edge of a local cluster of turbines	1
On a northwest-facing slope	1
Lots of vertical and lateral edge near tower base	1
Sum Score	______

We then aggregated the red-tailed hawk sum scores accordingly:

Sum Score	**Index of Collision Threat**
0 to 1	0
2 to 3	1
4 to 7	2

Our new scoring system of threat level to red-tailed hawk resulted in 70% correct classification of fatalities in our data base, which was a substantial improvement of our predictive power.

Additional modifications were made to the ratings of collision threat to burrowing owl and golden eagle, the fatalities of which associated significantly with ratings of 10-m grid cells for their orientation to prevailing winds and to the larger topography of which each is part. Wind turbines on slopes exposed to either northwest or southwest winds killed disproportionately more burrowing owls, and wind turbines on slopes exposed to one of these prevailing wind directions as well as perpendicular to the other prevailing wind direction killed disproportionately more golden eagles. We added the value 1 to the ratings of turbines with these conditions. Additional improvements to our rating system may be possible following continued hypothesis-testing between avian fatalities in the APWRA and wind and topographic conditions.

Table 2 summarizes the new scoring systems and how each of these indices fared at representing the fatalities in our data base. The documented fatalities associated strongly with the indices produced. For example, wind turbines rated the greatest threat level to golden eagles also were reported by Smallwood and Thelander (2004) to have killed more than three times the number of eagles compared to the number expected by chance, and the turbines rated least threatening to eagles also killed only 28% of the number expected by chance.

Table 2. Summary of fatalities and number of turbines associated with each Index value, as well as the proportion of the total fatality search effort, and the ratio of the observed and expected number of fatalities associated with each index value. Expected values are the total number of fatalities of the species multiplied by the proportion of the fatality search effort (proportion of cumulative time turbines were searched).

Species, Index value	**Proportion of fatality search effort**	**No. turbines**	**Fatalities**	**Observed ÷ Expected fatalities**
Golden eagle			54	
0	0.52372	1643	8	0.28
1	0.26261	1093	6	0.41
2	0.15474	1022	30	3.59
3	0.05893	316	10	3.14
Red-tailed hawk			213	
0	0.51202	1773	64	0.59
1	0.37154	1742	99	1.25
2	0.11644	559	50	2.02
American kestrel			59	
0	0.51147	1370	15	0.50
1	0.34319	2202	26	1.26
2	0.14535	502	18	2.10
Burrowing owl			69	
0	0.43029	2121	12	0.40
1	0.22798	1062	12	0.76
2	0.27644	704	29	1.52
3	0.06529	187	16	3.55

We tried several approaches to combining the indices of collision threat among our four focal raptor species. The disparity in index values between golden eagle and burrowing owl, and between red-tailed hawk and burrowing owl, made simple approaches difficult. The turbines rated more dangerous to burrowing owl were rarely also rated more dangerous to golden eagle or red-tailed hawk. We found that the ratings corresponded fairly well between golden eagle and red-tailed hawk, as well as between burrowing owl and American kestrel. In order to more equitably select turbines dangerous to both groups of raptors, we settled upon conditional statements, because this approach was more directed toward identifying the most dangerous wind turbines to these two relatively disparate groups of raptors. Derelict wind turbines were excluded from this assessment because they are addressed separately in the mitigation plan. Table 3 presents the conditional statements and what we suggest are their associated tiers of shutdown/relocation priority, and Figure 1 illustrates the frequency distribution of the wind turbines in these tiers.

Table 3. Conditional statements used to identify tiers of wind turbines to consider for shutdown or relocation in priority order.

GOEA index	operator	RTHA index	operator	BUOW index	operator	AMKE index	Priority Tier	Number of turbines
≥3	and	≥2	and	≥1	and	≥1	1	34
≥1	or	≥1	and	≥3	and	≥1	1	66
≥3	or	≥2	and	≥3	or	≥2	1	30
≥3	and	≥2	and	---	and	---	2	113
---	and	---	and	≥2	and	≥2	2	51
≥2	and	≥2	and	≥1	and	≥1	3	225
≥1	and	≥2	and	≥1	and	≥1	3	134
≥1	and	≥1	and	---	and	---	4	1101
else the turbine was assigned to Tier 5							5	2544

