

**DRAFT STUDY DESIGN FOR TESTING COLLISION RISK OF FLODESIGN WIND  
TURBINE IN PATTERSON PASS WIND FARM IN THE ALTAMONT PASS WIND  
RESOURCE AREA (APWRA)**

K. Shawn Smallwood

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FloDesign and enXco have agreed to use the Patterson Pass Wind Farm to test whether the FloDesign wind turbine will cause bird fatalities due to collisions. I was asked to design an experiment that would maximize the likelihood of detecting an effect of the new wind turbine model. To do this, I relied on four years of fatality monitoring data to identify the wind turbines associated with the highest rates of found bird carcasses. I then assigned the high-fatality turbines to a FloDesign replacement treatment and a control group treatment, and I replicated and interspersed the treatments. The resulting design is a Before-After, Control-Impact (BACI) study, and it includes behavior surveys to facilitate the interpretation of the fatality finds and to quantify how birds behave and react to the new turbine design compared to the conventional design.

**Fatality searches**

From among the 336 wind turbines monitored over four years (2005-2009) in the Patterson Pass project, I calculated detected fatality rates per wind turbine. I did not adjust these detected fatality rates for searcher detection error or scavenger removal rates, because I was attempting to characterize the numbers of bird carcasses actually found. I also omitted European starlings, because starlings, which are non-native, are often killed by wind turbines at Patterson Pass. Detected fatality rates represented the number of non-starling birds found per MW per year.

However, the four years of fatality monitoring I relied upon was based on an average of about 30 days between searches, whereas the search interval proposed for the FloDesign study will be twice per week. Additional fatality searches might be performed by the Alameda County Avian Monitoring team (M-team), because the M-team would like to use the study as an opportunity to develop new detection rate adjustments. Therefore, I assumed we can achieve a 2-day search interval. Assuming a 2-day search interval, I used my analysis of the American kestrel-burrowing owl study (KB study reported in SRC document P-154) to adjust the number of birds we can expect to find. All small bird carcasses found over the four years of monitoring were multiplied by 2.0, all small raptors and medium-sized non-raptors were multiplied by 1.4, and all large birds were multiplied by 1.0. All rates of detected fatalities appearing in this report henceforth will be based on this adjustment for a 2-day search interval.

I identified 83 wind turbines in 27 clusters of 1 to 5 turbines each, and at which searchers detected an average of 10.23 (SE = 0.93) bird carcasses/MW/yr. This detected fatality rate was nearly five times greater than the detected fatality rate of 2.38 (SE = 0.25) carcasses/MW/yr at

the other 253 wind turbines in Patterson Pass. Thus, I used the 27 clusters as my initial sampling population to maximize the likelihood that fatalities would be at the turbines searched during the study to test the collision risk of the FloDesign turbine.

Sixteen of the 27 high-fatality clusters included entire turbine strings, and 11 clusters composed portions of strings. Clusters composed of entire strings were desirable for inclusion in the experimental design, because turbine strings, rather than individual turbines, have served as sampling units in the old-generation portion of the APWRA. Turbine strings have been the sampling unit because the old-generation turbines are so closely spaced that it is often uncertain which turbine killed a bird. However, including clusters composing a portion of a turbine string is also desirable, because some of these clusters were associated with very high detected fatality rates. Selecting sub-string clusters for replacement with FloDesign turbines could -- due to the replacement ratio of about two FloDesign turbines for every three existing turbines -- introduce extra spacing between the FloDesign turbine(s) and the existing turbines. On the other hand, selecting sub-string clusters for use as experimental controls would not change the turbine spacing, so the most efficient monitoring effort in these cases would be to search the entire string of turbines, including the selected cluster and the other turbines in the same string. Therefore, I balanced the selection of high-fatality clusters by selecting clusters composing entire strings with a minimum of 7.5 carcasses/MW/yr, and by selecting sub-string clusters with a minimum of 10 carcasses/MW/yr. These restrictions reduced the sampling population to 19 high-fatality clusters, including 13 clusters composed of entire strings, and 6 composed of portions of strings.

I randomly ordered the high-fatality clusters of wind turbines remaining in the sampling pool, 1 through 19. The first clusters in the order were assigned to the FloDesign replacement treatment until the assignments involved 10 FloDesign turbines replacing existing or recently removed turbines. The replacement ratio was 1 FloDesign turbine for 2 existing turbines in a cluster, 2 FloDesign turbines for 3 or 4 existing turbines, and 3 FloDesign turbines for 5 existing turbines. Once the sample of 10 FloDesign turbines had been assigned to high-fatality clusters, I assigned the next clusters in the order to the control group, adding clusters until at least 20 turbines in the clusters were assigned to the control treatment.

I assigned FloDesign turbines to the first seven high-fatality clusters in the order (Table 1). In these clusters, two turbines are scheduled for removal by 15 February 2013, due to SRC hazardous turbine ratings, and another two were already removed as a result of these ratings. Accounting for the two removed turbines, the overall replacement ratio was 1 MW of FloDesign turbines for 1.04 MW of existing turbines. By 2013, the replacement ratio will be 1 MW of FloDesign turbines for 0.91 MW of existing turbines.

