Burrowing Owl Carcass Distribution around Wind Turbines

K. Shawn Smallwood

14 July 2008

The question of whether burrowing owl feather piles might be distributed around wind turbines differently than carcasses of other species was raised in the Alameda County Scientific Review Committee meeting of 8 July 2008. The implication was that if predation is the predominant fatality mechanism resulting in such a high proportion of burrowing owl fatalities being discovered as feather piles, then perhaps we can see evidence of this predation in a difference in distribution of feather piles. I pursued the answer to the question, though it was not obvious which distribution of carcasses or feather piles might lead one to believe that predation is a more common cause of burrowing owl fatalities than wind turbine collisions. If predators were bringing captured burrowing owls to turbines for feeding, one would expect to find more of the carcasses or feather piles directly under the tower, but otherwise it is not obvious that the distribution of burrowing owl fatalities should be indicative of predation versus wind turbine collision.

One possible pattern that might suggest predation as opposed to turbine strikes would be a random or uniform distribution of distances between the carcasses and the turbines. This expectation would be based on the assumption that predators capture burrowing owls independent of the distance of burrowing owls from the wind turbine, but this assumption would be valid only if burrowing owls pay no attention to the locations of wind turbines and behave as if the wind turbines are not present. However, if burrowing owls attempt to keep a certain distance from wind turbines while foraging or traveling, then the random capture pattern relative to wind turbine locations would not be reasonable.

The distribution of distances of carcasses from wind turbines due to collisions must be influenced by physics to certain extents. The likelihood of collision with the turbine blades probably increases with distance from the hub, as the rotor-swept area increases with distance from the hub. As the risk of collision increases with distance from the hub, farther distances from the turbine might be more frequent to a certain threshold, beyond which the frequency of deposited carcasses likely drop steadily due to a limit on the amount of energy in the carcass throw. The throw distance will depend a great deal on whether the carcass was struck on the blades upstroke or downstroke. Solid downstroke collisions will push the bird right into the ground, whereas solid upstroke collisions will toss the bird higher into the air and away from the turbine. The distance at which the turbine can be thrown from solid upstroke collisions will be influenced by wind speed and steepness of the slope in the direction of throw. Glancing collisions likely add considerable noise to patterns of distribution of distances from the turbine. To summarize, it is unclear which pattern of distances from turbines one should expect to be typical of turbine collisions, but there probably should be fewer carcasses found within a very close distance to the turbine, a spike in carcasses toward the middle to outer reaches of the blades’ length from the hub, and a declining number of carcasses at increasingly greater distances from the turbine.

Methods

I queried the baseline and current monitoring program data sets of fatalities to create frequency distributions. I selected fatalities that were regarded as possibly, probably, or certainly caused by wind turbines, but I will point out that the majority of fatalities are considered as probably caused by wind turbines based on location. I also selected carcasses associated with wind turbines and within 125 m of wind turbines. I omitted fatality records associated with Diablo Winds turbines, i.e., Vestas V47 model turbines. I then compared the resulting frequency distributions visually.

When examining the frequency distributions, it is important to consider the distribution that would reflect a random or uniform pattern, which one might expect of predation as being the only cause of fatalities, and if one assumed the movements of a particular bird species were independent of turbine location. If fatality locations were independent of turbine locations, then the number of places where a carcass can be detected will increase with increasing distance from the turbine. Using the circumference of a circle to approximate the likelihood of finding a carcass as the distance from the turbine increases, the number of meters from the turbine would be multiplied by 6.28 (i.e., 2π), so if the turbine row consisted of 1 turbine, the circumference of the search area at 1 m is 6.28, at 10 m is 62.8, and at 50 m is 314. Of course, most turbine rows consist of more than 1 turbine, so the multiplier will actually be smaller than 6.28 in most cases. Nevertheless, the number of fatalities should increase with distance from the turbine to at least 50 m, assuming carcass location was independent of turbine location.