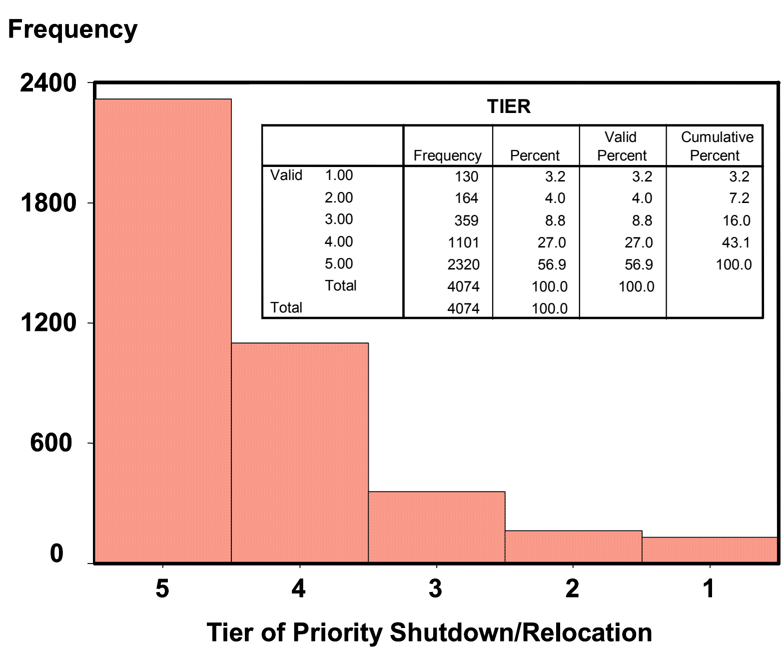

Figure 1. Frequency distribution of the Index of Raptor Threat based on collision threat ratings for golden eagle, red-tailed hawk, American kestrel and burrowing owl. Turbines in Tier 1 were regarded as highest threat.

Turbines in priority tier 1 (130) and Tier 2 (164) ought to be relocated or permanently shut down. Turbines in tier 3 are more numerous, including 359 turbines, and should be strongly considered for shutdown or relocation, perhaps considering additional factors as well. Figure 2 depicts the spatial distribution of the turbines by priority tiers for consideration of being relocated or shut down. After these initial sets of turbines are identified for relocation or shut-down, some additional turbines will likely be identified for relocation or shutdown because they are otherwise left isolated and therefore pose a new threat to raptors. Another group of turbines will be identified for relocation or shutdown after we incorporate the location and attribute data of the 1,085 turbines yet to be included in our data base (WEST, Inc is working to fill this data base gap).

Restricting our assessment to the wind turbines we have characterized in our data set, and beginning it with mortality estimates representing the averages between the low and high ends of the uncertainty ranges in Smallwood and Thelander (2004), we estimated the changes in mortality due to the selective shutdown of the turbines in Tiers 1 and 2 and Tiers 1 through 3. We assume these turbines are shut down rather than relocated. A shutdown of all turbines in Tiers 1 and 2 would remove 47 MW of rated capacity from the 4,074 turbines considered, or about 10.7% of the APWRA's annual production, and shutdown of all turbines in Tiers 1 through 3 would remove 89 MW of capacity, or about 20.3% of annual production. Table 4 summarizes the mortality changes predicted by shutting down all 294 turbines in Tiers 1 and 2, and Table 5 summarizes mortality changes predicted by shutting down all 653 turbines in Tiers 1 through 3.

Table 4. Summary of fatality and mortality reductions after shutting down all wind turbines within priority tiers 1 and 2, totaling 47 MW of rated capacity or 10.65% of the capacity used in this exercise.

Focal Raptor Species	Total Fatality Estimate		Total Fatality Reduction	Total Mortality Reduction (deaths/MW/year)
	Among 4,074 turbines	Among turbines in Tiers 1-3		
Golden eagle	72	21	29%	21%
Red-tailed hawk	191	37	19%	10%
American kestrel	152	26	17%	8%
Burrowing owl	179	34	19%	10%

Table 5. Summary of fatality and mortality reductions after shutting down all wind turbines within priority tiers 1 through 3, totaling 89 MW of rated capacity or 20.30% of the capacity used in this exercise.

Focal Raptor Species	Total Fatality Estimate		Total Fatality Reduction	Total Mortality Reduction (deaths/MW/year)
	Among 4,074 turbines	Among turbines in Tiers 1-3		
Golden eagle	72	46	64%	55%
Red-tailed hawk	191	69	36%	20%
American kestrel	152	43	28%	11%

Burrowing owl	179	53	30%	13%

Shutting down turbines in tiers 1 through 3 would substantially lessen golden eagle mortality in the APWRA, and would be fairly effective at reducing red-tailed hawk fatalities. The total fatalities of American kestrel and burrowing owl are estimated to decline up to 30%, although the reductions are less promising on a per-MW basis. Overall, the indices of collision threat contributed effectively to careful selection of wind turbines for consideration to be shut down, and the turbines we selected would contribute disproportionately to reductions in raptor fatalities.

