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Date:	April 27, 2010
To:	Sandra Rivera
Cc:	Altamont Pass Wind Resource Area Scientific Review Committee
From:	The Monitoring Team
Subject:	**Possible Revisions to the Altamont Pass Wind Resource Area Monitoring Plan Program**

At the request of Alameda County, the monitoring team has investigated options for revising the monitoring program on the basis of information collected to date. The objective is to reduce costs associated with the monitoring program so that more resources can be devoted to other tasks associated with reducing avian fatalities. Specifically, we investigated options for reducing costs that would maintain statistical power to detect changes in the annual mortality rate of the four focal species.

There are several possible ways to achieve cost reductions. One option would be to discontinue the current monitoring protocol. Another option would entail modifying the existing protocol by either reducing the number of turbines sampled or increasing the search interval. A third type of option involves achieving efficiencies; this approach would not necessarily preclude implementation of the other options. Based on experience in the field, recommendations to achieve efficiency include using dogs to search for fatalities, implementing a modern electronic data collection system, discontinuing collection of information on mortalities of nonnative species such as rock doves, and reducing effort in other ways (e.g., discontinuing the collection of bird use or bird behavior data). These options are discussed in detail below.

Discontinue Monitoring

One option is to discontinue monitoring annual trends in avian fatality rates throughout the Altamont Pass Wind Resource Area (APWRA), instead devoting currently allocated resources into other areas of investigation such as the burrowing owl study, research into adjustment factors, implementation of the Quality Assurance/Quality Control study, or other areas identified by the Scientific Review Committee.

The advantage of this option is that it frees up significant resources to pursue other areas of research and monitoring with applicability to the issue of high avian mortality in the APWRA. The major disadvantage of this option is that additional information on trends in the annual rate of turbine-related avian mortality in the APWRA would no longer be collected, leaving several questions—such as the effectiveness of hazardous turbine removals, seasonal shutdowns, and other mitigation measures—unresolved. Moreover, there would no longer be a contemporaneous baseline against which to measure the effectiveness of repowering to reduce turbine-related avian mortality.

Modify Existing Protocol

Continue Existing Monitoring Program at a Reduced Number of Turbines

The first option for modifying the current avian fatality monitoring program is to reduce the number of turbines sampled. Currently, the monitoring program samples approximately 50% of all turbines. Some turbine types (such as the Kenetech 56-100) are relatively common and have a consistently high raptor fatality rate. Other turbine types (such as the V47) are rare and have a comparatively low raptor fatality rate. In 2008, for example, 2,730 Kenetech 56-100 turbines were deployed in the APWRA, whereas only 31 V47 turbines were deployed. Reducing the number of turbines sampled for some turbine types would not result in a reduction in statistical power, assuming the reductions do not result in a geographic bias.

Reductions in survey effort below the census level will logarithmically increase the probability of variance between estimates of fatalities and the actual fatality rate (Zar 1984). The relationship between sample size and the reliability of estimates is influenced by the "population" size (in this case, the total number of turbines or strings in the APWRA) and the distribution and variability of outcomes across locations (in this instance, the fatality rate at each location).

To evaluate the effect of sample size on the accuracy of fatality estimates, the monitoring data for 2005–2009 (hereafter referred to as the *reference dataset*) were analyzed as if representative of a homogenous statistical population. Each group of unadjusted fatalities data was subsampled within each type of turbine 30 times with various levels of "monitoring effort" (e.g., subsample size) to calculate the range and variability in the estimate of mean raptor fatalities per megawatt (MW) per year.[1] For example, we considered the impacts of decreasing monitoring effort on the Kenetech 56-100 (typical old generation turbine type) and V47 turbines (Diablo Winds relatively small modern repowered turbine type) in the APWRA. The actual mean unadjusted fatality rates for these turbine types are presented in Table 1.

