Assessment of Three Proposed Adaptive Management Plans for Reducing Raptor Fatalities in the Altamont Pass Wind Resource Area

Shawn Smallwood

1 June 2010

The Alameda County Scientific Review Committee (SRC) was asked by Alameda County to comment on its proposed adaptive management plan (AMP), which was presented to the SRC on 29 April 2010. Along with the County's AMP were two additional AMPs proposed by the wind companies and Audubon Society/Californians for Renewable Energy (CARE). My comments on the AMPs, herein, update initial comments I provided in a draft assessment dated 26 May 2010. Missing from the earlier draft, but addressed herein, were fatality rate estimates from wind projects already repowered (Diablo Winds and Buena Vista) or undergoing planning for repowering (Tres Vaqueros). This time I also accounted for changes in estimated effectiveness of mitigation measures as old-generation turbines are phased out and replaced by new turbines. This time I also examined the effectives of measures on a company-by-company and sometimes project-by-project basis rather than applying a single APWRA fatality rate universally across all wind companies. My assessment was directed specifically at four focal raptor species: golden eagle, red-tailed hawk, American kestrel, and burrowing owl.

Methods

To assess the AMPs, I first organized a crosswalk of proposed measures between the three AMPs, and I tried to restate them so that they could be interpreted quantitatively (Table 1). For example, I expressed the percentages of turbines to be relocated or shut down as the number of turbines and the total rated capacity of those rated by the SRC as relatively more hazardous, so that proposed relocations or shutdowns could be related to estimated fatality rates. At the top of the list of measures in Table 1 are the four measures that would directly affect raptor fatalities in the APWRA.

As a basis for assessing proposed measures, I first estimated fatality rates per wind company (Appendix). Specifically, I took averages between estimates that were adjusted for scavenger removal based on Smallwood (2007a) and Smallwood et al. (2010), the former adjustments derived from the APWRA and the latter derived from scavenger removal trials across the USA. I lacked sufficient monitoring data to estimate fatality rates caused by turbines owned by Northwind Energy in the same manner as I did for the other companies, so I used my models of fatality rates regressed on turbine size (Smallwood 2010) to estimate fatalities at Northwind. I also used these models to estimate fatality rates caused by old-generation wind turbines prior to repowering where repowering already took place or where turbines have been shutdown in preparation for repowering.

In most cases, estimates of fatality rates during the current study (2005-2009) served as my new "baseline" against which to compare projected fatality rates following proposed changes in the APWRA. To give credit to the fatality reductions achieved at Buena Vista and Diablo Winds,

however, my baseline estimates at these projects would have represented conditions during earlier times, such as during the 1998-2003 period typically referred to as the baseline period.

To assess the effectiveness of hazardous turbine relocations, I relied on measured effects over the first two years of the Avian Protection Program (Smallwood 2008). I assumed all of the hazardous turbines slated for relocation in plan would in fact be relocated and not removed. This assumption matters because relocations were projected to have much smaller effects than removals, totaling a 6% reduction for all four focal raptors due to relocation and a 13% reduction due to removal (Smallwood 2008). However, adding the turbines rated by the SRC in March 2010 would likely increase the percentage reduction due to hazardous turbine removals, whereas I do not anticipate that this addition would substantially change the effects of turbine relocations. (A new assessment, including all the SRC-rated turbines, would inform the effects of proposed relocations versus removals.) The effect of turbine relocations was allowed to decline as AMPs phased in repowering, because the turbine relocations apply only to old-generation turbines.

To assess the effectiveness of repowering, I assumed that (1) shutdown turbines will be replaced quickly by modern turbines, (2) repowered wind turbines would be at least the size of the 1-MW Mitsubishi turbines used in the Buena Vista Wind Energy project, and (3) fatality reductions would be consistent with the 81% reduction of target raptor fatalities measured so far at Buena Vista (Smallwood 2009). For the repowering measures I estimated the fatalities that would continue after the stated percentage of capacity is shut down as well as those that would be caused at 81% lower rate amongst the repowered turbines.

To assess the effectiveness of seasonal shutdowns, I first considered estimates of effectiveness in Smallwood (2007b), but I ended up relying more heavily on monthly fatality rates between baseline and current study periods (Smallwood 2009). December was the only month when turbines were consistently shut down during the current study, so to measure the effects of the winter shutdown I subtracted the mean fatality rate in December during the current study from that of the baseline study (1998-2002). The December shutdown resulted in a 40.5% reduction in focal raptor species fatalities during that particular month. Therefore, assuming this level of reduction would extend to a 3.5-month shutdown (according to CUP requirements), I estimated 40.5% lower fatality rates during November, December, January and half of February.

The schedules in the settling parties' AMPs were complex, requiring me to divide my assessment into many discreet time periods to address suites of measures applied uniquely to each period. This division of the assessment resulted in periods ranging in duration from fractions of a year to multiple years, which meant that the 3.5-month winter shutdown periods were sometimes included in their entirety within assessment periods, and sometimes divided by these periods. This division also meant that winter shutdowns composed varying portions of each assessment period, ranging from one out of 9 months to 3.5 out of 12 months. For each assessment period, I estimated the percentage reduction attributable to seasonal shutdown by comparing monthly fatality rates between my new baseline (2005-09) period and the same set of months in the AMP schedule and which compose the specific assessment period. In other words, if the assessment period was 11 January 2010 to 30 September 2010 (0.72 years), then I added baseline fatality rates for the last 20 days of January and all of February through September, and I compared this total to the sum of winter shutdown-adjusted rates applied to January 11 to February 15 and added to monthly fatality rates from February 15 through September. The only difference will have been the 40.5% reduction during the

period January 11 to February 15. The cumulative difference of the 0.72-year period (11 January to 30 September) was then projected to the total rated capacity of applicable turbines within a company's portfolio or within a specific project. Furthermore, the effect of seasonal shutdowns was allowed to decline as AMPs phased in repowering, because seasonal shutdowns would apply only to old-generation turbines.

There was no empirical foundation available to assess unproductive turbine removals, so I simply guessed that the removal of all unproductive turbines/towers might reduce target raptor fatalities by 5%. I assumed that about 200 unproductive towers were in the APWRA recently, so I adjusted my initial 5% effect by the proportion of unproductive towers remaining at various action dates in the AMP schedules. Furthermore, the effect of unproductive tower removal was allowed to decline as AMPs phased in repowering, because unproductive tower removals would not apply to repowered turbines.

I assessed the effectiveness of proposed measures over a three year period, from January 2010 to January 2013, as well as over an eight year period inclusive of the first three years. I assumed that the Santa Clara turbine field (200 turbines at 19 MW total capacity) will be exempt from management actions, as claimed by the County and the companies, though I eliminated this assumption when assessing the Audubon/CARE plan because it did not indicate that Santa Clara turbines will be exempt. Finally, I assumed AWI will continue to operate its turbines as before, because Alameda County allowed AWI to miss earlier repowering deadlines, to operate without renewed permits for ≥21 months, and to operate hazardous turbines required for shutdown in the CUPs or recommended for shutdown by the SRC.

Comments on Fatality Reduction Measures

The Settling Parties have produced AMPs that, as written, cannot reduce target raptor fatalities by 50% over the next three years (Tables 2-6). The County and the companies' AMPs will not achieve a 50% fatality reduction, even after eight years. The Audubon/CARE plan does not achieve a 50% reduction over the first three years, but it exceeds the 50% reduction goal after eight years (Tables 5 and 6).

All three of the AMPs will result in more than three thousand focal raptor fatalities over the first three years (Table 5). Over eight years, the Audubon/CARE plan results in more than six thousand focal raptor fatalities, and the companies' plan results in more than nine thousand focal raptor fatalities (Table 6). These large numbers of fatalities are projected even though the effectiveness of all three AMPs benefited from wind projects that have already been repowered or that are shutdown in anticipation of repowering (Tables 2-4). Offsetting the benefits each AMP inherited from ongoing repowering projects, the effectiveness of each AMP was also obstructed by wind companies or specific wind projects that will not participate in part or in whole with the proposed management actions (Tables 2-4). For example, AWI owns a significant portion of the wind turbine capacity in the APWRA, but AWI is not participating with any of the AMPs beyond the existing CUP requirements, and even these requirements have been relaxed by Alameda County over the last several years. In another example, the Santa Clara turbines cause high fatality rates, so their exemption from the County's and companies' AMPs would act as a drag on APWRA-wide fatality reductions.

Table 1. Crosswalk of proposed mitigation measures in adaptive management plans of Alameda County, the wind companies, and Audubon/CARE.