I assigned control treatment status to seven high-fatality clusters, not including one that I had to exclude because two of the three turbines in the cluster had already been removed due to high SRC hazard ratings (Table 1). The control group includes 22 wind turbines in high-fatality clusters (two are missing from the original 24 addresses selected due to SRC hazard ratings).

However, I recommend searching another 4 turbines in the control group because they complete the strings in which two high-fatality clusters are located.

The high-fatality clusters to be replaced by FloDesign turbines averaged 15.77 (SE = 2.80) carcasses/MW/yr, and those in the control group averaged 10.45 (SE = 0.84) carcasses/MW/yr. At these rates, we can expect to find about 16 non-starling bird carcasses at FloDesign sites during a year, assuming no difference in collision rates, and we can expect to find about 15 non-starling carcasses at control sites during a year ( $1.43 \text{ MW} \times 10.45 \text{ deaths/MW/yr}$ ).

Table 1. Study design. Wind turbines in red rows represent the FloDesign replacement treatment, and turbines in blue rows represent the control treatment. The turbines in a gray row were omitted from the study because 2 of the 3 turbines were already removed. Turbines in 3 additional rows were listed as alternates (not colored).

Treatment	String	Turbine addresses	FloDesign turbines	Notes
Replace	449	231, 232, 233	2	
Replace	460.1	175, 176	1	176 scheduled for removal
Replace	444	299, 300	1	299 scheduled for removal
Replace	461	114, 115, 116, 117	2	117 already removed (HRT)
Replace	450	234, 235, 236	2	
Replace	459	323	1	
Replace	464.1	136, 137, 138	1	136 already removed (HRT)
Control	435	17, 18, 19		Search 20 also -- nearby
Control	469	75, 76, 77, 78, 79		
Control	453	45, 46, 47		Search 48-50 in same string
Control	441	283, 284 (278, 279)		(Addresses mislabeled by M-team)
Control	466	157, 158, 159, 160		160 removed already
Control	463	60, 61, 62		61 & 62 removed already -- omit cluster
Control	451	39, 40, 41		39 removed already
Control	483	224, 225, 226, 227		
Control	446	306, 307, 308		
Control	430	248, 249		Search 243-247 in same string
Control	427	331, 332, 333		

### Behavior surveys

I will work with Lee Neher to select optimum survey stations from which to monitor bird behaviors during 20-min sessions, at least twice per week, at and around wind turbines selected for the fatality study. Preliminarily, I estimate that 8 survey sites will provide full coverage of all wind turbines included in the study, and all will be within several hundred meters of the observer. These surveys will integrate methodology from past behavior and use surveys in the Altamont Pass, yielding geo-referenced positions, so that the birds' locations and behaviors can

be related to slope and wind conditions and to wind turbine locations to understand how birds react to the old wind turbines and to the new FloDesign wind turbines. Also, fatality rates will be related to use rates so that any changes in mortality (i.e., an index of deaths per capita) can be detected in the BACI design.

Surveys will be oriented toward wind turbines included in the BACI study. GIS will be used to delineate the airspace visible to the observer at each station, and so use rates will be adjusted to the volume of airspace that is visible. During the 20 min session, all detected birds will be recorded on maps, and along with a suite of attributes such as species, behavior, height above ground, direction of flight, and number in group. Individual birds will be tracked for more detailed mapping, whereby positions will be mapped sequentially at a much higher frequency. The frequency of mapping has yet to be decided, but it will be on the order of every several seconds, so that line features can represent flight paths of the birds. Birds selected for this higher frequency of data collection will be chosen based on decision rules yet to be developed, but not all birds will be treated this way because the observer would potentially be overwhelmed by bird activity on occasion.

Examples of metrics of interest include the following: Number of birds observed/session; Bird-minutes/session; Number of flights through the rotor zone during operating and non-operating periods; Flights within 20 m of rotors during operating and non-operating periods; Bird-minutes perched on wind turbine (including where on the turbine the bird was perched); Proportion of approach vectors toward turbine, e.g., parallel to rotor axis and perpendicular to rotor axis, and from windward or leeward to rotor; Evasive behaviors exhibited by birds flying close to wind turbines; and, Reactions of birds flying through the rotor's wake and in front of the rotors to detect any effects of turbulence at the leeward aspect and increased wind speed at the windward aspect. The observer will not be attempting to keep track of all of these metrics, but rather will follow a protocol that can yield these metrics during analysis.

### **References Cited**

Smallwood, K. S. 2010. Review of American Kestrel-Burrowing owl (KB) Scavenger Removal Adjustments Reported in Alameda County Avian Monitoring Team's M21 for the Altamont Pass Wind Resource Area. [http://www.altamontsrc.org/alt\\_doc/p154\\_smallwood\\_kb\\_removal\\_rates\\_041610.pdf](http://www.altamontsrc.org/alt_doc/p154_smallwood_kb_removal_rates_041610.pdf)