Table 1. Actual Raptor Fatalities by Turbine Type (per MW/year)

Turbine Type	Fatalities per MW	Standard Deviation	All Raptors per Turbine	Standard Deviation	Percent with Fatalities
Kenetech 56-100	2.065061	3.75094803	0.20650611	0.3750948	0.56287425
V-47	0.763315	0.76687317	0.50378788	0.50613629	0.65909091

[1] The raptor fatalities used for this analysis are the "raw" unadjusted fatalities per MW. There is consensus in the scientific community that these values do not represent the total fatalities, and should be adjusted to some greater or lesser extent relative to the interval of search and corresponding detection probability. However, the search interval was consistently close to 33–34 days during 2005–2009 for these turbines. Therefore, questions or issues surrounding fatality adjustments would not affect the relationship between survey effort (percent of turbines monitored) and the number of actual raptor detections.

For both these turbine types the variance in the calculated estimate increased logarithmically with decreased sampling effort (Figure 1). In the case of the V47 turbines, the ratio between the range of calculated estimates and the "actual" estimate neared 20% with a 33% monitoring effort (Table 2). Conversely, this ratio was only 13% with a 33% monitoring effort for the Kenetech 56-100 data (Table 3).

Figure 1. Sampling Effort versus Variance of 30 Simulated Subsamples per Level of Effort for Each Turbine Type Taken from the Reference Data

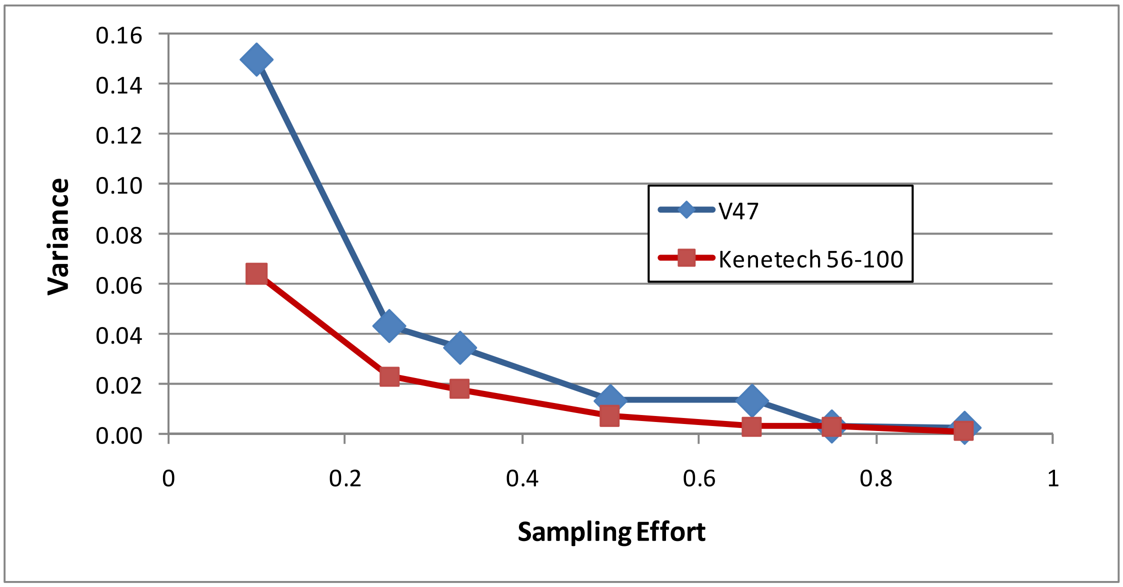

Table 2. Estimates of Raptor Fatalities per MW for V47 Turbines Based on 30 Subsamples of the Reference Data for Each Level of Simulated Monitoring Effort

Percent Subsampled	Grand Mean	Upper 95%	Lower 95%	Standard Deviation	Range	Variance	Standard Error	Coefficient of Variation	1/2 Range/ Mean
0.1	0.75	0.39	1.52	0.15	0.07	51.40	1.01	0.75	0.39
0.25	0.75	0.21	1.02	0.04	0.04	27.88	0.68	0.75	0.21
0.33	0.77	0.19	0.69	0.03	0.03	24.10	0.44	0.77	0.19
0.5	0.77	0.12	0.49	0.01	0.02	15.13	0.32	0.77	0.12
0.75	0.76	0.12	0.42	0.01	0.02	15.48	0.28	0.76	0.12
0.9	0.78	0.06	0.21	0.00	0.01	7.55	0.13	0.78	0.06