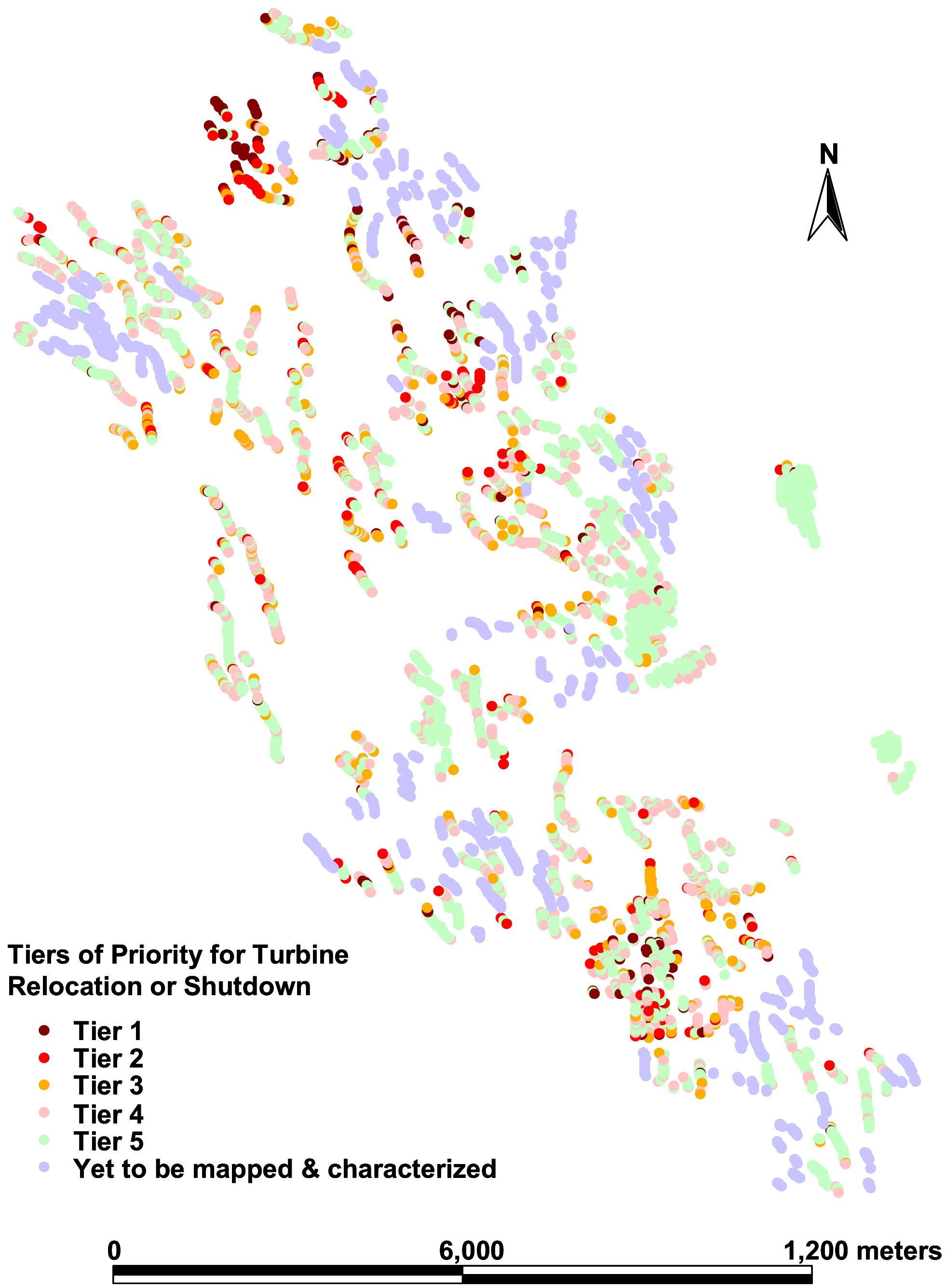

Figure 2. Map of wind turbine locations depicting Ratings of Raptor Threat across the APWRA.

