

Power analysis to determine sample size for blade painting study

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Revision 18SEP07: This analysis follows the same methods as in document P57 (described below) with several changes:

1) Calculate powers for all species combined, and combined species excluding BUOW.
 2) Simulate new data incorporating a 4-month winter shutdown of all turbines. Shutdown effects differ by species and also by whether the turbine blades lock or feather. The estimated shutdown effects used for the simulation were pulled from documents M16d and M16e. Out of the 17 months in the projected study period (July 2008 - Nov 2009), 5 months fall in winter (Nov-Feb) during this 17 month period. *As a reminder, no recommendation has been made by the SRC regarding shutdown during the 2008-09 winter.*

Additional changes to shutdown simulations:

- a) Assume 13 WEG turbines (250kW) are painted and 7 are controls. Only the WEGs lock.
- b) Add in a scenario for 25% reduction.
- c) Add in a 1.3 level of overdispersion as another data point.

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:

<u>overdispersion</u>
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:

<u>Actual reductions</u>
10%
30%
50%

Worksheets: The following tables are contained in this file:

1. COMBINE_ALL_NO_SHUT
Probability (power) of finding a statistically significant reduction in fatalities of **all combined focal raptors**, based on **no winter shutdown**.
2. COMBINE_EXC_BUOW_NO_SHUT
Probability (power) of finding a statistically significant reduction in fatalities of **combined focal raptors excluding BUOW**, based on **no winter shutdown**.
3. COMBINE_ALL_WINTSHUT
Probability (power) of finding a statistically significant reduction in fatalities of **all combined focal raptors**, based on **winter shutdown Nov-Feb**.
4. COMBINE_EXC_BUOW_WINTSHUT
Probability (power) of finding a statistically significant reduction in fatalities of **combined focal raptors excluding BUOW**, based on **winter shutdown Nov-Feb**.
5. AMKE_WINTSHUT
Probability (power) of finding a statistically significant reduction in fatalities of **AMKE** focal raptors, based on **winter shutdown Nov-Feb**.
6. BUOW_WINTSHUT
Probability (power) of finding a statistically significant reduction in fatalities of **BUOW** focal raptors, based on **winter shutdown Nov-Feb**.
7. GOEA_WINTSHUT
Probability (power) of finding a statistically significant reduction in fatalities of **GOEA** focal raptors, based on **winter shutdown Nov-Feb**.
8. RTHA_WINTSHUT
Probability (power) of finding a statistically significant reduction in fatalities of **RTHA** focal raptors, based on **winter shutdown Nov-Feb**.

Table 1. Probability of finding a statistically significant reduction in fatalities of **four focal raptor species combined** in the data, given that a reduction of 10%, 30%, or 50% actually occurred. Simulations were **based on all turbines operating through winter**. Powers greater than 0.80 are highlighted.

species	# control turbines	# painted turbines	over-dispersion	actual reduction		
				10%	30%	50%
COMBINE ALL 4 SPECIES	80	80	10	0.075	0.45	0.905
COMBINE ALL	80	80	15	0.22	0.65	0.97
COMBINE ALL	80	80	20	0.41	0.74	0.965
COMBINE ALL	100	100	10	0.085	0.55	0.985
COMBINE ALL	100	100	15	0.24	0.75	1
COMBINE ALL	100	100	20	0.445	0.82	0.985
COMBINE ALL	135	170	10	0.105	0.705	0.995
COMBINE ALL	135	170	15	0.34	0.87	1
COMBINE ALL	135	170	20	0.545	0.89	1
COMBINE ALL	150	250	10	0.155	0.82	1
COMBINE ALL	150	250	15	0.405	0.95	1
COMBINE ALL	150	250	20	0.65	0.935	1
COMBINE ALL	200	200	10	0.12	0.75	1
COMBINE ALL	200	200	15	0.29	0.915	1
COMBINE ALL	200	200	20	0.485	0.945	1
COMBINE ALL	250	150	10	0.04	0.645	1
COMBINE ALL	250	150	15	0.18	0.825	1
COMBINE ALL	250	150	20	0.375	0.88	0.995

Table 2. Probability of finding a statistically significant reduction in **three focal raptor species combined (excluding BUOW)** in the data, given that a reduction of 10%, 30%, or 50% actually occurred. Simulations were **based on all turbines operating through winter**. Powers greater than 0.80 are highlighted.