Table 3. Estimates of Raptor Fatalities per MW for Kenetech 56-100 Turbines Based on 30 Subsamples of the Reference Data for Each Level of Simulated Monitoring Effort

Percent Subsampled	Grand Mean	Upper 95%	Lower 95%	Standard Deviation	Range	Variance	Standard Error	Coefficient of Variation	1/2 Range/ Mean
0.1	1.45	0.25	0.87	0.06	0.05	17.45	0.30	1.45	0.25
0.25	1.54	0.15	0.76	0.02	0.03	9.90	0.25	1.54	0.15
0.33	1.53	0.13	0.54	0.02	0.02	8.76	0.18	1.53	0.13
0.5	1.57	0.09	0.33	0.01	0.02	5.53	0.10	1.57	0.09
0.75	1.56	0.06	0.26	0.00	0.01	3.56	0.08	1.56	0.06
0.9	1.53	0.06	0.24	0.00	0.01	3.61	0.08	1.53	0.06

These results strongly indicate that a reduced sampling effort that achieves the same statistical power could be devised for the un-repowered portion of the APWRA. The Monitoring Team is currently in the process of evaluating sample size requirements for each turbine type using the methods outlined above. We plan to assess sample size requirements for each turbine type, and then make recommendations for distributing that sample size across the operating groups. Use of operating groups as the means of stratification will help to ensure that the sampling scheme is geographically balanced. Within an operating group, a proportion of the turbines or strings of a particular type that need to be sampled will be designated as “always sampled,” while the rest will be apportioned to be sampled on a rotating basis using a “rotating panel” sampling scheme (see below).

Table 4. Estimates of Raptor Fatalities per MW Based on 30 Subsamples of the Reference Data for Each Level of Simulated Monitoring Effort by Turbine Type[2]

Turbine Type	Percent Subsampled	Grand Mean	Standard Deviation	Range	Variance	Standard Error	Coefficient of Variation	1/2 Range/ Mean
250 kilowatt (kW)	0.5	1.05	0.05	0.09	0.00	0.01	4.40	0.04
	0.66	1.05	0.05	0.09	0.00	0.01	4.40	0.04
	0.75	1.04	0.05	0.09	0.00	0.01	4.43	0.04
	0.9	1.06	0.04	0.09	0.00	0.01	4.21	0.04
Bonus	0.1	2.73	0.88	3.83	0.77	0.16	32.18	0.70
	0.25	2.62	0.53	2.06	0.28	0.10	20.17	0.39
	0.33	2.95	0.34	1.17	0.11	0.06	11.38	0.20
	0.5	2.67	0.24	1.01	0.06	0.04	9.06	0.19
	0.66	2.72	0.21	0.78	0.04	0.04	7.55	0.14
	0.75	2.67	0.19	0.67	0.04	0.04	7.27	0.13
	0.9	2.72	0.08	0.28	0.01	0.01	2.76	0.05
Enertech	0.1	3.58	2.18	9.46	4.75	0.40	60.91	1.32
	0.25	2.77	0.97	3.51	0.95	0.18	35.04	0.63
	0.33	3.03	1.12	3.89	1.26	0.21	37.14	0.64
	0.5	3.15	0.53	2.18	0.28	0.10	16.84	0.35
	0.66	2.98	0.44	1.56	0.19	0.08	14.69	0.26
	0.75	3.12	0.36	1.52	0.13	0.07	11.57	0.24
	0.9	3.03	0.28	1.18	0.08	0.05	9.37	0.19
Howden	0.1	0.98	0.95	3.03	0.90	0.17	96.78	1.54
	0.25	0.63	0.35	1.56	0.13	0.06	56.03	1.24
	0.33	0.71	0.25	1.04	0.06	0.05	35.74	0.74
	0.5	0.74	0.17	0.70	0.03	0.03	22.92	0.47
	0.66	0.66	0.16	0.64	0.03	0.03	25.00	0.49
	0.75	0.60	0.09	0.40	0.01	0.02	14.51	0.33
	0.9	0.64	0.07	0.25	0.00	0.01	10.56	0.20
KVS33	0.25	0.49	0.25	0.99	0.06	0.05	51.84	1.02
	0.33	0.38	0.17	0.71	0.03	0.03	45.96	0.94
	0.5	0.42	0.13	0.61	0.02	0.02	31.95	0.72
	0.66	0.45	0.09	0.46	0.01	0.02	18.90	0.51
	0.75	0.44	0.07	0.26	0.01	0.01	16.27	0.30
	0.9	0.44	0.05	0.20	0.00	0.01	11.43	0.23
Micon	0.1	2.10	1.26	5.26	1.59	0.23	60.22	1.25
	0.25	1.95	0.87	3.57	0.76	0.16	44.75	0.92
	0.33	1.82	0.50	2.19	0.25	0.09	27.38	0.60
	0.5	2.06	0.37	1.56	0.13	0.07	17.81	0.38
	0.66	1.98	0.30	1.46	0.09	0.05	15.21	0.37
Micon (cont.)	0.75	2.06	0.25	1.09	0.06	0.05	12.24	0.27