	County plan		Companies' plan		Audubon/CARE plan	
Measure	**Date**	**Description**	**Date**	**Description**	**Date**	**Description**
Hazardous turbine relocation	9/30/10	Relocate 30 turbines (4.41 MW) rated 9-10, allowing ESI to trade 1 KVS33 for 4 100-kw turbines	9/30/10	Relocate 26 turbines (4.01 MW) rated 9-10, allowing ESI to trade 2 KVS33 for 4 100-kw turbines	8/30/10	Relocate 74.77 MW of turbines rated 7-10
	2/15/11	Relocate 213 turbines (20.275 MW) rated 8.0 & 8.5	2/15/11	Relocate 33 turbines (3.03 MW) rated 8.5		
	2/15/12	Relocate 275 turbines (24.08 MW) rated 7.5	9/30/13	enXco removes 43 turbines (3.85 MW) rated 8.0 if 50% goal unmet by 9/30/13 (appears in repowering section of companies' AMP)		
Removal of unproductive towers	9/30/10	Remove all but 57 allotted unproductive turbines		Apparently, allotted towers will not be removed	2010	Remove all unproductive towers/turbines within 60 days of SRC approval
	2/28/11	Remove all unproductive turbines				
Seasonal shutdown		3.5 months according to CUPs		3.5 months according to CUPs		AUG/SEP shutdowns followed by bird hazing each year until 4/1/14
Repowering	5/30/11	25% of ESI shut down	12/31/11	25% repowered by ESI		Restoration bond and compensatory mitigation
	12/31/11	50% of ESI shut down	9/30/13	SeaWest removes 25% if 50% goal unmet by 9/30/13	4/1/11	25% removed
	2/15/15	75% of ESI shut down if 50% reduction unmet by 9/30/14			4/1/12	50% removed
	2/15/13	25% of SeaWest & enXco shut down if 50% unmet by 9/30/12			4/1/14	100% removed
	2/15/15	50% of SeaWest & enXco shut down if 50% unmet by 9/30/14				
AMP measures revisited	1/1/14	SRC prioritizes measures again if 50% goal unmet by 9/30/13				
	4/1/14	Companies propose updated				

		AMP		
	7/1/14	County acts on updated AMP		
Additional studies		Contingent on Planning Director deciding studies are needed and designed properly	Will fund if combined costs of studies, NCCP staff and monitoring do not exceed existing monitoring cost	Required along with a golden eagle study to inform repowering and develop siting protocol
Fatality monitoring			Will not increase budget & requires NCCP and additional study costs to be included within existing monitoring budget	Continues to assess effectiveness of management measures
Compliance monitoring		No consequences for failure to comply	No compliance monitoring proposed	$1k/day for missing deadlines; fines to go to raptor habitat conservation

Table 2. Effects of management measures in County Plan. Acronyms for terms in equations include d = deaths, MW = megawatts, yrs = years, rep = repowering adjustment, HTR = adjustment for hazardous turbine relocation, UTR = adjustment for unproductive tower removal, SSD = adjustment for seasonal shutdown. The first three years are indicated by yellow highlight and the following five years are indicated by green highlight.

			Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unproductive tower removal	
Project or Company	**Time period**	**Basis**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**
Buena Vista 38 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009)	127.7/yr	---	---	---	---	---	---	---
	2010-12	Smallwood (2009): 23.95 d/yr	72	81%	72	81%	72	81%	72	81%
	2013-18	Smallwood (2009): 23.95 d/yr	120	81%	120	81%	120	81%	120	81%
	3 yrs	127.7 d/yr × 3 yrs = **383**	**72**	**81%**	**72**	**81%**	**72**	**81%**	**72**	**81%**
	8 yrs	127.7 d/yr × 8 yrs = **1,022**	**192**	**81%**	**192**	**81%**	**192**	**81%**	**192**	**81%**
Tres Vaqueros 25 MW	Baseline	Smallwood's (2010) estimates of fatality rates before and after repowering	72.5/yr	---	---	---	---	---	---	---
	2010	25 MW shutdown awaiting repowering	0	100%	0	100%	0	100%	0	100%
	2011-12	Smallwood (2010): 19 d/yr	38	74%	38	74%	38	74%	38	74%
	2013-18	Smallwood (2010): 19 d/yr	95	74%	95	74%	95	74%	95	74%
	3 yrs	72.5 d/yr × 3 yrs = **218**	**38**	**83%**	**38**	**83%**	**38**	**83%**	**38**	**83%**
	8 yrs	72.5 d/yr × 8 yrs = **580**	**133**	**77%**	**133**	**77%**	**133**	**77%**	**133**	**77%**
Diablo Winds 20.46 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009) applied to old turbines before repowering. [a]	71.4/yr	---	---	---	---	---	---	---
	2010-12	Smallwood (2009): 39.39 d/yr	118	45%	118	45%	118	45%	118	45%
	2013-18	Smallwood (2009): 39.39 d/yr	197	45%	197	45%	197	45%	197	45%
	3 yrs	71.4 d/yr × 3 years = **214**	**118**	**45%**	**118**	**45%**	**118**	**45%**	**118**	**45%**
	8 yrs	71.4 d/yr × 8 years = **571**	**315**	**45%**	**315**	**45%**	**315**	**45%**	**315**	**45%**
NextEra 277 MW	Baseline	See Appendix: 2.2888 d/MW/yr during 2005-09	634/yr	---	---	---	---	---	---	---
	1/11/10-9/30/10, 0.72 yrs	No repower: 2.2888 d/MW/yr × 277 MW × 0.72 yrs = 456 × 0.863 SSD = 394	456	0%	394	13%	394	13%	394	13%
	9/30/10-2/15/11, 0.375 yrs	Relocated 2.3 MW of turbines rated 9-10 & removed ~75% of unproductive towers: 2.2888	238	0%	111	53%	118	50%	114	52%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unproductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
		d/MW/yr × 277 MW × 0.375 yrs = 238 × 0.4664 SSD = 111 × 1.06 HTR = 118 × 0.9625 UTR = 114								
	2/28/11.	Removed all unproductive towers.	185	0%	185	0%	181	2%	172	7%
	2/15/11-5/30/11, 0.292 yrs	Relocated 14.5 MW of turbines rated 8-10: 2.2888 d/MW/yr × 277 MW × 0.292 yrs = 185 × 0.98 HTR = 181 × 0.95 UTR = 172								
	5/30/11-12/31/11, 0.583 yrs	25% repowered: 2.2888 d/MW/yr × 69.25 MW × 0.19 rep × 0.5833 yrs = 18. 75% not repowered: 2.2888 d/MW/yr × 207.75 MW × 0.5833 yrs = 277 × 0.769 SSD = 213 × 0.98 HTR = 209 × 0.95 UTR = 199	295	20%	231	38%	227	39%	217	41%
	12/31/11–1/11/13, ~1 yr	50% repowered: 2.2888 d/MW/yr × 138.5 MW × 0.19 rep = 60. 50% not repowered: 2.289 d/MW/yr × 138.5 MW = 317 × 0.80 SSD = 254 × 0.98 HTR = 249 × 0.95 UTR = 237	377	41%	314	50%	309	51%	297	53%
	2/15/12-1/11/13, 0.92 yrs	Relocated 27.7 MW of turbines rated 7.5-10 among 50% of turbines not repowered: 2.2888 d/MW/yr × 138.5 MW × 0.92 yrs = 292 × 0.80 SSD = 233 × 0.94 HTR = 219 × 0.95 UTR = 208 50% repowered: 2.2888 d/MW/yr × 138.5 MW × 0.92 yrs × 0.19 rep = 55.	347	40%	288	51%	274	53%	263	55%
	1/11/13-2/15/15, 1.08 yrs	50% repowered: 2.2888 d/MW/yr × 138.5 MW × 0.19 rep × 1.08 yrs = 65. 50% not repowered: 2.2888 d/MW/yr × 138.5 MW × 1.08 yrs = 342 × 0.80 SSD = 274 × 0.94 HTR = 257 × 0.95 UTR = 244	407	41%	339	51%	322	53%	309	55%
	2/15/15-1/11/18,	75% repowered: 2.2888 d/MW/yr × 207.75 MW × 0.19 rep × 3.92 yrs = 354.	975	61%	851	66%	821	67%	798	68%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unproductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
	3.92 yrs	25% not repowered: 2.2888 d/MW/yr × 69.25 MW × 3.92 yrs = 621 × 0.80 SSD = 497 × 0.94 HTR = 467 × 0.95 UTR = 444								
	3 years	634 d/yr × 3 yrs = **1,902**	**1,898**	**0%**	**1,523**	**20%**	**1,503**	**21%**	**1,457**	**23%**
	8 years	634 d/yr × 8 yrs **= 5,072**	**3,280**	**35%**	**2,713**	**47%**	**2,646**	**48%**	**2,564**	**49%**
enXco 73.13 MW	Baseline	See Appendix: 3.5614 d/MW/yr during 2005-09	260/yr	---	---	---	---	---	---	---
	1/11/10-9/30/10, 0.72 yrs	No repower: 260 d/yr × 0.72 yrs = 187 × 0.863 SSD = 162	187	0%	162	13%	162	13%	162	13%
	9/30/10-2/15/11, 0.375 yrs	Relocated 0.37 MW of turbines rated 9-10 & removed ~75% of unproductive towers: 260 d/yr × 0.375 yrs = 98 × 0.4664 SSD = 45 × 1.06 HTR = 48 × 0.9625 UTR = 46	98	0%	45	54%	48	51%	46	53%
	2/28/11.	Removed all unproductive towers.	260	0%	208	20%	204	22%	194	25%
	2/15/11-2/15/12, 1 yr	Relocated 4.975 MW of turbines rated 8-10: 260 d/yr × 1 yr = 260 × 0.80 SSD = 208 × 0.98 HTR = 204 × 0.95 UTR = 194								
	2/15/12-1/11/13, 0.92 yrs	Relocated 11.275 MW of turbines rated 7.5-10: 260 d/yr × 0.92 yrs = 239 × 0.80 SSD = 191 × 0.94 HTR = 180 × 0.95 UTR = 171	239	0%	191	20%	180	25%	171	28%
	1/11/13-2/15/13, 0.093 yrs	260 d/yr × 0.093 yrs = 24 × 0.4664 SSD = 11 × 0.94 HTR = 10 × 0.95 UTR = 9	24	0%	11	54%	10	58%	9	63%
	2/15/13-2/15/15, 2 yrs	25% repowered: 3.5614 d/MW/yr × 18.28 MW × 0.19 rep × 2 yrs = 25. 75% not repowered: 3.5614 d/MW/yr × 54.85 MW × 2 yrs = 391 × 0.80 SSD = 313 × 0.94 HTR = 294 × 0.95 UTR = 279	416	20%	338	35%	319	39%	304	42%
	2/15/15-	50% repowered: 3.5614 d/MW/yr × 36.565 MW	465	40%	387	50%	368	53%	353	55%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unproductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
	1/11/18, 3 yrs	× 0.19 rep × 3 yrs = 74 50% not repowered: 3.5614 d/MW/yr × 36.565 MW × 3 yrs = 391 × 0.80 SSD = 313 × 0.94 HTR = 294 × 0.95 UTR = 279								
	3 years	260/yr × 3 yrs = **780**	**784**	**0%**	**606**	**22%**	**594**	**24%**	**573**	**27%**
	8 years	260/yr × 8 yrs = **2,080**	**1,689**	**19%**	**1,342**	**35%**	**1,291**	**38%**	**1,239**	**40%**
SeaWest non-Santa Clara 23.395 MW	Baseline	See Appendix: 4.34 d/MW/yr during 2005-09	102/yr	---	---	---	---	---	---	---
	1/11/10-9/30/10, 0.72 yrs	No repower: 102 d/yr × 0.72 yrs = 73 × 0.863 SSD = 63	73	0%	63	14%	63	14%	63	14%
	9/30/10-2/15/11, 0.375 yrs	Relocated 0.04 MW of turbines rated 9-10 & removed ~75% of unproductive towers: 102 d/yr × 0.375 yrs = 38 × 0.4664 SSD = 17 × 1.06 HTR = 19 × 0.9625 UTR = 18	38	0%	17	55%	19	50%	18	53%
	2/28/11.	Removed all unproductive towers.	102	0%	82	20%	80	22%	76	25%
	2/15/11-2/15/12, 1 yr	Relocated 0.575 MW of turbines rated 8-10: 102 d/yr × 1 yr = 102 × 0.80 SSD = 82 × 0.98 HTR = 80 × 0.95 UTR = 76								
	2/15/12-1/11/13, 0.92 yrs	Relocated 2.145 MW of turbines rated 7.5-10: 102 d/yr × 0.92 yrs = 94 × 0.80 SSD = 75 × 0.94 HTR = 71 × 0.95 UTR = 67	94	0%	75	20%	71	25%	67	29%
	1/11/13-2/15/13, 0.093 yrs	102 d/yr × 0.093 yrs = 9 × 0.4664 SSD = 4 × 0.94 HTR = 4 × 0.95 UTR = 4	9	0%	4	56%	4	56%	4	56%
	2/15/13-2/15/15, 2 yrs	25% repowered: 4.34 d/MW/yr × 5.85 MW × 0.19 rep × 2 yrs = 10. 75% not repowered: 4.34 d/MW/yr × 17.55 MW × 2 yrs = 152 × 0.80 SSD = 122 × 0.94 HTR =	162	20%	132	35%	124	39%	118	42%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unproductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
	2/15/15-1/11/18, 3 yrs	114 × 0.95 UTR = 108 50% repowered: 4.34 d/MW/yr × 11.7 MW × 0.19 rep × 3 yrs = 29 50% not repowered: 4.34 d/MW/yr × 11.7 MW × 3 yrs = 152 × 0.80 SSD = 122 × 0.94 HTR = 114 × 0.95 UTR = 108	181	41%	151	51%	143	53%	137	55%
	3 years	102 d/yr × 3 yrs = **306**	**307**	**0%**	**241**	**20%**	**233**	**24%**	**224**	**27%**
	8 years	102 d/yr × 8 yrs = **816**	**659**	**20%**	**528**	**35%**	**504**	**38%**	**483**	**41%**
SeaWest Santa Clara 19 MW	Baseline	See Appendix: 4.34 d/MW/yr during 2005-09	82/yr	---	exempt	---	exempt	---	exempt	---
	3 years	82 d/yr × 3 yrs = **246**	**246**	**0%**	**246**	**0%**	**246**	**0%**	**246**	**0%**
	8 years	82 d/yr × 8 yrs = **656**	**656**	**0%**	**656**	**0%**	**656**	**0%**	**656**	**0%**
AWI 95.7 MW	Baseline	See Appendix	317/yr	---	---	---	---	---	---	---
	2010-12	Assumed AWI will operate as usual: 317 d/yr × 3 yrs = 951 × 0.80 SSD = 761	951	0%	761	20%	761	20%	761	20%
	2013-18	Same as above. 317 d/yr × 5 yrs = 1,585 × 0.80 SSD = 1,268	1,585	0%	1,268	20%	1,268	20%	1,268	20%
	3 yrs	317 d/yr × 3 yrs = **951**	**951**	**0%**	**761**	**20%**	**761**	**20%**	**761**	**20%**
	8 yrs	317 d/yr × 8 yrs = **2,536**	**2,536**	**0%**	**2,029**	**20%**	**2,029**	**20%**	**2,029**	**20%**
Northwind 12.09 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009)	46/yr	---	---	---	---	---	---	---
	3 years	46 d/yr × 3 yrs = **138**	**138**	**0%**	**138**	**0%**	**138**	**0%**	**138**	**0%**
	8 years	46 d/yr × 8 yrs = **368**	**368**	**0%**	**368**	**0%**	**368**	**0%**	**368**	**0%**
Total	**3 years**	**5,138**	**4,552**	**11%**	**3,743**	**27%**	**3,703**	**28%**	**3,627**	**29%**
Total	**8 years**	**13,701**	**9,828**	**28%**	**8,276**	**40%**	**8,134**	**41%**	**7,979**	**42%**

[a] Note that the predicted rate based on regression models in Smallwood (2009) were 0.03 deaths/MW/yr greater than the rate reported in Smallwood and Karas (2009).

Table 3. Effects of management measures in Companies' Plan. Acronyms for terms in equations include d = deaths, MW = megawatts, yrs = years, rep = repowering adjustment, HTR = adjustment for hazardous turbine relocation, UTR = adjustment for unproductive tower removal, SSD = adjustment for seasonal shutdown. The first three years are indicated by yellow highlight and the following five years are indicated by green highlight.

			Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unpro-ductive tower removal	
Project or Company	**Time period**	**Basis**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**
Buena Vista 38 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009)	127.7/yr	---	---	---	---	---	---	---
	2010-12	Smallwood (2009): 23.95 d/yr	72	81%	72	81%	72	81%	72	81%
	2013-18	Smallwood (2009): 23.95 d/yr	120	81%	120	85%	120	85%	120	85%
	3 yrs	127.7 d/yr × 3 yrs = **383**	**72**	**81%**	**72**	**81%**	**72**	**81%**	**72**	**81%**
	8 yrs	127.7 d/yr × 8 yrs = **1,022**	**192**	**81%**	**192**	**81%**	**192**	**81%**	**192**	**81%**
Tres Vaqueros 25 MW	Baseline	Smallwood's (2010) estimates of fatality rates before and after repowering	72.5/yr	---	---	---	---	---	---	---
	2010	25 MW shutdown awaiting repowering	0	100%	0	100%	0	100%	0	100%
	2011-12	Smallwood (2010): 19 d/yr	38	74%	38	74%	38	74%	38	74%
	2013-18	Smallwood (2010): 19 d/yr	95	74%	95	74%	95	74%	95	74%
	3 yrs	72.5 d/yr × 3 yrs = **218**	**38**	**83%**	**38**	**83%**	**38**	**83%**	**38**	**83%**
	8 yrs	72.5 d/yr × 8 yrs = **580**	**133**	**77%**	**133**	**77%**	**133**	**77%**	**133**	**77%**
Diablo Winds 20.46 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009) applied to old turbines before repowering. [a]	71.4/yr	---	---	---	---	---	---	---
	2010-12	Smallwood (2009): 39.39 d/yr	118	45%	118	45%	118	45%	118	45%
	2013-18	Smallwood (2009): 39.39 d/yr	197	45%	197	45%	197	45%	197	45%
	3 yrs	71.4 d/yr × 3 years = **214**	**118**	**45%**	**118**	**45%**	**118**	**45%**	**118**	**45%**
	8 yrs	71.4 d/yr × 8 years = **571**	**315**	**45%**	**315**	**45%**	**315**	**45%**	**315**	**45%**
NextEra's 277 MW	Baseline	See Appendix: 2.2888 d/MW/yr during 2005-09	634/yr	---	---	---	---	---	---	---
	1/11/10-9/30/10, 0.72 yrs	No repower: 634 d/yr × 0.72 yrs = 456 × 0.863 SSD = 394	456	0%	394	14%	394	14%	394	14%
	9/30/10-	Relocated 2.3 MW of turbines rated 9-10 &	238	0%	123	48%	130	45%	125	47%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unpro-ductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
	2/15/11, 0.375 yrs	removed ~75% of unproductive towers: 634 d/yr × 0.375 yrs = 238 × 0.5157 SSD = 123 × 1.06 HTR = 130 × 0.9625 UTR = 125								
	2/15/11-12/31/11, 0.792 yrs	Relocated 6.4 MW of turbines rated 8.5-10: 634 d/yr × 0.792 yrs = 502 × 0.8236 SSD = 413 × 0.98 HTR = 405 × 0.9625 UTR = 390	502	0%	413	18%	405	19%	390	22%
	12/31/11-1/11/13, 1.04 yr	25% repowered: 2.2888 d/MW/yr × 69.25 MW × 0.19 rep × 1.04 yr = 31. 75% not repowered: 2.289 d/MW/yr × 207.75 MW × 1.04 yr = 495 × 0.80 SSD = 396 × 0.98 HTR = 388 × 0.9625 UTR = 373	526	20%	427	35%	419	36%	404	39%
	1/11/13-1/11/18, 5 yrs	25% repowered: 2.2888 d/MW/yr × 69.25 MW × 0.19 rep × 5 yrs = 151. 75% not repowered: 2.2888 d/MW/yr × 207.75 MW × 5 yrs = 2,377 × 0.80 SSD = 1,902 × 0.98 HTR = 1,864 × 0.9625 UTR = 1,794	2,528	20%	2,053	35%	2,015	36%	1,945	39%
	3 years	634 d/yr × 3 yrs = **1,902**	**1,722**	**9%**	**1,357**	**29%**	**1,348**	**29%**	**1,313**	**31%**
	8 years	634 d/yr × 8 yrs **= 5,072**	**4,250**	**16%**	**3,410**	**33%**	**3,363**	**34%**	**3,258**	**36%**
enXco 73.13 MW	Baseline	See Appendix: 3.5614 d/MW/yr during 2005-09	260/yr	---	---	---	---	---	---	---
	1/11/10-9/30/10, 0.72 yrs	260 d/yr × 0.72 yrs = 187 × 0.863 SSD = 162	187	0%	162	20%	162	20%	162	20%
	9/30/10-1/11/13, 2.28 yrs	Removed ~75% of unproductive towers: 260 d/yr × 2.28 yrs = 593 × 0.78 SSD = 462 × 0.9625 UTR = 445	593	0%	462	22%	462	22%	445	25%
	1/11/13-9/30/13, 0.72 yrs	260 d/yr × 0.72 yrs = 187 × 0.863 SSD = 161 × 0.9625 UTR = 155	187	0%	161	14%	161	14%	155	17%
	9/30/13-	Relocated 3.85 MW of turbines rated 8: 260 d/yr	1,113	0%	890	20%	872	22%	839	25%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unpro-ductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
	1/11/18, 4.28 yrs	× 4.28 yrs = 1,113 × 0.80 SSD = 890 × 0.98 HTR = 872 × 0.9625 UTR = 839								
	3 years	No repower: 260/yr × 3 yrs = **780**	**780**	**0%**	**624**	**20%**	**624**	**20%**	**607**	**22%**
	8 years	No repower: 260/yr × 8 yrs = **2,080**	**2,080**	**0%**	**1,664**	**20%**	**1,657**	**20%**	**1,601**	**23%**
SeaWest non-Santa Clara 23.395 MW	Baseline	See Appendix: 4.34 d/MW/yr during 2005-09	102/yr	---	---	---	---	---	---	---
	1/11/10-9/30/10, 0.72 yrs	102 d/yr × 0.72 yrs = 73 × 0.863 SSD = 63	73	0%	63	14%	63	14%	63	14%
	9/30/10-1/11/13, 2.28 yrs	Removed ~75% of unproductive towers: 102 d/yr × 2.28 yrs = 233 × 0.78 SSD = 182 × 0.9625 UTR = 175	233	0%	182	22%	182	22%	175	25%
	1/11/13-1/11/18, 5 yrs	No repower: 102 d/yr × 5 yrs = 510 × 0.80 SSD = 408 × 0.9625 UTR = 393	510	0%	408	21%	408	21%	393	23%
	3 years	No repower: 102 d/yr × 3 yrs = **306**	**306**	**0%**	**245**	**20%**	**245**	**20%**	**238**	**22%**
	8 years	No repower: 102 d/yr × 8 yrs = **816**	**816**	**0%**	**653**	**20%**	**653**	**20%**	**631**	**23%**
SeaWest Santa Clara 19 MW	Baseline	See Appendix: 4.34 d/MW/yr during 2005-09	82/yr	---	exempt	---	exempt	---	exempt	---
	3 years	82 d/yr × 3 yrs = **246**	**246**	**0%**	**246**	**0%**	**246**	**0%**	**246**	**0%**
	8 years	82 d/yr × 8 yrs = **656**	**656**	**0%**	**656**	**0%**	**656**	**0%**	**656**	**0%**
AWI 95.7 MW	Baseline	See Appendix	317/yr	---	---	---	---	---	---	---
	2010-12	Assumed AWI will operate as usual: 317 d/yr × 3 yrs = 951 × 0.80 SSD = 761	951	0%	761	20%	761	20%	761	20%
	2013-18	Same as above. 317 d/yr × 5 yrs = 1,585 × 0.80 SSD = 1,268	1,585	0%	1,268	20%	1,268	20%	1,268	20%
	3 yrs	317 d/yr × 3 yrs = **951**	**951**	**0%**	**761**	**20%**	**761**	**20%**	**761**	**20%**
	8 yrs	317 d/yr × 8 yrs = **2,536**	**2,536**	**0%**	**2,029**	**20%**	**2,029**	**20%**	**2,029**	**20%**

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unpro-ductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
Northwind 12.09 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009)	46/yr	---	---	---	---	---	---	---
	3 years	46 d/yr × 3 yrs = **138**	**138**	**0%**	**138**	**0%**	**138**	**0%**	**138**	**0%**
	8 years	46 d/yr × 8 yrs = **368**	**368**	**0%**	**368**	**0%**	**368**	**0%**	**368**	**0%**
Total	**3 years**	**5,138**	**4,371**	**15%**	**3,599**	**30%**	**3,590**	**30%**	**3,531**	**31%**
Total	**8 years**	**13,701**	**11,346**	**17%**	**9,420**	**31%**	**9,366**	**32%**	**9,183**	**33%**

[a] Note that the predicted rate based on regression models in Smallwood (2009) were 0.03 deaths/MW/yr greater than the rate reported in Smallwood and Karas (2009).