Because the 100-KW Vestas wind turbines were turned off from November 2005 through February 2007, I had an opportunity to compare feather pile and carcass distances from turbines during long periods when the turbines were operating and not operating. The benefit of this comparison was the higher likelihood that predation caused at least most of the fatalities while the wind turbines were not operating. If predation was to generate a different spatial distribution of feather piles or carcasses from wind turbines, then this pattern ought to be detectable at the Vestas turbines. The period I selected for comparison was 9 months of the shutdown, or February through October, thereby excluding carcasses or feather piles that my have been deposited prior to the shutdown and also assuring that the same months of the year were compared between the shutdown and operating periods. I used a liberal buffer between the early November 2005 shutdown and the comparison period because the turbines were turned on briefly during January 2006.

Results and Discussion

All of the frequency distributions in Figures 1 and 2 depict peaks in numbers of carcasses at distances from the turbines that correspond with intermediate to about twice the terminal aspects of the rotor-swept area. All the graphs also depict steady declines in the numbers of fatalities as distances increase beyond the peaks. They also depict drops in frequencies of carcasses at the closest distances from the turbines. All of these patterns are consistent with the pattern I would expect from wind turbine collisions.

The frequency distributions of burrowing owl carcass distances from wind turbines appeared the same between the baseline and current program periods (Figure 1). These distributions also appeared similar to those generated by carcass discoveries of rock pigeons, western meadowlarks, American kestrels, and red-tailed hawks (Figures 1 and 2), suggesting no difference in fatality mechanism among these species.

The frequency distributions of distance from turbines appeared different, however, when comparing burrowing owl carcasses to burrowing owl feather piles (Figure 2). There were fewer feather piles and more carcasses of burrowing owl very close to wind turbines, which is a difference that was opposite of what I would expect of feather piles indicating predation as a predominant cause of mortality in this data set. Another difference was a larger proportion of feather piles than carcasses being found at about 50 m from wind turbines. The biological significance of this difference is unclear to me, and otherwise the two frequency distributions appeared the same.

Though the number of burrowing owl feather piles was small while the Vestas turbines did not operate, the frequency distribution of distances from the wind turbines suggested a difference from the distribution observed while the turbines operated (Figure 3). During the period of non-operation, fewer feather piles accumulated nearby the Vestas turbines than were seen during the period of operations. Also, the feather piles averaged 11 m farther away from the turbines while they did not operate compared to when they operated. However, no difference was obvious for carcasses other than feather piles (Figure 3).

I also examined feather piles of western meadowlarks at the Vestas turbines while they were shutdown and while they operated, because western meadowlarks exhibited similar patterns of mortality as burrowing owls around these turbines during these two periods (see SRC document P76). The western meadowlark also provided larger sample sizes than did burrowing owls. During turbine operations, the frequency distribution of western meadowlark feather pile distances from turbines appeared similar to what was observed for all carcasses at all turbines, but the distribution shifted when the turbines were shutdown (Figure 4). This shift resembled the shift seen in Figure 3 for burrowing owl feather piles. However, the mean distance of feather piles from the turbines did not differ between the operational and shutdown periods.

The spatial pattern of western meadowlark feather piles around the shutdown Vestas turbines corresponded more with what I would expect of predation as the primary cause of death if western meadowlarks paid little attention to the locations of wind turbines. However, the pattern did not really indicated uniformity or randomness with respect to the turbine's location, but rather disproportionately more carcasses closer to the turbines. This pattern suggests to me that predators of western meadowlarks launched attacks from the wind turbines while the wind turbines were not operating, catching more meadowlarks nearer the wind turbines.

Overall, the patterns in Figures 1 and 2 failed to convince me one way or the other over whether predation or turbine collisions caused more of the fatalities discovered by the monitoring team. The weight of the evidence in the frequency distributions points to turbine collisions, but as I pointed out earlier, if burrowing owls are regulating their distances from wind turbines, then predator capture locations should also reflect this regulation. Unfortunately, if burrowing owls regulate their distances from wind turbines, it might just happen that their regulation mirrors the distribution of carcass deposition one might expect from turbine collisions. More lines of evidence will be needed to answer the question the SRC and monitoring team repeatedly ask about the causes of mortality of burrowing owls.