[2] Some turbine types such as the 250 kW and KVS33 have very few turbines/strings in the data and cannot be sub-sampled at low effort. Polenko turbines were excluded from this analysis because they had relatively too few strings and fatalities.

Turbine Type	Percent Subsampled	Grand Mean	Standard Deviation	Range	Variance	Standard Error	Coefficient of Variation	1/2 Range/ Mean
Nordtank	0.9	2.08	0.09	0.37	0.01	0.02	4.51	0.09
	0.1	1.42	2.03	7.05	4.11	0.37	142.56	2.48
	0.25	1.84	0.91	3.45	0.83	0.17	49.49	0.94
	0.33	1.67	0.66	3.25	0.44	0.12	39.89	0.98
	0.5	1.65	0.41	1.45	0.17	0.08	25.05	0.44
	0.66	1.77	0.32	1.48	0.10	0.06	18.11	0.42
	0.75	1.70	0.28	1.17	0.08	0.05	16.21	0.34
	0.9	1.71	0.14	0.53	0.02	0.03	8.16	0.15
Vestas	0.1	1.48	0.92	3.27	0.84	0.17	62.23	1.11
	0.25	1.37	0.52	2.04	0.27	0.10	38.32	0.75
	0.33	1.55	0.46	1.50	0.21	0.08	29.56	0.48
	0.5	1.57	0.37	1.48	0.13	0.07	23.37	0.47
	0.66	1.51	0.23	0.90	0.05	0.04	14.99	0.30
	0.75	1.49	0.20	0.78	0.04	0.04	13.63	0.26
	0.9	1.51	0.11	0.40	0.01	0.02	7.18	0.13
Windmatic	0.25	1.88	2.50	10.26	6.24	0.46	132.88	2.73
	0.33	2.97	3.19	10.26	10.18	0.58	107.52	1.73
	0.5	2.06	1.64	5.79	2.69	0.30	79.49	1.40
	0.66	2.22	1.01	3.92	1.02	0.18	45.41	0.88
	0.75	2.71	0.95	3.31	0.90	0.17	35.02	0.61
	0.9	2.41	0.65	2.20	0.42	0.12	26.95	0.46

In general, it is possible to reduce the proportion of turbines monitored in large homogenous samples without affecting fatality rate estimates. However, in comparatively small populations of turbines, reduced sampling effort may result in an estimate that is not representative of that actual population mean. The relationship between sampling effort and sampling power is specific to each turbine type because the rate, variability, and distribution of fatalities across strings differs in accordance to the risk each turbine type presents, its placement in the APWRA, and other factors (including randomness).