Table 4. Effects of management measures in Audubon/CARE's Plan. Acronyms for terms in equations include d = deaths, MW = megawatts, yrs = years, rep = repowering adjustment, HTR = adjustment for hazardous turbine relocation, UTR = adjustment for unproductive tower removal, SSD = adjustment for seasonal shutdown. The first three years are indicated by yellow highlight and the following five years are indicated by green highlight.

			Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unpro-ductive tower removal	
Project or Company	**Time period**	**Basis**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**	**No. killed**	**Reduc-tion**
Buena Vista 38 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009)	127.7/yr	---	---	---	---	---	---	---
	2010-12	Smallwood (2009): 23.95 d/yr	72	81%	72	81%	72	81%	72	81%
	2013-18	Smallwood (2009): 23.95 d/yr	120	81%	120	85%	120	85%	120	85%
	3 yrs	127.7 d/yr × 3 yrs = **383**	**72**	**81%**	**72**	**81%**	**72**	**81%**	**72**	**81%**
	8 yrs	127.7 d/yr × 8 yrs = **1,022**	**192**	**81%**	**192**	**81%**	**192**	**81%**	**192**	**81%**
Tres Vaqueros 25 MW	Baseline	Smallwood's (2010) estimates of fatality rates before and after repowering	72.5/yr	---	---	---	---	---	---	---
	2010	25 MW shutdown awaiting repowering	0	100%	0	100%	0	100%	0	100%
	2011-12	Smallwood (2010): 19 d/yr	38	74%	38	74%	38	74%	38	74%
	2013-18	Smallwood (2010): 19 d/yr	95	74%	95	74%	95	74%	95	74%
	3 yrs	72.5 d/yr × 3 yrs = **218**	**38**	**83%**	**38**	**83%**	**38**	**83%**	**38**	**83%**
	8 yrs	72.5 d/yr × 8 yrs = **580**	**133**	**77%**	**133**	**77%**	**133**	**77%**	**133**	**77%**
Diablo Winds 20.46 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009) applied to old turbines before repowering. [a]	71.4/yr	---	---	---	---	---	---	---
	2010-12	Smallwood (2009): 39.39 d/yr	118	45%	118	45%	118	45%	118	45%
	2013-18	Smallwood (2009): 39.39 d/yr	197	45%	197	45%	197	45%	197	45%
	3 yrs	71.4 d/yr × 3 years = **214**	**118**	**45%**	**118**	**45%**	**118**	**45%**	**118**	**45%**
	8 yrs	71.4 d/yr × 8 years = **571**	**315**	**45%**	**315**	**45%**	**315**	**45%**	**315**	**45%**
NextEra' 277 MW	Baseline	See Appendix: 2.2888 d/MW/yr during 2005-09	634/yr	---	---	---	---	---	---	---
	1/11/10-8/30/10, 0.637 yrs	No repower: 634 d/yr × 0.637 yrs = 404 × 0.80 SSD = 323	404	0%	323	20%	323	20%	323	20%
	8/30/10-	Relocated 44 MW of turbines rated 7-10 &	370	0%	333	10%	313	15%	297	20%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unpro-ductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
	4/1/11, 0.583 yrs	removed unproductive towers: 634 d/yr × 0.583 yrs = 370 × 0.90 SSD = 333 × 0.94 HTR = 313 × 0.95 UTR = 297								
	4/1/11-4/1/12, 1 yr	25% repowered: 2.2888 d/MW/yr × 69.25 MW × 0.19 rep = 30. 75% not repowered: 2.289 d/MW/yr × 207.75 MW = 475 × 0.80 SSD = 380 × 0.94 HTR = 358 × 0.95 UTR = 340	505	20%	410	35%	388	39%	370	42%
	4/1/12-4/1/13, 1 yr	50% repowered: 2.2888 d/MW/yr × 138.5 MW × 0.19 rep = 60. 50% not repowered: 2.289 d/MW/yr × 138.5 MW = 317 × 0.80 SSD = 254 × 0.94 HTR = 238 × 0.95 UTR = 226	377	41%	314	50%	298	53%	286	55%
	4/1/13-1/11/18, 4.78 yrs	100% repowered: 2.2888 d/MW/yr × 277 MW 0.19 rep × 4.78 yrs = 576	576	81%	576	81%	576	81%	576	81%
	3 years	634 d/yr × 3 yrs = **1,902**	**1,656**	**13%**	**1,380**	**27%**	**1,322**	**30%**	**1,276**	**33%**
	8 years	634 d/yr × 8 yrs **= 5,072**	**2,232**	**56%**	**1,956**	**61%**	**1,898**	**63%**	**1,852**	**63%**
enXco 73.13 MW	Baseline	See Appendix: 3.5614 d/MW/yr during 2005-09	260/yr	---	---	---	---	---	---	---
	1/11/10-8/30/10, 0.637 yrs	No repower: 260 d/yr × 0.637 yrs = 166 × 0.80 SSD = 132	166	0%	132	20%	132	20%	132	20%
	8/30/10-4/1/11, 0.583 yrs	Relocated 44 MW of turbines rated 7-10 & removed unproductive towers: 260 d/yr × 0.583 yrs = 152 × 0.90 SSD = 136 × 0.94 HTR = 128 × 0.95 UTR = 122	152	0%	136	10%	128	15%	122	20%
	4/1/11-4/1/12, 1 yr	25% repowered: 3.5553 d/MW/yr × 18.2825 MW × 0.19 rep = 12. 75% not repowered: 3.5553 d/MW/yr × 54.8475	207	20%	168	35%	159	39%	151	42%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unpro-ductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
	4/1/12-4/1/13, 1 yr	MW = 195 × 0.80 SSD = 156 × 0.94 HTR = 147 × 0.95 UTR = 139 50% repowered: 3.5553 d/MW/yr × 36.565 MW × 0.19 rep = 25. 50% not repowered: 3.5553 d/MW/yr × 36.565 MW = 130 × 0.80 SSD = 104 × 0.94 HTR = 98 × 0.95 UTR = 93	155	41%	129	50%	123	53%	118	55%
	4/1/13-1/11/18, 4.78 yrs	100% repowered: 3.5553 d/MW/yr × 73.13 MW 0.19 rep × 4.78 yrs = 236	236	81%	236	81%	236	81%	236	81%
	3 years	260/yr × 3 yrs = **780**	**680**	**13%**	**565**	**27%**	**542**	**30%**	**523**	**33%**
	8 years	260/yr × 8 yrs = **2,080**	**916**	**56%**	**801**	**61%**	**778**	**63%**	**759**	**63%**
SeaWest 42.395 MW	Baseline	See Appendix: 4.34 d/MW/yr during 2005-09	184/yr	---	---	---	---	---	---	---
	1/11/10-8/30/10, 0.637 yrs	No repower: 184 d/yr × 0.637 yrs = 117 × 0.80 SSD = 94	117	0%	94	20%	94	20%	94	20%
	8/30/10-4/1/11, 0.583 yrs	Relocated 11.375 MW of turbines rated 7-10 & removed unproductive towers: 184 d/yr × 0.583 yrs = 107 × 0.90 SSD = 97 × 0.94 HTR = 91 × 0.95 UTR = 86	107	0%	97	10%	91	15%	86	20%
	4/1/11-4/1/12, 1 yr	25% repowered: 4.34 d/MW/yr × 10.6 MW × 0.19 rep = 9. 75% not repowered: 4.34 d/MW/yr × 31.8 MW = 138 × 0.80 SSD = 110 × 0.94 HTR = 104 × 0.95 UTR = 99	147	20%	119	35%	113	39%	108	42%
	4/1/12-4/1/13, 1 yr	50% repowered: 4.34 d/MW/yr × 21.2 MW × 0.19 rep = 17. 50% not repowered: 4.34 d/MW/yr × 21.2 MW = 92 × 0.80 SSD = 74 × 0.94 HTR = 69 × 0.95	109	41%	91	50%	86	53%	83	55%