Seasonal shutdown

Shutting down all of the wind turbines during fall and winter (October through February) would likely reduce mortality by half of current levels, while costing the turbine owners 32% of their wind power output, and shutting down the turbines only during winter would reduce mortality by a third and annual production by about 16%.[c] Some examples of results for a fall/winter shutdown are in Table 6, and other examples are in Table 7 for a winter-time shutdown. In our examples, we use the middle value between the low and high mortality estimates in the CEC final report as a baseline. The ratio of χ^2 observed to expected numbers of fatalities during fall and winter were used as multipliers against the number of fatalities one would expect of a uniform distribution of the total fatalities across seasons, accounting for the differential proportions of the year spanned by each season.[d] For example, winter was defined by Smallwood and Thelander as November 15 through the end of February, or 3.5 months (0.29 years). The total annual fatalities estimated for red-tailed hawk was 255, so 255 x 0.29 = 74 red-tailed hawk fatalities during winter, assuming a uniform distribution of fatalities among seasons. Then, using the ratio of observed to expected fatalities in winter as a multiplier, we get 1.35 x 74 = 100 red-tailed hawk fatalities estimated for winter. Thus, shutting down turbines in winter would result in a 39% reduction in red-tailed hawk fatalities (Table 7).

Table 6. Fall and winter influence on turbine-caused mortality and the benefits attributable to fall/winter shutdown. The APWRA produced 32% of its power during this period in 1999.

Species	**Annual fatality estimate**	**Obs÷Exp in fall**	**Obs÷Exp in winter**	**Percent decrease in total fatalities**	**Percent decrease in deaths/kWh/ year**	**Ratio of fall/winter to Spring/Summe r mortality**
Golden eagle	96	1[a]	1[a]	44	17	1.7
Red-tailed hawk	255	1.32	1.35	59	39	3.0
American kestrel	203	0.70	1.61	57	37	2.8
Burrowing owl	240	0.84	1.20	47	22	1.9
Raptors	1091	1.00	1.27	52	29	2.3
Birds	3244	0.82	1.15	45	20	1.8

[a] χ^2 test result was not significant.

[c] Based on turbine output data for the year 1999 across the APWRA.

[d] These ratios are needed because fatality search efforts were unequal between seasons.

Table 7. Winter influence on turbine-caused mortality and the benefits attributable to a winter shutdown. The APWRA produced 16.4% of its power during this period in 1999.

Species	**Annual fatality estimate**	**Obs÷Exp in winter**	**Percent decrease in total fatalities**	**Percent decrease in deaths/kWh/year**	**Ratio of winter to spring, summer & fall mortality**
Golden eagle	96	1[a]	29	20	2.2
Red-tailed hawk	255	1.35	39	34	3.6
American kestrel	203	1.61	47	45	5.2
Burrowing owl	240	1.20	35	28	3.0
Raptors	1091	1.27	37	31	3.3
Birds	3244	1.15	34	26	2.8

[a] χ^2 test result was not significant.

In Table 6, the estimated number of deaths during fall and winter, as well as during spring and summer, were divided by the proportion of the year's power output during these seasons,[e] resulting in 17 to 39% reductions in mortality among the raptors listed in the table. However, a more dramatic representation of the disproportionate fall and winter mortality is summarized in the right-hand column of the table, which shows the ratio between fall and winter mortality and spring and summer mortality, factoring in power output to each estimate of mortality. For example, red-tailed hawks are killed 3 times more often per kWh during fall and winter than during spring and summer, and American kestrels are killed 2.8 times more often. Wind power during fall and winter causes a much greater impact to birds than it does during spring and summer.

In Table 7, the estimated mortality during winter as opposed to the rest of the year indicated that a winter-time shutdown would result in 20% to 45% reductions in mortality among the raptors listed in the table. The ratio between winter mortality and mortality throughout the rest of the year was 5.2 for American kestrel, and 2.2 for golden eagle, meaning a winter-time shutdown would save more than twice the number of golden eagles as expected by chance, and more than five times the American kestrels. Based on our assessment, a winter shutdown may make better sense than a fall and winter shutdown. We recommend that a shutdown extend from November 1 until the end of February at the earliest. Additional investigation of the merits of an early spring shutdown also should be performed.

During winter, winds in the APWRA are sporadic and often inadequate for generating power. The blades of wind turbines often move while not actually generating electrical power. These moving blades can still strike and kill birds, however. During winter, and perhaps part of the fall and part of the early spring, wind turbines should be shut down and their blades kept from moving. If feasible, turbine blades should be kept from moving whenever the turbine is not generating power, no matter the time of year.

[e] Again, we used data representing the entire APWRA in 1999.

It may be possible to continue operating a select minority of the wind turbines during winter without causing raptor fatalities. These select turbines might be those in wind walls, as well as turbines on ridge crests in the interior of strings. Additional analysis will be needed to justify the selection of these turbines.