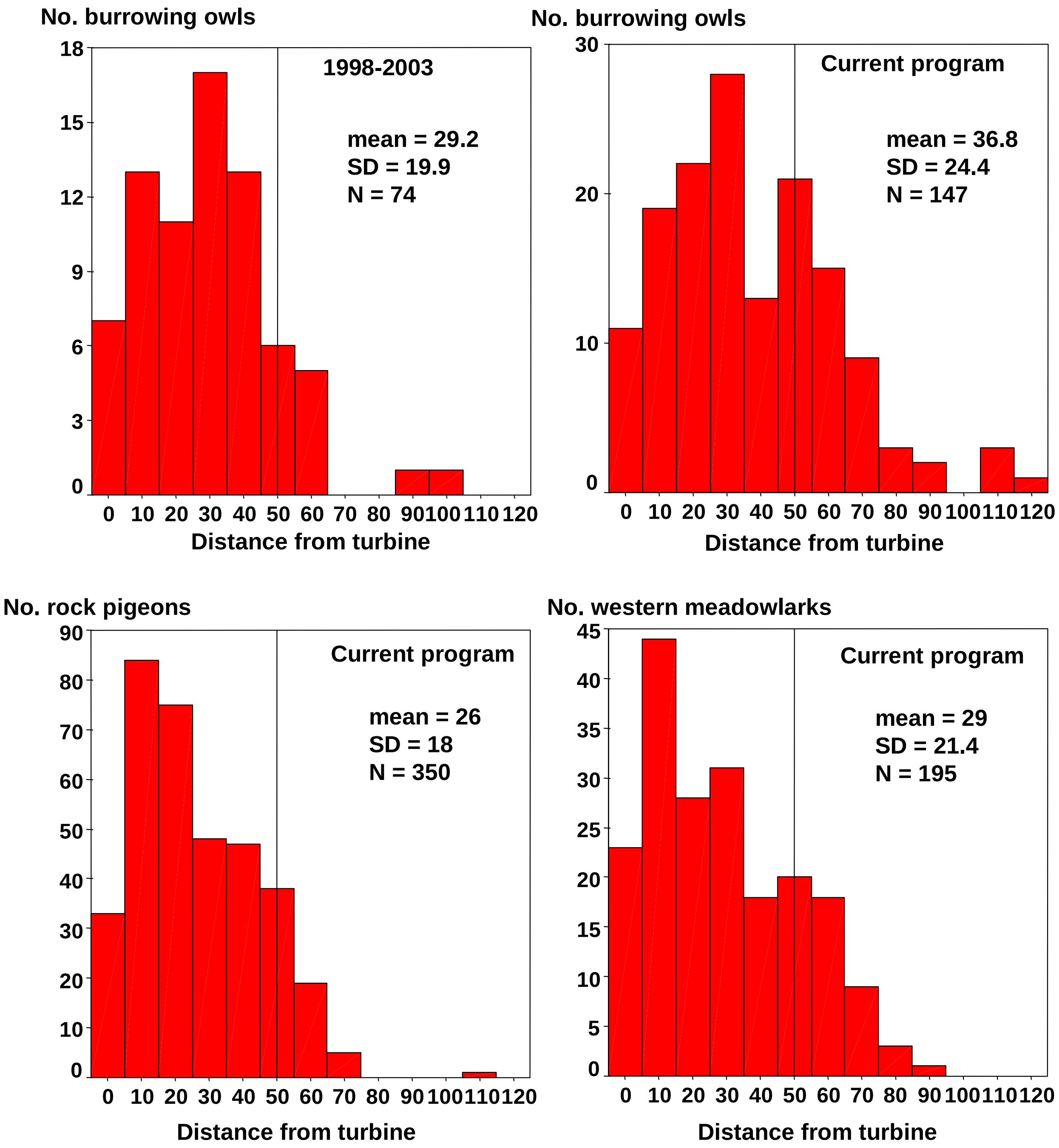

Figure 1. Frequency distributions of distance (m) from wind turbines where carcasses were found of burrowing owls in 1998-2003 (top left graph), burrowing owls in 2005-2007 (top right graph), rock pigeons (bottom left graph), and western meadowlarks (bottom right graph).