To maximize power and minimize error reductions in the proportion of turbines/strings monitored, the Bonus and Kenetech 56-100 turbines should be the first area of focus. These types are widely distributed, and have a consistently high unadjusted raptor fatality rate of approximately 0.33 raptors per string per year. Reduced effort near 33% of the turbines should be sufficient to achieve a representative 3-year sample. Monitoring of the remaining turbine types should be adjusted to ensure that the desired power is achieved based on the results of the simulations presented herein. The actual number of turbines/strings expected to be in operation should be considered for the remaining turbine types. The fatality rates for turbine types with very few members (e.g., 250 kW or Polenko) could be assumed if monitoring them is not cost effective because they represent a very small proportion of the APWRA fatalities.

Table 5. Number of Strings and Detected Raptor Fatalities 2005–2009 by Turbine Type from the Reference Data

Turbine Type	Number of Locations (Strings)	Raptor Fatalities	Raptors per MW	Raptors per Turbine
250 kW	5	8	0.84	0.21
Bonus	231	208	2.72	0.23
Enertech	48	61	2.99	0.12
Howden	29	23	0.63	0.21
Kenetech 56-100	416	565	1.54	0.15
KVS 33	21	16	0.43	0.17
Micon	95	70	2.05	0.13
Nordtank	43	23	1.69	0.11
Polenko	4	4	1.67	0.17
V-47	44	45	0.76	0.50
Vestas	38	48	1.51	0.14
Windmatic	18	13	2.49	0.16

Other groups, such as the V47 Diablo Winds turbine, might warrant a complete census. Changes to the APWRA, such as the deployment of modern turbines, will require adjustments to the sampling regime. Similarly, turbine types that are decommissioned or scheduled for decommissioning may not warrant monitoring if they do not represent the long-term conditions at the APWRA.

Some turbine types are distributed widely across the APWRA in a variety of geographic and micro-settings called “plots” in the APWRA schema. Spatial variability in bird use and collision risk factors can influence fatality rates within turbine types, and may result in an uneven distribution of fatalities on the landscape. Spatial variability may vary annually due to environmental conditions, bird use, or randomness, or may be consistently uneven due to these or other factors.

In cases where the monitoring effort is reduced below the census level, spatial variability in fatalities must be addressed to acquire a “representative” sample for each turbine type. Monitoring designs that are clumped or spatially biased can bias the estimate of fatality rates positively or negatively. Spatial bias cannot be addressed simply through randomization because randomized spatial designs tend to be “sticky” or “clumped.” A spatially balanced design incorporates both randomization and spatial stratification to reduce sampling error and bias (Stevens and Olsen 2003; Stevens and Olsen 2004).

A well-tested approach (EPA 2010) is to distribute sampling effort evenly across space within an area using adaptive cluster and spatially balanced randomization routines. These samples are then parsed into rotating panels of effort, where some sites (perhaps 50% of the subsample) are monitored every year, and other sites are rotated through annually. This approach provides consistent trends data at some locations, while increasing the geographic coverage of the overall (3 year) sampling effort. EPA maintains a variety of geographic information system–based tools for designing spatially balanced sampling regimes that can be readily applied in the APWRA.

One advantage of reducing the sampling effort at common turbine types is that it maintains the characteristics of the current monitoring program while reducing costs. The same metrics are measured, and a similar level of statistical power is achieved. Characteristics of the sampling effort that can influence estimates in unpredictable ways are maintained, thus preserving the comparability of data across years. One disadvantage is that the reduction in cost may not be sufficient to allow the funding of other research priorities, depending on the exact design that is selected.

Continue Existing Monitoring Program with an Increased Search Interval

The second option for modifying the current avian fatality monitoring program is to reduce the search interval, and thus the manpower required to implement the current monitoring protocol. Currently, the monitoring program utilizes an approximately 30-day search interval. Presumably, increasing the search interval to 60 days would reduce costs by approximately 50%, while increasing the search interval to 45 days would reduce costs by approximately 25%.

The advantage of this option is that it maintains most of the characteristics of the current monitoring plan while reducing costs in a very straightforward and predictable way. The same metrics are measured, and the same or nearly the same statistical power is achieved.