Cease rodent control program

The turbine owners began participating with a rodent control program in 1997 by funding the County to provide rodent control services and by recruiting land owners to participate with the program. This program was never subjected to a public review and no CEQA document was prepared to summarize its environmental impacts, including indirect and cumulative impacts. Being out of compliance with CEQA, this program should be terminated. Additionally, Thelander et al. (2003) and Smallwood and Thelander (2004) found that the program did not reduce bird activity levels or mortality to the degree expected by the turbine owners, and in some cases may have contributed to additional raptor mortality. For these reasons, the turbine operators agreed to cease participation in the rodent control program. We concur with this measure and assert that by doing so the turbine owners will not be in violation of CEQA in this regard.

To promote the health of the ecosystem, we also recommend that the turbine owners and County take additional steps to recruit land owners to desist with their rodent control programs.

Retrofit electric distribution poles so they are APLIC-compliant

Many electric poles in the APWRA pose electrocution hazards to birds, although it should be kept in mind that mortality due to electrocutions is much lower than due to bird collisions with wind turbines. All of the poles in the APWRA should be APLIC-compliant. Poles that should be retrofitted first are those supporting equipment such as riser elements, lightning arrestors, capacitors, transformers, regulators and switches. Proper insulation and spacing should be added to every pole in the APWRA.

Move rock piles

Rock piles created artificially during construction of the APWRA should be relocated when they are within 60 m of operating wind turbines. Each of these rock piles need to be moved at least 140 m away, and at least 200 m from any other wind turbines. The preferable location to move these rock piles is downslope to lower elevations, such as in ravines or nearer valleys. In the December 2004 WEST Inc plan, concern was raised that removing rock piles was a concern to FWS due to potential impacts to San Joaquin kit fox. However, the piles were placed as refugia for kit fox prey and moving them, rather than removing them, will still serve that purpose. Moving rock piles away from turbines will also lesson the attraction factor for raptors to forage near turbines.

Retrofit tower pads

Wherever fossorial mammals are found to be burrowing under tower pads, fill holes and pad overhangs with soil and surround pad with gravel out to a perimeter of at least 5 feet from the pad. Use sufficient gravel to cover the ground by a few inches. This measure will discourage mammals from burrowing under tower pads.

Move parts and equipment away from wind turbines

At various locations in the APWRA, wind turbine parts and pieces of equipment are stored on the ground nearby operating wind turbines. These collections of parts and equipment are heavily utilized by desert cottontails for cover, and may draw the attention of foraging golden eagles. These parts and pieces of equipment should be moved to locations that are at least 200 m from operating wind turbines.

Remove derelict wind turbines

All wind towers and turbines not working any more should either be repaired and put back into service immediately or removed from the APWRA. Both behavioral and fatality evidence suggest that wind turbines adjacent to derelict turbines are more dangerous. Apparently aware of when wind turbines are operating, raptors may preferentially perch on derelict turbines while the blades of others are moving. Perched raptors often instigate approach and avoidance behaviors by other flying raptors, and these behaviors may often be made nearby the adjacent turbines with moving blades. Derelict turbines should be repaired or removed and their pads either abandoned or used by a translocated turbine, depending on the situation.

Derelict turbines removed from the ends of rows (strings) should be left vacated and the site decommissioned. Derelict turbines removed from the interiors of turbine strings should be replaced by whichever turbine composes the most dangerous end of the string, where danger is assessed by steepness of slope and exposure to prevailing northwest or southwest winds in priority order.

Remove superfluous meteorological towers

All non-working or superfluous meteorological towers, and especially those supported in place by guy wires, need to be identified and removed from the APWRA. Evidence from other settings and other studies demonstrated that these sorts of structures are hazardous to low-flying birds such as western meadowlarks, horned larks, and burrowing owls.

The removal of meteorological towers, guy wires supporting decommissioned wind turbines, and overhead lines should not be regarded as mitigation measures for the continued operation of existing wind turbines when these removals were part of a repowering project. The only removals of these types of structures to be considered mitigation under this plan will be those that are not part of an ongoing repowering project.

Off-site compensatory mitigation

The CEC has developed some mitigation alternatives for consideration by the Counties, regulators, industry, species experts and other stakeholders (Chart 1). We also present the pros and cons to consider about each alternative. For an existing wind farm, we recommend a fee based on known mortality that should be adjusted annually to account for reduction in mortality documented by scientific monitoring of fatalities. For repowering and all new projects, we recommend a combination of our physical and impact bases. Both systems are equity-based with incentives to avoid, reduce and minimize avian impacts. We acknowledge that these recommended alternatives are in need of refining and that actual fees will need to based and periodically adjusted to account for real estate values, but believe they serve as a starting point for further negotiation.