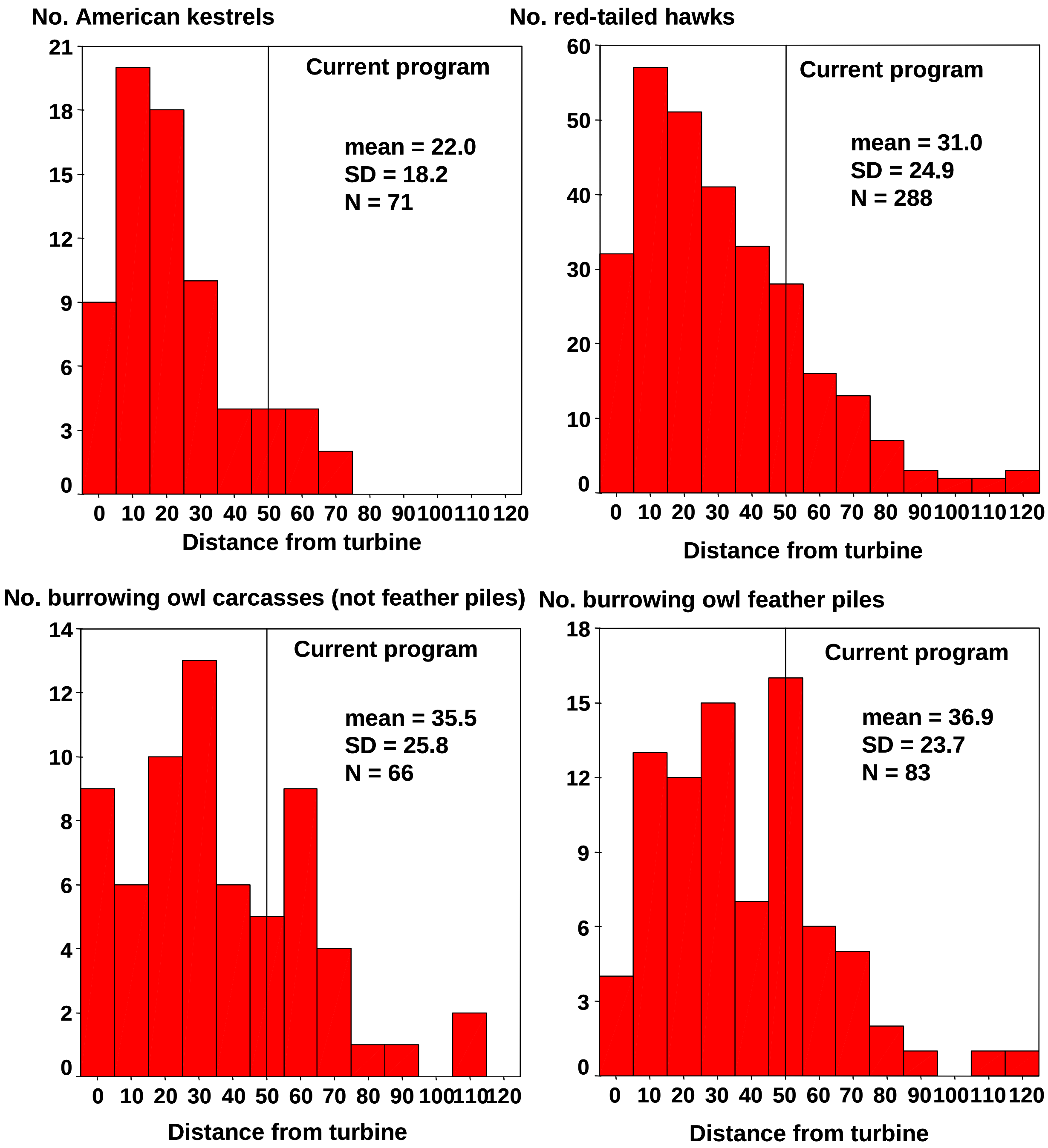

Figure 2. Frequency distributions of distance (m) from wind turbines where carcasses were found of American kestrels (top left graph), red-tailed hawks (top right graph), burrowing owl carcasses other than feather piles (bottom left graph), and burrowing owl feather piles (bottom right graph).