Project or Company	Time period	Basis	Repower effect		Seasonal shutdown effect		Hazard turbine removal		Unpro-ductive tower removal	
			No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion	No. killed	Reduc-tion
		UTR = 66								
	4/1/13-1/11/18, 4.78 yrs	100% repowered: 4.34 d/MW/yr × 42.395 MW × 0.19 rep × 4.78 yrs = 167	167	81%	167	81%	167	81%	167	81%
	3 years	No repower: 184 d/yr × 3 yrs = **552**	**480**	**13%**	**401**	**27%**	**384**	**30%**	**371**	**33%**
	8 years	No repower: 184 d/yr × 8 yrs = **1,472**	**647**	**56%**	**568**	**61%**	**551**	**63%**	**538**	**63%**
AWI 95.7 MW	Baseline	See Appendix	317/yr	---	---	---	---	---	---	---
	2010-12	Assumed AWI will operate as usual: 317 d/yr × 3 yrs = 951 × 0.80 SSD = 761	951	0%	761	20%	761	20%	761	20%
	2013-18	Same as above. 317 d/yr × 5 yrs = 1,585 × 0.80 SSD = 1,268	1,585	0%	1,268	20%	1,268	20%	1,268	20%
	3 yrs	317 d/yr × 3 yrs = **951**	**951**	**0%**	**761**	**20%**	**761**	**20%**	**761**	**20%**
	8 yrs	317 d/yr × 8 yrs = **2,536**	**2,536**	**0%**	**2,029**	**20%**	**2,029**	**20%**	**2,029**	**20%**
Northwind 12.09 MW	Baseline	Models of fatality rates regressed on turbine size (Smallwood 2009)	46/yr	---	---	---	---	---	---	---
	3 years	46 d/yr × 3 yrs = **138**	**138**	**0%**	**138**	**0%**	**138**	**0%**	**138**	**0%**
	8 years	46 d/yr × 8 yrs = **368**	**368**	**0%**	**368**	**0%**	**368**	**0%**	**368**	**0%**
Total	**3 years**	**5,138**	**4,133**	**20%**	**3,473**	**32%**	**3,375**	**34%**	**3,297**	**36%**
Total	**8 years**	**13,701**	**7,339**	**46%**	**6,362**	**54%**	**6,264**	**54%**	**6,186**	**55%**

[a] Note that the predicted rate based on regression models in Smallwood (2009) were 0.03 deaths/MW/yr greater than the rate reported in Smallwood and Karas (2009).

Table 5. Projected AMP effectiveness from 1/11/10 to 1/11/13 and expressed as percent reduction in total focal species fatalities over three years from the 5,138 fatalities that would accumulate in the absence of any changes to the APWRA.

	Management Plan		
Measure	**County**	**Companies**	**Audubon & CARE**
Unproductive turbine removal	1.5%	1.1%	1.5%
Hazardous turbine relocation	0.8%	0.2%	1.9%
Seasonal shutdown	15.8%	15.1%	12.8%
Repowering	11.4%	14.9%	19.6%
Total reduction	29.4%	31.3%	35.8%
Total fatalities remaining in plan	*3,627*	*3,531*	*3,297*

Table 6. Projected AMP effectiveness from 1/11/10 to 1/11/18 and expressed as percent reduction in total focal species fatalities over eight years from the 13,701 fatalities that would accumulate in the absence of any changes to the APWRA.

	Management Plan		
Measure	**County**	**Companies**	**Audubon & CARE**
Unproductive turbine removal	1.1%	1.3%	0.6%
Hazardous turbine relocation	1.0%	0.4%	0.7%
Seasonal shutdown	11.3%	14.0%	7.2%
Repowering	28.3%	17.2%	46.4%
Total reduction	41.8%	33.0%	54.9%
Total fatalities remaining in plan	*7,979*	*9,183*	*6,186*

The following are several fundamental reasons why the AMPs cannot achieve the stated goal:

Schedules are too slow.—Each AMP takes too long before management actions must meet deadlines. Until actions are taken to reduce fatalities, fatalities will continue at current rates. The most significant delay in the schedules is the time to repowering.

Repowering is given insufficient weight.—Compared to the effects of repowering, hazardous turbine relocations and unproductive tower removals will contribute very little to the overall effectiveness of the three AMPs, ranging from a fraction of a percent to less than two percent reductions (Tables 5 and 6).

Relocations of SRC-rated turbines are projected to increase burrowing owl fatalities.—The SRC ratings of turbines for hazard level omitted burrowing owl from consideration. My assessment of the performance of hazardous turbines (Smallwood 2008) indicated that relocating these turbines could actually increase burrowing owl fatalities. Because burrowing owl fatalities contribute substantially to total target raptor fatalities, their increased fatality rate counteracts the reductions in the other target species fatalities that could be achieved by relocating hazardous turbines. Specific relocation or removal guidelines are needed for burrowing owls (see Smallwood et al. 2009).

Non-participating companies and turbines obstruct the goal.—According to the companies and the County, 19 MW of SeaWest turbines (Santa Clara)[1] are to be exempt from AMPs. Northwind Energy operates another 12.09 MW of turbines that have not been subject to management actions and apparently will not be in the future. AWI operates another 95.7 MW of wind turbines (90.2 MW of non-vacant addresses currently) for which there does not appear to be any commitment for AMP actions. Thus, 121.29 MW of the 479 MW in operational or vacant tower status, or 25% of the APWRA's current capacity, will not be participating in the proposed AMPs. This 25% of the capacity will impede the goal because now the 50% fatality reduction will need to be achieved based on actions directed toward 75% of the APWRA.

No consequences for non-compliance.—Unless firm consequences for noncompliance are incorporated into the management plan, the history of agreements, promises, and permit management in the APWRA fails to convince me that the proposed measures will be implemented or enforced.

Additional Comments

Many of the measures proposed by the County and the companies are contingent on not achieving the 50% fatality reduction threshold by various future dates. However, it might be helpful to reaffirm that the SRC is the body that will determine whether the 50% reduction goal was met. Since the SRC made this determination at the end of the first three years of the Avian Protection Program, the wind companies have repeatedly stated that they disagree with the SRC's determination. For the 50% fatality reduction threshold to be meaningful, the settling parties need to decide whether the SRC is going to make the determination and whether its determination is going to be final.

In the County's plan, the SRC will prioritize management measures in early 2014 if the 50% fatality reduction threshold has not been met. I am concerned that this measure might mislead some readers into believing that new measures are yet to be discovered and assessed. However, in 2007 the SRC considered all the measures available to it and issued a set of recommendations. The SRC again considered the measures in 2010 and issued essentially the same prioritized list of management measures as it did in 2007. The recommendations did not change substantially, partly because the monitoring data reinforced the SRC's repowering recommendation, and partly because the monitoring data were unable to inform the SRC on the effectiveness of recommended management measures. Another reason for lack of change in the recommendations may be that there are no other viable measures to consider. It remains unlikely, given the County's proposed implementation schedule and cut-backs in the monitoring budget, that the SRC will be any better informed about the effectiveness of management measures by 2014, so it is unlikely that the SRC will change its prioritization of measures. It would be misleading to imply that the SRC will prioritize a new set of management measures.

[1] The Santa Clara exclusion is new to me; I was previously unaware that these turbines of the alleged exemption of these turbines because no mention of it appears in the 22 September 2005 Board Resolution or in the settlement agreement.

The County's AMP measure 1.g., assigning credits for the removals of turbines rated <7, should be supported by differences in fatality rates. That is, fatality rates should be compared among groups of wind turbines rated 10, 9.5, 9, 8.5, …<7. This comparison is possible, but complicated and would take some time. Also, it would help if the companies would inform the analyst about exactly when hazardous turbines were relocated over the past several years. However, crediting turbines for those removed as part of repowering projects, as proposed in the County's AMP, will counteract the fatality reductions achieved due to repowering. This crediting would further impede the goal.

The County's AMP measure 4 requires compliance monitoring, which is warranted, but I noticed that there are no consequences for missed deadlines or compliance failures. The County should promise to enforce the AMP and should add consequences for compliance failures.

The County's AMP measure 5.b. includes a list of additional studies that might be required if the Planning Director determines they are necessary and designed properly. I thought the SRC was assembled to advise the County on matters such as this. The SRC submitted its additional study recommendations. The AMP should commit to either requiring the studies or not.

The County's AMP measure 5.c. implies that the CALWEA scavenger removal study might be implemented instead of a study recommended by the SRC. The SRC has not yet recommended the CALWEA study. If the Planning Director approves the CALWEA study at this time, he will do so without consulting the SRC.

The County proposes covering the costs of the SRC's recommended additional studies by using the existing monitoring budget. That is, the fatality monitoring would need to be cut back considerably to afford the additional studies. As a case in point, the KB study cost about half the budget for a typical year of fatality monitoring. The level of monitoring reduction that would be needed to accommodate even one of the additional studies would be severe. The purpose of the additional studies was intended to facilitate the interpretation of the fatality monitoring data, so the purpose of the studies would be partly defeated in the County's and companies' AMPs (the results of the studies could be applied retroactively to past monitoring data, however).