Chart 1. Offsite compensatory mitigation guideline alternatives.

Physical basis of fee	***Pros***	***Cons***
1. Per turbine 2. Per m^2 rotor swept area 3. Per MW rated capacity 4. Per KW-hour (perhaps following first year)	1. Would be assessed evenly across wind farms 2. Nos. 2, 3, or 4 the most consistent 3. Easy to enforce 4. Minimal follow up for industry or fee assessors	1. Per turbine may not be the most equitable 2.Doesn't distinguish between areas that have high bird use/kills and low bird use/kills

Impact basis of fee	***Pros***	***Cons***
1. Number of birds observed/hour at height domain of proposed rotor plane during preconstruction surveys 2. Number of birds killed/MW/year or some similar metric based on post-construction monitoring 3. Estimated or realized total number of birds killed based on post-construction monitoring	1. Good relationship to actual impacts 2. Could weight for different species 3. Real time impact and mitigation 4. Incentive to reduce bird kills	1. Difficult to determine preexisting conditions if turbines exist on the site 2. Although standardized survey would be required, could be a potential for ongoing disagreements

From the alternatives in Chart 1, we put together the following phased, impact-based mitigation fee system for the continued operation of the existing turbines in the APWRA.

From Chart 1 we also put together the following phased, impact-based mitigation fee system for any new or repowered wind projects in the APWRA.

Phased, Impact-based Mitigation Fee for continued operations of existing turbines in the APWRA

(1) Use the middle values between the low and high ends of the mortality range estimates in the CEC final report in order to assess the per-kWh fee:

5.60 bird fatalities per MW of rated capacity per year,
1.88 raptor fatalities per MW of rated capacity per year,
3.72 non-raptor bird fatalities per MW of rated capacity per year.

Assuming we assess a premium fee to raptors of 2 times the fee for non-raptor birds (standard bird), we arrive at 7.48 standard birds per MW per year. Assuming we assess 0.1 cents per kWh for every 1 standard bird/MW/year, then in this case we would assess 0.748 cents per kWh.

(2) Pay fee per kWh generated during the previous year.

The assessed fee is multiplied by last year's total kWh to arrive at an offsite mitigation fund. For example, assuming a 113-MW project generated 200,000,000 kWh last year, the fee assessment would net $1,496,000. Assuming the APWRA generated about 874,700,000 kWh last year, the APWRA-wide fee assessment would be $6,542,756.

(3) The fee is paid into an interest-bearing account dedicated as an offsite mitigation fund. After three years, fatality monitoring data are used to compare mortality during that time period to mortality estimates used in the original fee assessment. Fee overpayments are then refunded to the owners, less interest, and the rest remains part of the mitigation fund. The fatality monitoring data are used to adjust the fee into the future, linking the observed mortality levels to a new per-kWh fee. Applicant pays adjusted fee henceforth unless and until applicant again funds scientific monitoring to detect whether any new conditions, such as new mitigation measures or new turbines, resulted in reduced mortality. Documented changes in mortality could lead to another refund and another adjustment in the per-kWh fee.

Phased, Impact-based Mitigation Fee for New Wind Farms

(1) Based on preconstruction surveys and bird observations per hour, estimate mortality in order to asses per-kWh fee:

Bird mortality (deaths/MW/year) = 0.109 + 0.0755×Birds observed/hour (1)
$r^2 = 0.49$, RMSE = 1.17, P = 0.025

Raptor mortality (deaths/MW/year) = -0.207 + 0.0348×Birds observed/hour (2)
$r^2 = 0.70$, RMSE = 0.34, P = 0.003

Note: Eqns 1 and 2 are from CEC final report, and are based on all wind farms in the US from which estimates of bird activity levels and mortality levels were reported.

E.g., Preconstruction surveys detect 30 birds per hour during standardized point counts, averaged across seasons of the year within a project area slated for a 113-MW project. Eqn. 1 predicts bird mortality at 2.374/MW/year and raptor mortality at 0.837/MW/year, leaving non-raptor mortality at 1.537/MW/year. Assuming we assess a premium fee to raptors of 2 times the fee for non-raptor birds (standard bird), and assuming we assess 0.1 cents per kWh for every 1 standard bird/MW/year, then in this case we would assess 0.32 cents per kWh. Assuming this 113-MW project generates 200,000,000 kWh per year (on average), then the fee assessment would net $642,200 after the average year.