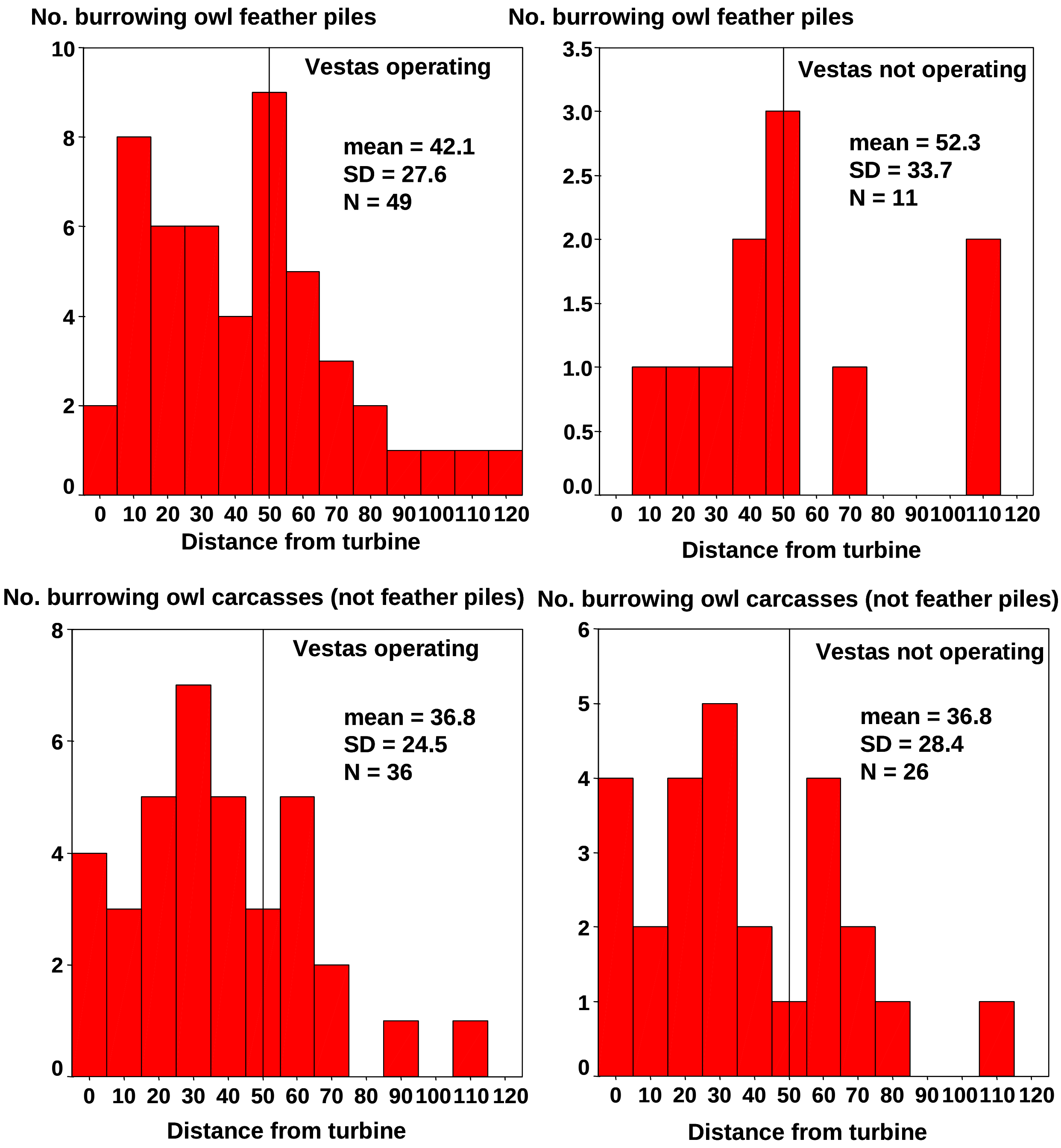

Figure 3. Frequency distributions of distance (m) from wind turbines where feather piles were found of burrowing owls at the 100-KW Vestas while they operated (top left graph) and did not operate (top right graph) over the same 9 month period between two years, and where burrowing owl carcasses other than feather piles were found at the Vestas turbines while