Power analysis to determine sample size for blade painting study
by Julie Yee

Method: Fatality numbers per turbine and monthly survey were randomly simulated using various sample sizes, overdispersions, and actual reductions (see below). Assuming monthly surveys from July 2008 through November 2009 (17 months) and up to 400 turbines, there were 6800 turbine searches simulated per each dataset simulation. Each simulated dataset was statistically analyzed to determine the probability, or power, of detecting a statistical difference between painted and non-painted blades, given that a specified effect was actually occurring (10%, 30%, or 50% reduction). This power was calculated from 200 iterations of simulating and analyzing datasets. This was repeated for various sample sizes to determine which sample sizes would achieve a high power of detection. Several rates of dispersion were also simulated.

Mean rates of deaths: I used mean rates of deaths provided by Shawn Smallwood based on the CEC study.

species	deaths /MW /year	deaths /250kWturbine /month	deaths /100kWturbine /month
AMKE	1.023	0.021313	0.008525
BUOW	1.348	0.028083	0.011233
GOEA	0.123	0.002563	0.001025
RTHA	0.365	0.007604	0.003042

Numbers of turbines: Six variations on the sample size were simulated:

# control turbines	# painted turbines
80	80
100	100
135	170
150	250
200	200
250	150

Overdispersion: The level of overdispersion can affect the ability of the analysis to detect effects. Preliminary analysis of first 18 months of monitoring data shows overdispersion falling between 1 and 1.5. Three different levels of overdispersion were simulated:

overdispersion
1.0
1.5
2.0

Actual reduction: The probability of detecting a reduction depends on the actual reduction. Large reductions (such as 50%) are more likely to be detected than small reductions (such as 10%). Three levels of actual reductions were simulated:

Actual reductions
10%
30%
50%

Worksheets: The following worksheets are contained in this file:

AMKE_NEG	Probability (power) of finding a statistically significant **reduction** in **AMKE** fatalities
BUOW_NEG	Probability (power) of finding a statistically significant **reduction** in **BUOW** fatalities
GOEA_NEG	Probability (power) of finding a statistically significant **reduction** in **GOEA** fatalities
RTHA_NEG	Probability (power) of finding a statistically significant **reduction** in **RTHA** fatalities
AMKE_POS	Probability (power) of finding a statistically significant **increase** in **AMKE** fatalities
BUOW_POS	Probability (power) of finding a statistically significant **increase** in **BUOW** fatalities
GOEA_POS	Probability (power) of finding a statistically significant **increase** in **GOEA** fatalities
RTHA_POS	Probability (power) of finding a statistically significant **increase** in **RTHA** fatalities

Table 1. Probability of finding a statistically significant **reduction** in AMKE fatalities in the data, given that a reduction of 10%, 30%, or 50% actually occurred. Powers greater than 0.80 are highlighted.

				actual reduction		
species	# control turbines	# painted turbines	overdispersion	10%	30%	50%
AMKE	80	80	1	0.05	0.20	0.53
AMKE	80	80	1.5	0.09	0.36	0.74
AMKE	80	80	2	0.26	0.57	0.89
AMKE	100	100	1	0.05	0.21	0.61
AMKE	100	100	1.5	0.09	0.42	0.85
AMKE	100	100	2	0.32	0.61	0.92
AMKE	135	170	1	0.05	0.29	0.76
AMKE	135	170	1.5	0.14	0.54	0.98
AMKE	135	170	2	0.33	0.81	0.99
AMKE	150	250	1	0.08	0.43	0.87
AMKE	150	250	1.5	0.16	0.66	1.00
AMKE	150	250	2	0.41	0.86	1.00
AMKE	200	200	1	0.06	0.32	0.83
AMKE	200	200	1.5	0.11	0.61	0.99
AMKE	200	200	2	0.30	0.82	1.00
AMKE	250	150	1	0.03	0.21	0.71
AMKE	250	150	1.5	0.07	0.52	0.96
AMKE	250	150	2	0.25	0.74	0.99

Table 2. Probability of finding a statistically significant **reduction** in BUOW fatalities in the data, given that a reduction of 10%, 30%, or 50% actually occurred. Powers greater than 0.80 are highlighted.

				actual reduction		
species	# control turbines	# painted turbines	overdispersion	10%	30%	50%
BUOW	80	80	1	0.06	0.23	0.56
BUOW	80	80	1.5	0.12	0.42	0.82
BUOW	80	80	2	0.33	0.65	0.93
BUOW	100	100	1	0.08	0.27	0.64
BUOW	100	100	1.5	0.15	0.45	0.89
BUOW	100	100	2	0.34	0.70	0.94
BUOW	135	170	1	0.07	0.41	0.86
BUOW	135	170	1.5	0.16	0.67	0.98
BUOW	135	170	2	0.43	0.81	1.00
BUOW	150	250	1	0.10	0.50	0.91
BUOW	150	250	1.5	0.25	0.77	0.99
BUOW	150	250	2	0.50	0.90	1.00
BUOW	200	200	1	0.06	0.41	0.92
BUOW	200	200	1.5	0.16	0.70	0.99
BUOW	200	200	2	0.38	0.87	1.00
BUOW	250	150	1	0.04	0.33	0.83
BUOW	250	150	1.5	0.08	0.60	0.99
BUOW	250	150	2	0.32	0.82	1.00