(2) Pay fee per kWh during first 3 years
Part of fee (e.g., 20%) covers fatality monitoring up to 3 years
Part of fee (e.g., 80%) goes to interest-bearing fund dedicated to offsite mitigation

Note: After 3 years the fund manager has spent $385,320 on fatality monitoring, which is non-refundable, and has $1,541,280 in the mitigation account, not including accumulated interest. The mitigation account may be refundable (see below).

(3) After first 3 years, monitoring data are used to compare observed to predicted avian mortality. The mitigation portion of any over-prediction is refunded to the applicant, less interest. Fatality monitoring data are also used to adjust fee into the future, linking the observed mortality levels to a new per-kWh fee. Applicant pays adjusted fee henceforth unless and until applicant again funds scientific monitoring to detect whether any new conditions, such as new mitigation measures or new turbines, resulted in reduced mortality. Documented changes in mortality could lead to another refund and another adjustment in the per-kWh fee.

Note: If observed mortality levels equal predicted levels, and the applicant opts out of any further fatality monitoring, then the per-kWh fee of 0.32 cents goes to the mitigation fund, accumulating $642,200 per year for purchase of conservation easements and fee title on lands deemed appropriate by the organization administering the fund.

Monitoring plan

A scientific monitoring plan for fatalities should be implemented and should last at least six years. The monitoring plan should be peer-reviewed before adoption. It should be implemented APWRA-wide in terms of spatial extent, and not spatially constrained in order to be treatment-specific. It will need to include a sufficiently large sample size of wind turbines and sufficiently frequent search rotations to enable the analyst to detect trends in mortality and to determine whether the mitigation measures were effective at achieving the goals of 50% reduction in three years and 85% reduction by six. Scavenger removal trials should be performed, but only on carcasses found in the APWRA and left on the ground where found. Search detection trials also should be performed, but only involving bird species that occur in the APWRA.

A behavior monitoring plan also needs to be developed, and should be comparable to the behavior observations made by Smallwood and Thelander (2004, 2005). The behavior monitoring should include half the turbines in the APWRA, and observations should be geo-referenced to X,Y,Z coordinates. Flight heights and specific flight behaviors should be recorded, along with species and weather conditions. Perching behavior should also be recorded.

Both monitoring plans will produce data that could be subjected to new χ^2-based hypothesis tests using the methods of Smallwood (1993, 2002). These hypothesis tests will be capable of generating some insight about the effectiveness of individual mitigation measures.

Contingency Measures

Grazing management

If within three years a 50% reduction in mortality has not been achieved, then a grazing plan must be implemented that reduces visual exposure of prey to raptors out to a distance of 50 m from wind turbines estimated to pose the highest threat levels to raptors. Smallwood and Thelander (2004) proposed experimental relaxation of grazing pressure in the APWRA, noting that the high uncertainty of the effect of relaxed grazing pressure justifies a limited implementation of this measure, initially. Several areas within the APWRA should be subjected to reduced stocking rates in order to observe changes in raptor activity and mortality.

Bird flight diverters

If within three years a 50% reduction in mortality has not been achieved, then bird flight diverters need to be installed just beyond the ends of all the turbine strings that include end turbines rated ≥ 2 for level of threat to raptors. These end-of-row pylons would be designed according to the recommendations in Smallwood and Thelander (2004).

Blade painting

Although the CEC final report recommended blade painting as a priority measure, the CEC recognizes that the cost of painting blades already up and running, as well as paying the license fees for the painting scheme and the paint, will be excessive. The CEC does not recommend blade painting as part of this mitigation plan, but we do recommend that repowering projects incorporate blade painting on about 25% of the new turbines, including every other turbine in half of the turbine strings. The benefits of this measure would extend to the entire industry by testing whether the Hodos et al. (2001) painting scheme is effective at reducing raptor mortality.

Repowering

A monitoring plan similar to the one the CEC recommends herein should be required as a permit condition of each repowering project. Every repowering project in the APWRA should make use of CEC data and CEC data interpretation to avoid high-risk locations and to minimize impacts to birds in other ways (Smallwood and Thelander 2004, Smallwood and Neher 2005). Some examples follow:

- Shut down and lock the blades of wind turbines during the winter and late fall months;
- Avoid placing wind turbines near the bottoms of ravines or valleys;
- Avoid placing wind turbines on slopes exposed to the prevailing winds, and favor slopes that tend to be leeward to the prevailing winds;
- Avoid placing turbines on steep slopes;
- Avoid placing turbines in ridge saddles;
- Use tower heights and rotor diameters that minimally maintain a distance of 29 m between the ground and the lowest reach of the rotor plane;
- Deploy turbines with the Hodos et al. painting scheme unless and until field research determines it is ineffective;
- Cluster the turbines as much as is practical, and avoid isolating turbines;
- Do not pile rocks near turbines, and do not store turbine parts, towers, or equipment near turbines;
- Install tower pads less likely to be sought by burrowing animals for cover, and spread gravel around the pad out to 5 feet to deter small mammals;
- Do not perform rodent control within the project area;
- Minimize vertical and lateral edge in the construction of the tower laydown area;
- Underground all electric distribution lines;
- If meteorological towers are necessary, use towers that do not require guy wires for support; and,
- Require removal of non-operating or derelict turbines, as well as their towers within 30 days they cease operating (except, of course, intentional seasonal shutdowns).
- A working group should be established to review the monitoring plan, the monitoring results and periodically review the adaptive management plan.

SUMMARY ASSESSMENT OF MITIGATION MEASURES

In the following table, H = high effect, M = medium effect, L = low effect, and U = unknown. These assessments are estimates, and only a few can be estimated quantitatively.

Mitigation Measure	Golden eagle	Red-tailed hawk	American kestrel	Burrowing owl
Relocation of select turbines	H	H	H	H
Seasonal shutdown	H	H	H	H
Cease rodent control	M	M	L	M
Retrofit distribution poles	L	M	L	L
Move rock piles	U	M	L	M
Retrofit tower pads	M	M	L	L
Move parts & equipment	M	M	L	H
Remove derelict turbines	U	M	M	L
Remove superfluous meteorological towers	L	L	L	M
Off-site compensation	M	M	M	M
Monitoring plan	H	H	H	H
Grazing management	M	M	M	H
Blade painting	U	U	U	U
Bird flight diverters	H	M	U	H
Repowering	H	H	H	H

We made no effort to attribute our estimates of mortality reduction due to separate mitigation measures. For example, our estimates of the percent reductions in fatalities will overlap between the selective turbine shutdowns and the fall/winter shutdowns. Additional assessment could remove this overlap, but will require some more time. For the purpose of comparing options, we left the assessment in its current state of completeness, but remain willing to carry it further.

REFERENCES

Haney, A., and R.L. Power. 1996. Adaptive management for sound ecosystem management. Environmental Management 20:879-886.

Hodos, W., A. Potocki, T. Storm, and M. Gaffney. 2001. Reduction of motion smear to reduce avian collisions with wind turbines. Pages 88-105 *in* S. S. Schwartz, ed., Proceedings of National Avian-Wind Power Planning Meeting IV, Carmel, California. Avian Subcommittee of the National Wind Coordinating Committee, Washington, D.C.

Holling, C.S. (ed.). 1978. Adaptive environmental assessment and management. John Wiley & Sons, New York.

National Research Council. 1986. Ecological knowledge and environmental problem-solving: concepts and case studies. National Academy Press, Washington, D.C.

Shrader-Frechette, K.S., and E.D. McCoy. 1992. Statistics, costs and rationality in ecological inference. Tree 7: 96-99.

Smallwood, K.S. 1993. Understanding ecological pattern and process by association and order. Acta Oecologica 14(3):443-462.

Smallwood, K.S. 2002. Habitat models based on numerical comparisons. Pages 83-95 in Predicting species occurrences: Issues of scale and accuracy, J. M. Scott, P. J. Heglund, M. Morrison, M. Raphael, J. Haufler, and B. Wall, editors. Island Press, Covello, California.

Smallwood, K. S., and M. L. Morrison. 2003. 2003 Progress Report: San Joaquin kangaroo rat (*Dipodomys nitratoides*) Conservation Research at Resources Management Area 5, Lemoore Naval Air Station. Progress report to U.S. Department of the Navy, Lemoore, California. 56 pp. + 58 figures.

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. 531 pp.

Smallwood, K. S., and L. Neher. 2005. Repowering the APWRA: Forecasting and minimizing avian mortality without significant loss of power generation. California Energy Commission report: In press.

Smallwood, K. S. and C. Thelander. 2005. Bird mortality at the Altamont Pass Wind Resource Area, March 1998 – September 2001 Final Report. National Renewable Energy Laboratory, Golden, Colorado. In press.

Smallwood, K.S., J. Beyea and M. Morrison. 1999. Using the best scientific data for endangered species conservation. Environmental Management 24:421-435.

Thelander, C.G. S. Smallwood, and L. Rugge. 2003. Bird risk behaviors and fatalities at the Altamont Pass Wind Resource Area. Period of Performance: March 1998—December 2000. National Renewable Energy Laboratory, NREL/SR-500-33829. U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia.

Walters, C.J. 1986. Adaptive management of renewable resources. McGraw-Hill, New York.