they operated (bottom left graph) and did not operate (bottom right graph).

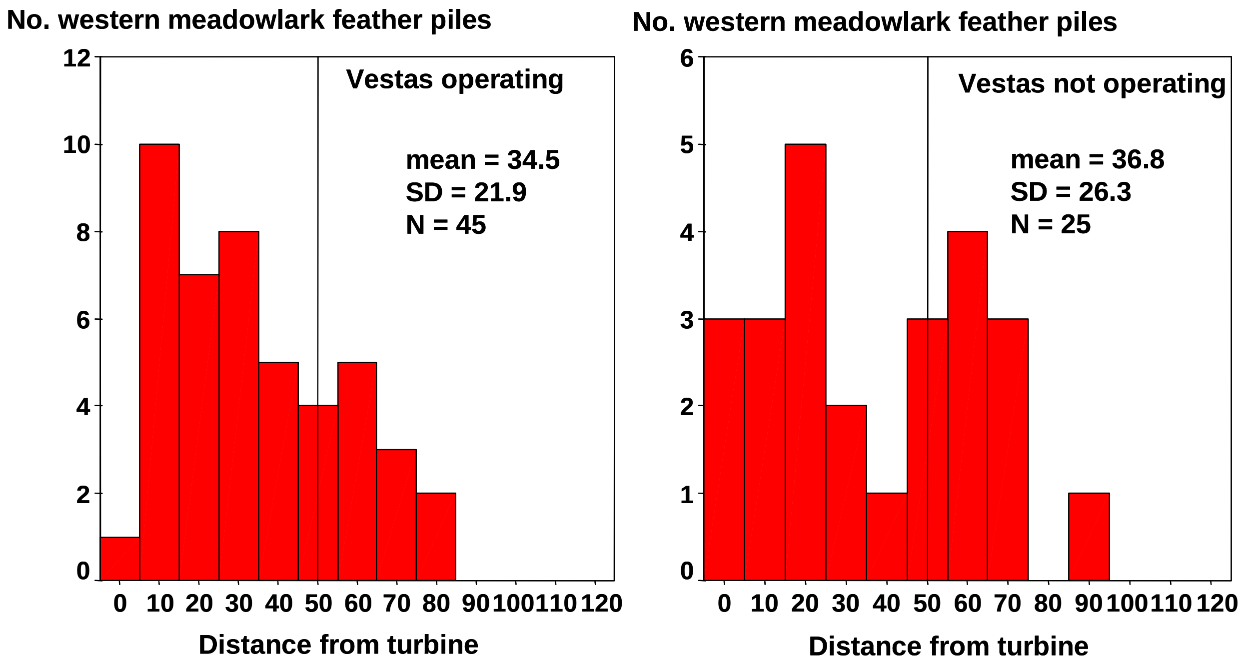

Figure 4. Frequency distributions of distance (m) from wind turbines where feather piles were found of western meadowlarks at the 100-KW Vestas turbines while they were operating (left graph), and while they were shut down over the same 9-month period the preceding year (right graph).