Audubon/CARE's AMP would require that the wind companies pay a restoration bond, as well as compensatory mitigation for the fatalities that cannot be avoided, and a $1,000/day fine for missed deadlines. In an SRC meeting on 29 April 2010, County staff argued that these measures were inappropriate for an AMP because they do not directly reduce fatalities. However, the County's AMP also includes multiple measures that do not directly reduce fatalities, including compliance monitoring.

The County followed up on the restoration bond issue by distributing a memo (P136) dated 16 October 2009, but which was sent to the SRC in late May 2010. This memo characterized the restoration bond as nothing more than a bond to guarantee that the turbines and related infrastructure are removed from the APWRA when the turbines are no longer productive. In making this characterization, Alameda County referenced Condition No. 4 of the Board of Supervisor's Resolution R-2005-453. However, the County neglected to reference or discuss Condition No. 7 of the same Board Resolution. Condition No. 7 was titled, "Avian Wildlife

Protection Program & Schedule." It described how the Board envisioned the implementation of the Avian Wildlife Protection Program, and in doing so it integrated the restoration bond (Condition No. 4). Specifically, it stated, "*If at any such time the Permittee ceases to participate in the Program or per these conditions is deemed to be non-cooperative by the Planning Director, the Permittee, upon a duly-noticed hearing for revocation of the Permit, shall be responsible for restoring or otherwise reclaiming the facility site(s) to pre-project conditions, or shall forfeit the Reclamation Bond referenced above as Condition 4*." By incorporation into Condition No. 7, and by its wording, Condition No. 4 appears to have been intended as a compliance enforcement tool directed to the Avian Wildlife Protection Plan. Audubon and CARE are justified in proposing payment of the restoration bond as part of its AMP.

On Adaptive Management

The Settling Parties refer to their proposed management plans as *adaptive management* plans. In this assessment, I adopted the Settling Parties' use of the term adaptive management, but I want to point out that I do so to be consistent with the plans I reviewed, whereas I disagree with the use of the term in this case. Adaptive management is a means for reducing uncertainty in understanding of how human actions affect the environment while also taking those actions. It is a structured process, in which scientific hypotheses are established prior to the action(s), along with alternative management prescriptions to be implemented as a result of testing those hypotheses (Lancia et al. 1996, McLain and Lee 1996). Then, management actions and research are conducted simultaneously. In the case of mitigation, implementing the measures would proceed simultaneously with a research program linked to alternative management prescriptions. One of the most important tenets of adaptive management is to identify the range of possible prescriptions in advance at the start of the adaptive management program (Holling 1986, Walters 1986).

The plans proposed by the companies and the County will not provide the means to reduce uncertainty in how the management measures perform individually. Furthermore, the SRC recommended in its last meeting that no more effort should be directed toward attempting to measure the effectiveness of individual management measures. Instead, the SRC recommended that fatality monitoring be used to assess the effectiveness of the program as a whole and to inform repowering so that siting can be more effectively planned to minimize bird fatalities. Furthermore, no alternative management prescriptions have been identified or planned. The proposed management plans are not adaptive.

Holling (1978) described the need to formulate a team to develop and implement the adaptive management program. He recommended that a project manager be assigned, who would compile the information and prepare the initial plan elements. This project manager was clearly intended to be a scientist. Additional scientists with complimentary expertise in quantitative analysis and subject disciplines would form the core group of the team, and their recommendations would be passed onto a group of managers. Finally, the managers would pass on their recommendations to the policy-makers, though these steps were not envisioned as separate, but rather as interactive and transparent among all components of the team. Some may argue that in the case of the Alameda County Avian Protection Program, Holling's recommended team elements are present, but I would argue that they are not present in the form that Holling

envisioned. For example, the management plans presented to the SRC were formulated by parties other than the SRC. In another example, the decision over whether to implement the CALWEA study was made by managers without any substantial input from the SRC.

The essential steps in any project developed around adaptive management are to:

(1) Compile, process, and interpret all existing data in collaboration with all stakeholders;
(2) Develop project goals and objectives, and put them in writing;
(3) Develop or refine working model and hypotheses;
(4) Implement the prescriptions at appropriate spatial and temporal scales;
(5) Monitor results using appropriate replication and treatment controls;
(6) Evaluate and test monitoring data, and,
(7) Return to step #3 (Haney and Power 1996).

In this case, however, the management measures being proposed will not be implemented in an experimental fashion. Few hypotheses have been tested adequately so far, and the County and company plans will further reduce the capacity of the monitoring to provide data useful for testing hypotheses. Given that the proposed management measures would be implemented once before repowering takes place, it would be unrealistic to expect that step (7), above, will ever take place. For these reasons, I suggest that the proposed plans are not adaptive management plans.

References

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

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

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

Lancia, R. A., C. E. Braun, M. W. Collopy, R. D. Dueser, J. G. Kie, C. J. Martinka, J. D. Nichols, T. D. Nudds, W. R. Porath, and N. G. Tilghman. 1996. ARM! For the future: adaptive resource management in the wildlife profession. Wildlife Society Bulletin 24:436-442.

McLain, R. J. and R. G. Lee. 1996. Adaptive management: promises and pitfalls. Environmental Management 20:437-442.

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

Smallwood, S. 2007b. Estimated Effects of Full Winter Shutdown and Removal of Tier I & II Turbines. SRC Document S19, http://www.altamontsrc.org/alt_doc/alt_settlement/s19_smallwood_estimated_effects_shutdown_and_tier_1_2_removal_3_19_07.pdf. 1 pp.

Smallwood, K. S. 2008. Assessment of Relocation/Removal of Altamont Pass Wind Turbines Rated as Hazardous by the Alameda County SRC. Alameda County SRC document P-103. 10 pp. http://www.altamontsrc.org/alt_doc/p103_assessment_of_src_recommendations_to_relocate_rated_turbines.pdf

Smallwood, K. S. 2009. Fatality Rates in the Altamont Pass Wind Resource Area 1998-2009. P145_Smallwood Fatality Monitoring Results 12-31-09.

Smallwood, K. Shawn. 2010. Baseline Fatality Rates at Tres Vaqueros Wind Project: Report to East Bay Regional Park District. Oakland, California.

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

Smallwood, K. S., L. Neher, and D. A. Bell. 2009. 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., D. A. Bell, S. A. Snyder, and J. E. DiDonato. 2010. Novel scavenger removal trials increase estimates of wind turbine-caused avian fatality rates. Journal of Wildlife Management (75: In press).

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

APPENDIX

Company Contributions to Avian Fatalities in the Altamont Pass Wind Resource Area

K. Shawn Smallwood

In a recent report (Smallwood 2009), I summarized my comparisons of avian and bat fatality rates caused by wind turbines in the APWRA. I compared fatality rates between the baseline (1998-2003) and current study (2005-2009) periods, among years and seasons, and by size of wind turbine. I also examined patterns in the data for evidence of the effectiveness of mitigation measures, which the wind companies implemented to various degrees in response to the SRC's recommendations for reducing raptor fatalities in the APWRA. In support of my assessment of proposed management plans by parties to the 2007 settlement agreement, I compared fatality rates among wind companies during the current study period.

METHODS

Field methods were described in Smallwood and Karas (2009) and analytical methods were described in Smallwood (2009). The only difference in methodology applied in this study was how I estimated annual fatalities per company. To estimate annual fatalities, I first multiplied estimates of fatalities per megawatt (MW) of rated capacity per year in each monitored turbine row by the MW of rated capacity owned by a particular wind company. Then I took the average of the product among turbine rows, as well as the 90% confidence interval (CI) of the mean. Fatality rates were derived from fatality searches at both operational and non-operational turbines, so expanding the mean fatality rates to total capacities owned by each company was appropriate, though some small bias might have resulted if the monitoring team had stopped searching for fatalities at wind turbine addresses where the wind turbines had been removed. Another difference between this study and the analysis summarized in Smallwood (2009) was that in this study I did not carry the error terms through adjustments for the effects of scavenger removal and searcher detection error; that is, I did not use the Delta method (Goodman 1960). I did not anticipate any substantial consequence from not carrying the error terms in this case.

RESULTS AND DISCUSSION

On a per-MW basis, wind turbines owned by AES SeaWest consistently caused the highest fatality rates, including for red-tailed hawks, burrowing owls, all raptors as a group, and all birds as a group (Figure 1). Wind turbines owned by NextEra caused the highest fatality rates for golden eagles. However, when the MW of rated capacity owned by each company was considered, NextEra emerged as the greatest contributor to annual fatalities of golden eagle, red-tailed hawk, American kestrel, burrowing owl, all raptors as a group, and all birds as a group (Figure 2). NextEra caused about five times more golden eagle fatalities than did any other wind company in the APWRA, as well as twice as many red-tailed hawks and American kestrels. Compared to the other wind companies in the APWRA, NextEra's wind turbines caused nearly three times as many raptor fatalities as a group and nearly three times as many birds as a group (Figure 2). Fatality rates can be reduced quickest by directing reduction measures to AES SeaWest, but they can be reduced most substantially by NextEra followed by AWI and enXco.