However, use of these disparate search intervals would require accurate and precise adjustment factors for carcass removal rates in order to maintain comparability across years. This would also likely confound comparisons across years—for small birds in particular, which are subject to higher carcass removal rates. The history of fatality monitoring in the APWRA strongly indicates that these adjustment factors are far from precise and are, moreover, likely to be inaccurate for some species. However, the savings from this cost reduction could be used to fund additional research on adjustment factors that may be applicable to solving this problem.

Options for Increasing Efficiency and Reducing Costs

The following recommendations—based on experience monitoring avian fatalities in the APWRA over the last 5 years—can be applied to any monitoring program that is deployed.

Option 1: Discontinue Collection of Information on Nonnative Species

Under the current monitoring protocol, 329 nonnative rock pigeons and European starlings were documented and processed in 2009. These species are considered pests; are not protected under the Migratory Bird Treaty Act or any other law; and are of no management concern, except with respect to their negative effects on native species. Both species nest in cavities and frequently make use of old generation turbines to nest, which may explain their prevalence in the fatality database.

Whenever one of these species is documented, the “feather spots” must be processed, often consuming up to 0.5 hour for a crew of two to three people (feathers are collected and removed from the site to ensure they are not double counted on the next survey—a time-consuming process). Individuals on the monitoring team have indicated that eliminating the need to process these species would have a significant effect on the number of turbines that could be searched daily.

The advantage of this option is that it would decrease costs. The disadvantage is that information on these species may potentially be used as a surrogate for other less common species.

Option 2: Discontinue Collection of Bird Use and Behavior Data

The monitoring protocol for collecting information on bird use and behavior in the APWRA over the last 5 years has changed four times. Some of the changes have made comparisons across years impossible for certain aspects of the information without significant and questionable statistical treatments to "adjust" the data to make comparison possible.

In view of this history, it is not unreasonable to consider eliminating the collection of this information. However, this option should not be implemented without further investigation.

The advantage of this option is a significant reduction in cost. However, information collected to date demonstrates that there are large annual variations in the total number of turbine-related avian fatalities in the APWRA. Most of this variation is likely due to differences between years in the number of birds utilizing the resources of the APWRA. Discontinuing the collection of this information would render an assessment of the effects of variation in bird use on the annual variations in turbine-related avian mortality rates impossible.

Option 3: Incorporate Dogs into Survey Teams to Increase Search Efficiency and Decrease Variability in Search Efficiency

The literature addressing monitoring of turbine-caused fatality is replete with references and research discussing the detection probability problem. The two critical parameters—carcass removal rate and searcher efficiency—are themselves influenced by factors such as environmental conditions, season, and carcass type (e.g., size, bird versus bat). These factors may confound each other because attempts to estimate carcass removal rates are also influenced by searcher efficiency. Results of the Buena Vista monitoring program indicate that searcher efficiency and carcass removal rates were variable both seasonally and in association with bird size.

Previous work has attempted to estimate these probabilities (e.g., Smallwood 2007) to calculate a reliably adjusted estimate of fatalities. This effort has resulted in some controversy, in part because attempts to determine these rates have been complicated by the seasonal variability noted in the Buena Vista program. Other efforts to monitor detection probabilities have found them to be similarly variable, especially when variability in searcher efficiency presents itself (Bailey et al. 2004). This variation has resulted in unacceptably wide confidence intervals (i.e., a lack of precision) around every estimate of total fatalities produced to date. While it may not be practical to completely remove uncertainty surrounding the detection probability issue, it is possible to reduce the uncertainty and controversy surrounding the approach.

The use of dogs and dog-handling teams presents itself in the literature as a straightforward method to reduce this variation while also reducing costs. The current sampling design implemented in the APWRA entails deployment of two- to three-person teams to survey turbines. Dog-handling teams comprise two surveyors and one dog. More importantly, all efforts to test dog-handler search efficiency for bird and bat fatalities have found the results to be positive. Trained and untrained animals dramatically increase searcher efficiencies (Homan et al. 2001; Arnett 2006).