Table 3. Probability of finding a statistically significant **reduction** in GOEA fatalities in the data, given that a reduction of 10%, 30%, or 50% actually occurred. Powers greater than 0.80 are highlighted.

				actual reduction		
species	# control turbines	# painted turbines	overdispersion	10%	30%	50%
GOEA	80	80	1	0.00	0.00	0.00
GOEA	80	80	1.5	0.03	0.05	0.06
GOEA	80	80	2	0.03	0.16	0.31
GOEA	100	100	1	0.00	0.00	0.01
GOEA	100	100	1.5	0.03	0.07	0.08
GOEA	100	100	2	0.08	0.19	0.42
GOEA	135	170	1	0.02	0.04	0.06
GOEA	135	170	1.5	0.05	0.10	0.22
GOEA	135	170	2	0.11	0.26	0.52
GOEA	150	250	1	0.07	0.09	0.15
GOEA	150	250	1.5	0.07	0.16	0.39
GOEA	150	250	2	0.11	0.36	0.61
GOEA	200	200	1	0.02	0.05	0.08
GOEA	200	200	1.5	0.06	0.12	0.26
GOEA	200	200	2	0.08	0.26	0.60
GOEA	250	150	1	0.01	0.01	0.01
GOEA	250	150	1.5	0.03	0.07	0.17
GOEA	250	150	2	0.06	0.21	0.50

Table 4. Probability of finding a statistically significant **reduction** in RTHA fatalities in the data, given that a reduction of 10%, 30%, or 50% actually occurred. Powers greater than 0.80 are highlighted.

				actual reduction		
species	# control turbines	# painted turbines	overdispersion	10%	30%	50%
RTHA	80	80	1	0.02	0.06	0.11
RTHA	80	80	1.5	0.08	0.15	0.33
RTHA	80	80	2	0.17	0.34	0.63
RTHA	100	100	1	0.04	0.06	0.18
RTHA	100	100	1.5	0.08	0.18	0.46
RTHA	100	100	2	0.18	0.39	0.72
RTHA	135	170	1	0.04	0.08	0.31
RTHA	135	170	1.5	0.06	0.28	0.66
RTHA	135	170	2	0.20	0.56	0.84
RTHA	150	250	1	0.03	0.14	0.44
RTHA	150	250	1.5	0.08	0.35	0.74
RTHA	150	250	2	0.20	0.62	0.91
RTHA	200	200	1	0.05	0.12	0.32
RTHA	200	200	1.5	0.06	0.29	0.68
RTHA	200	200	2	0.14	0.52	0.89
RTHA	250	150	1	0.03	0.06	0.22
RTHA	250	150	1.5	0.03	0.22	0.61
RTHA	250	150	2	0.10	0.49	0.84

Table 5. Probability of finding a statistically significant **increase** in AMKE fatalities in the data, given that a reduction of 10%, 30%, or 50% actually occurred.

				actual reduction		
species	# control turbines	# painted turbines	overdispersion	10%	30%	50%
AMKE	80	80	1	0.01	0.00	0.00
AMKE	80	80	1.5	0.02	0.00	0.00
AMKE	80	80	2	0.08	0.01	0.00
AMKE	100	100	1	0.01	0.00	0.00
AMKE	100	100	1.5	0.02	0.00	0.00
AMKE	100	100	2	0.07	0.01	0.00
AMKE	135	170	1	0.01	0.00	0.00
AMKE	135	170	1.5	0.01	0.00	0.00
AMKE	135	170	2	0.05	0.00	0.00
AMKE	150	250	1	0.01	0.00	0.00
AMKE	150	250	1.5	0.00	0.00	0.00
AMKE	150	250	2	0.03	0.00	0.00
AMKE	200	200	1	0.00	0.00	0.00
AMKE	200	200	1.5	0.01	0.00	0.00
AMKE	200	200	2	0.06	0.00	0.00
AMKE	250	150	1	0.01	0.00	0.00
AMKE	250	150	1.5	0.01	0.00	0.00
AMKE	250	150	2	0.07	0.01	0.00

There is a small chance of observing an increase in fatalities in the data even though blade painting is having an overall effect of reducing mortality. This type of error can occur with low probabilities (~5%) when the true effect of blade painting is a 10% reduction. For higher rates of reduction such as 30% or 50% reduction, we do not expect to see this error occur.