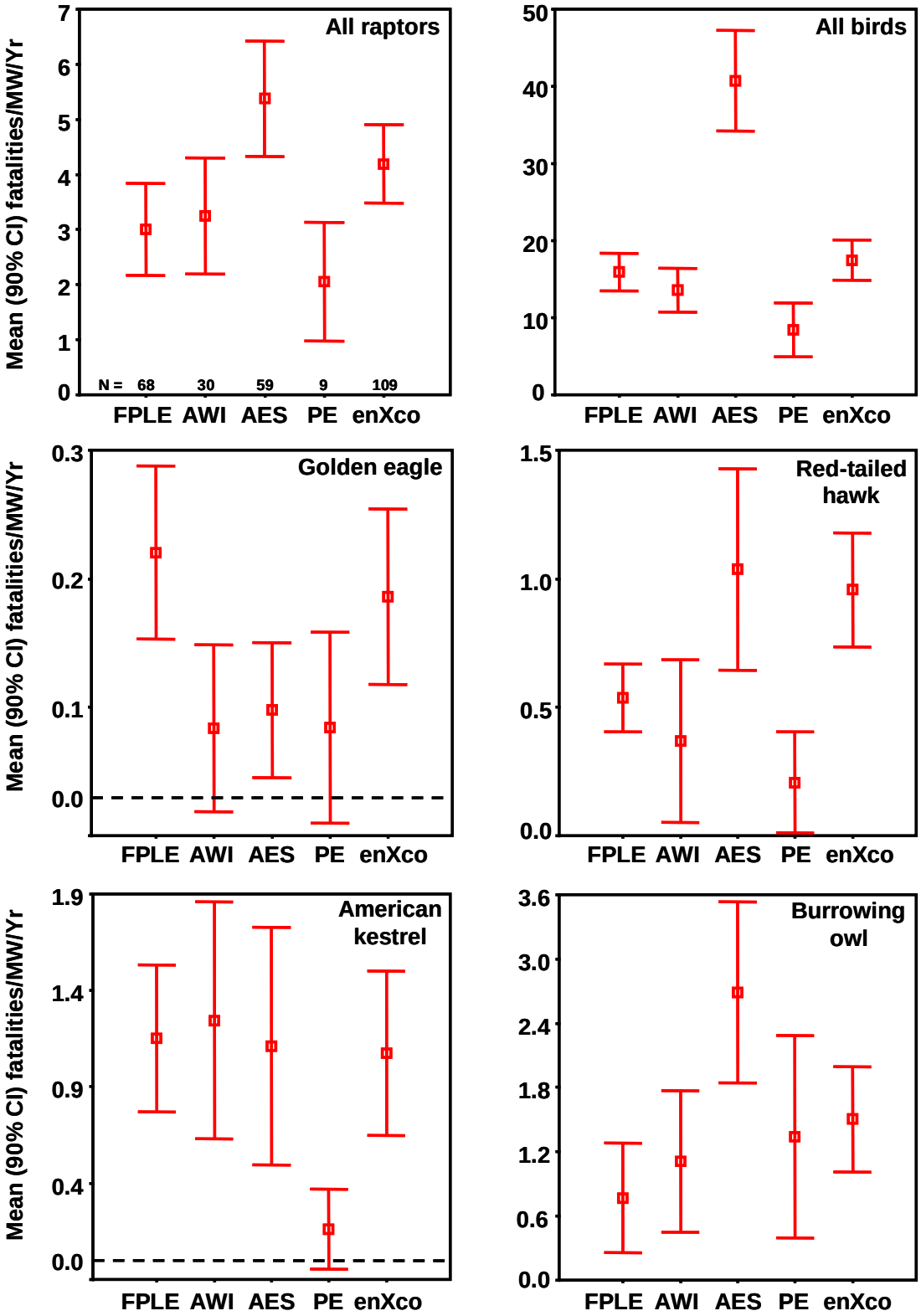

Figure 1. Mean and 90% confidence intervals in fatalities per MW per year among wind companies in the APWRA during 2005-2009, including only old-generation wind turbines and no wind walls in mixed ownership, and where FPLE = NextEra, AWI = Altamont Winds, Inc., AES = AES SeaWest, and PE = Pattern Energy.

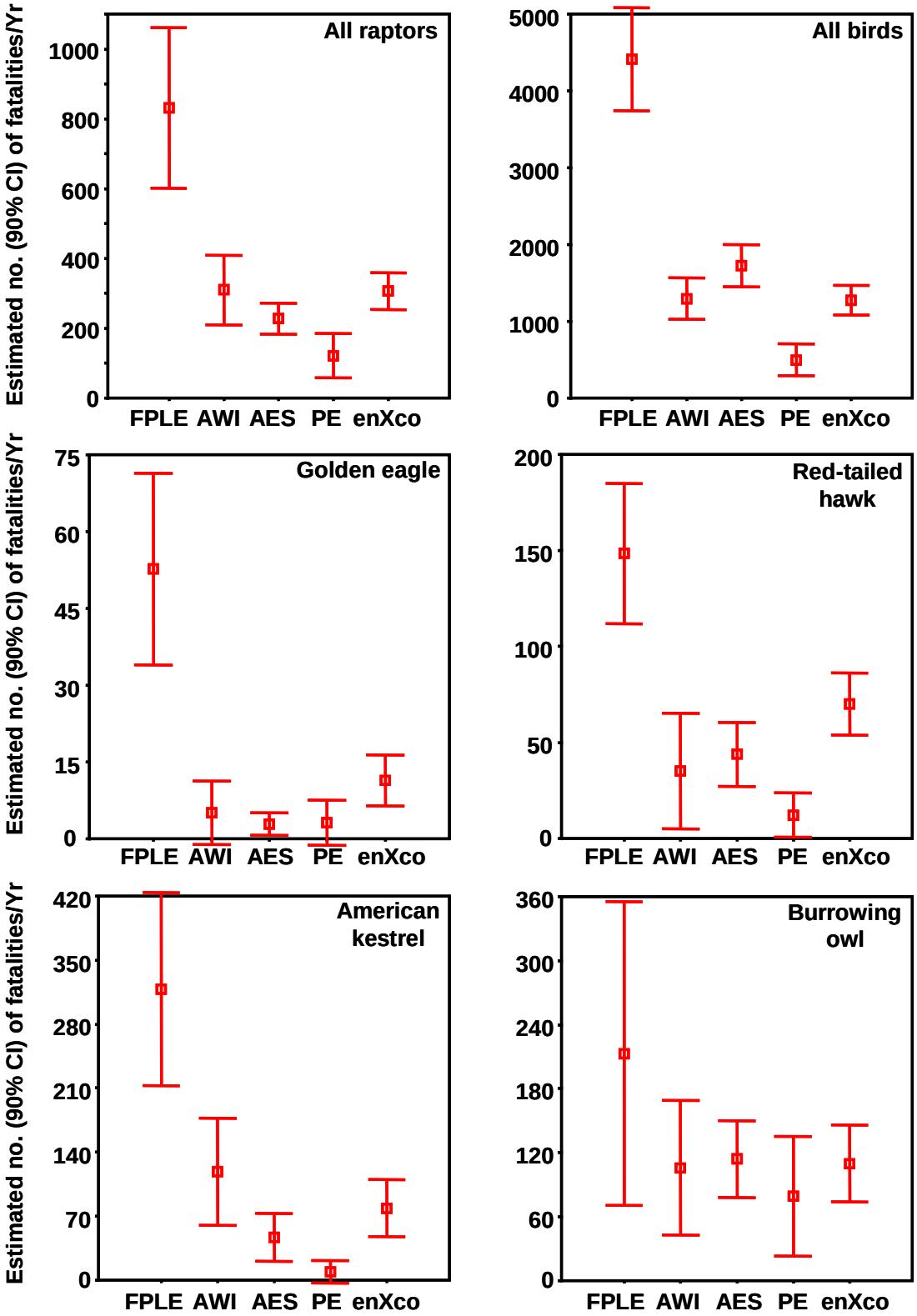

Figure 2. Estimated annual fatalities (and 90% confidence intervals) among wind companies in the APWRA during 2005-2009, where FPLE = NextEra, AWI = Altamont Winds, Inc., AES = AES SeaWest, and PE = Pattern Energy.