Current estimates of human-based searches show search efficiencies are very high for large birds. For example, field studies at Buena Vista found large bird search efficiencies to be seasonally variable, but on average they approached 90%. The scientific literature demonstrates improvements in search efficiencies from adding dogs; accordingly, search efficiencies might be expected to approach 100%. Similar improvements may be expected for medium and small birds, potentially eliminating search efficiency as a metric requiring continuous measurement.

Human search efficiencies are influenced by a number of factors, including vegetation height. Unlike humans, dog searches are not dependent on vegetation height because the dogs are low to the ground and rely on scent (Homan et al. 2006). The inclusion of dogs in the search program should substantially increase searcher efficiency while reducing seasonal and annual variation in search efficiency and reducing costs.

The advantages of incorporating this option are outlined above: reduced cost, increased searcher efficiency, and decreased variance in searcher efficiency. The disadvantage is that it introduces a new element into the monitoring program that would reduce direct comparability of annual estimates of turbine-related avian mortality to those of previous years. However, with some effort, the difference in efficiency between human searches and searches using dogs could be measured and used to adjust the annual estimates to make them more directly comparable.

A further advantage of this option would accrue if monitoring were to continue into the foreseeable future under the Habitat Conservation Plan/Natural Community Conservation Plan framework currently being investigated, in that the effects of repowering could be monitored at reduced costs with more accurate estimates. Another possible option would be to bring this method online in stages at repowered operating groups at the time repowering is completed. In that way, direct comparisons of repowered operating groups would be maintained, direct comparison of un-repowered operating groups would be maintained, and comparisons of repowered to un-repowered operating groups would be conservative because of the higher searcher efficiency achieved through the use of dogs.

Option 4: Incorporate a Modern Electronic Data Collection System to Improve the Efficiency and Information Quality of APWRA Monitoring

Problems associated with changing sampling regimes, inefficient data recording, evolving techniques, and variable data structures have made it difficult to maintain a common data repository and analytic framework. The current workflow requires substantial time for processing, postprocessing, and quality correcting the handwritten datasheets that are so standard in this field.

Modern electronic data collection and information management systems are industry standard in natural resource studies. These systems reduce error, virtually eliminate overhead associated with datasheet management, provide real-time geo-referencing, and can connect directly with the databases used to manage and evaluate results. These tools justify their costs by reducing the time needed to manage data and by facilitating substantial reductions in error.

Bird and bat turbine-caused fatalities can be monitored with increased efficiency by incorporating the best practices discovered in the APWRA and abroad. Use of modern technology to record data (handheld data recording devices with the Global Positioning System and wireless data transfer into an online database) would reduce uncertainty and reduce costs in the long-term.

Cost Implications

1. The current monitoring program costs approximately $1,074,000 per year and entails the sampling of approximately 2,500 turbines and the collection of bird use and behavior information at 83 locations sampled once each per month. Eliminating the monitoring program would permit the reallocation of these funds to other research and monitoring programs.
2. By reallocating the sampling effort, it may be possible to eliminate up to 1,000 turbines from the sampling protocol. However, this number must be considered preliminary until the remaining simulations can be completed for all turbine types and the distribution of these turbine types among operating groups can be assessed. Preliminary calculations indicate that this option could save approximately $230,769 per year in labor costs.
3. Increasing the search interval to 45 days would result in approximately the same amount of savings as the reduction in sampling effort. Increasing the search interval to 60 days would realize savings of up to 50%.
4. By discontinuing the processing and documentation of nonnative species fatalities, additional savings would be approximately $28,000 per year.
5. By discontinuing bird use monitoring, additional savings would be approximately $49,000 per year.
6. The costs associated with using dogs have not yet been evaluated because they entail an initial investment to start the program and may only make sense if one assumes monitoring will continue for at least several years.
7. Costs associated with implementing a modern electronic data collection system cannot be determined until other aspects of the monitoring program have been agreed upon. The equipment and startup time required to modernize the data collection system is relative to the overall level of effort for the monitoring program. Until the start-up costs have been determined, it is not possible to determine the amount of time that monitoring would have to continue until the investment was recovered. However, industry standards and industry experience consistently demonstrate numerous data quality and cost-efficiencies from deploying electronic information systems.

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