Table 6. Probability of finding a statistically significant **increase** in BUOW fatalities in the data, given that a reduction of 10%, 30%, or 50% actually occurred.

				actual reduction		
species	# control turbines	# painted turbines	overdispersion	10%	30%	50%
BUOW	80	80	1	0.01	0.00	0.00
BUOW	80	80	1.5	0.02	0.00	0.00
BUOW	80	80	2	0.11	0.03	0.00
BUOW	100	100	1	0.01	0.00	0.00
BUOW	100	100	1.5	0.02	0.00	0.00
BUOW	100	100	2	0.12	0.03	0.00
BUOW	135	170	1	0.01	0.01	0.00
BUOW	135	170	1.5	0.01	0.00	0.00
BUOW	135	170	2	0.06	0.00	0.00
BUOW	150	250	1	0.00	0.00	0.00
BUOW	150	250	1.5	0.00	0.00	0.00
BUOW	150	250	2	0.06	0.00	0.00
BUOW	200	200	1	0.01	0.00	0.00
BUOW	200	200	1.5	0.01	0.00	0.00
BUOW	200	200	2	0.05	0.01	0.00
BUOW	250	150	1	0.02	0.01	0.00
BUOW	250	150	1.5	0.01	0.00	0.00
BUOW	250	150	2	0.09	0.01	0.00

There is a small chance of observing an increase in fatalities in the data even though blade painting is having an overall effect of reducing mortality. This type of error can occur with low probabilities (~1-12%) when the true effect of blade painting is a 10% reduction. For higher rates of reduction such as 30% or 50% reduction, we do not expect to see this error occur.

Table 7. Probability of finding a statistically significant **increase** in GOEA fatalities in the data, given that a reduction of 10%, 30%, or 50% actually occurred.

				actual reduction		
species	# control turbines	# painted turbines	overdispersion	10%	30%	50%
GOEA	80	80	1	0.07	0.07	0.07
GOEA	80	80	1.5	0.03	0.01	0.01
GOEA	80	80	2	0.03	0.01	0.00
GOEA	100	100	1	0.02	0.02	0.02
GOEA	100	100	1.5	0.00	0.00	0.00
GOEA	100	100	2	0.03	0.01	0.00
GOEA	135	170	1	0.01	0.01	0.01
GOEA	135	170	1.5	0.00	0.00	0.00
GOEA	135	170	2	0.01	0.00	0.00
GOEA	150	250	1	0.01	0.01	0.01
GOEA	150	250	1.5	0.01	0.00	0.00
GOEA	150	250	2	0.02	0.00	0.00
GOEA	200	200	1	0.01	0.01	0.01
GOEA	200	200	1.5	0.01	0.01	0.00
GOEA	200	200	2	0.02	0.00	0.00
GOEA	250	150	1	0.03	0.02	0.01
GOEA	250	150	1.5	0.01	0.01	0.00
GOEA	250	150	2	0.02	0.01	0.00

There is a small chance of observing an increase in fatalities in the data even though blade painting is having an overall effect of reducing mortality. This type of error can occur with low probabilities (~7%) when the true effect of blade painting is a 10% reduction. For higher rates of reduction such as 30% or 50% reduction, we do not expect to see this error occur.

Table 8. Probability of finding a statistically significant **increase** in RTHA fatalities in the data, given that a reduction of 10%, 30%, or 50% actually occurred.

				actual reduction		
species	# control turbines	# painted turbines	overdispersion	10%	30%	50%
RTHA	80	80	1	0.02	0.01	0.01
RTHA	80	80	1.5	0.02	0.01	0.00
RTHA	80	80	2	0.05	0.01	0.00
RTHA	100	100	1	0.03	0.01	0.00
RTHA	100	100	1.5	0.02	0.01	0.00
RTHA	100	100	2	0.05	0.00	0.00
RTHA	135	170	1	0.01	0.01	0.00
RTHA	135	170	1.5	0.02	0.00	0.00
RTHA	135	170	2	0.03	0.00	0.00
RTHA	150	250	1	0.01	0.01	0.00
RTHA	150	250	1.5	0.00	0.00	0.00
RTHA	150	250	2	0.01	0.00	0.00
RTHA	200	200	1	0.02	0.01	0.00
RTHA	200	200	1.5	0.02	0.00	0.00
RTHA	200	200	2	0.01	0.00	0.00
RTHA	250	150	1	0.02	0.01	0.00
RTHA	250	150	1.5	0.02	0.00	0.00
RTHA	250	150	2	0.04	0.01	0.00

There is a small chance of observing an increase in fatalities in the data even though blade painting is having an overall effect of reducing mortality. This type of error can occur with low probabilities (~5%) when the true effect of blade painting is a 10% reduction. For higher rates of reduction such as 30% or 50% reduction, we do not expect to see this error occur.