species	# control turbines	# painted turbines	over-dispersion	actual reduction		
				10%	30%	50%
COMBINE 3 (AMKE, GOEA, RTHA)	80	80	10	0.04	0.315	0.635
COMBINE 3	80	80	15	0.135	0.415	0.915
COMBINE 3	80	80	20	0.325	0.66	0.925
COMBINE 3	100	100	10	0.07	0.325	0.765
COMBINE 3	100	100	15	0.145	0.515	0.945
COMBINE 3	100	100	20	0.36	0.685	0.94
COMBINE 3	135	170	10	0.09	0.415	0.93
COMBINE 3	135	170	15	0.2	0.72	0.995
COMBINE 3	135	170	20	0.405	0.845	1
COMBINE 3	150	250	10	0.1	0.545	0.985
COMBINE 3	150	250	15	0.255	0.81	1
COMBINE 3	150	250	20	0.48	0.91	1
COMBINE 3	200	200	10	0.065	0.44	0.97
COMBINE 3	200	200	15	0.15	0.725	1
COMBINE 3	200	200	20	0.37	0.89	1
COMBINE 3	250	150	10	0.035	0.34	0.89
COMBINE 3	250	150	15	0.11	0.645	0.99
COMBINE 3	250	150	20	0.26	0.81	0.99

Table 3. Probability of finding a statistically significant reduction in **four focal raptor species combined** in the data, given that a reduction of 10%, 25%, 30%, or 50% actually occurred. Simulations were **based on all turbines shutdown during Nov-Feb**. Powers greater than 0.80 are highlighted.

species	# control turbines	# painted turbines	over-dispersion	actual reduction			
				10%	25%	30%	50%
COMBINE ALL 4 SPECIES	80	80	10	0.44	0.82	0.90	1
COMBINE ALL	80	80	13	0.57	0.92	0.96	1
COMBINE ALL	80	80	15	0.72	0.94	0.98	1
COMBINE ALL	80	80	20	0.74	0.92	0.95	0.99
COMBINE ALL	100	100	10	0.61	0.93	0.97	1
COMBINE ALL	100	100	13	0.75	0.95	1.00	1
COMBINE ALL	100	100	15	0.83	0.98	0.99	1
COMBINE ALL	100	100	20	0.83	0.94	0.96	1
COMBINE ALL	135	170	10	0.88	1.00	1.00	1
COMBINE ALL	135	170	13	0.98	1.00	1.00	1
COMBINE ALL	135	170	15	0.99	1.00	1.00	1
COMBINE ALL	135	170	20	0.92	0.99	1.00	1
COMBINE ALL	150	250	10	0.96	1.00	1.00	1
COMBINE ALL	150	250	13	0.99	1.00	1.00	1
COMBINE ALL	150	250	15	1.00	1.00	1.00	1
COMBINE ALL	150	250	20	0.97	1.00	1.00	1
COMBINE ALL	200	200	10	0.95	1.00	1.00	1
COMBINE ALL	200	200	13	0.99	1.00	1.00	1
COMBINE ALL	200	200	15	0.99	1	1	1
COMBINE ALL	200	200	20	0.97	0.995	1	1
COMBINE ALL	250	150	10	0.895	1	1	1
COMBINE ALL	250	150	13	0.97	1	1	1
COMBINE ALL	250	150	15	0.97	1	1	1
COMBINE ALL	250	150	20	0.93	0.98	0.99	1

Table 4. Probability of finding a statistically significant reduction in **three focal raptor species combined (excluding BUOW)** in the data, given that a reduction of 10%, 25%, 30%, or 50% actually occurred. Simulations were **based on all turbines shutdown during Nov-Feb**. Powers greater than 0.80 are highlighted.

species	# control turbines	# painted turbines	over-dispersion	actual reduction			
				10%	25%	30%	50%
COMBINE 3 (AMKE, GOEA, RTHA)	80	80	10	0.06	0.19	0.26	0.59
COMBINE 3	80	80	13	0.09	0.23	0.34	0.735
COMBINE 3	80	80	15	0.14	0.32	0.41	0.84
COMBINE 3	80	80	20	0.33	0.62	0.62	0.935
COMBINE 3	100	100	10	0.07	0.25	0.33	0.705
COMBINE 3	100	100	13	0.09	0.31	0.40	0.875
COMBINE 3	100	100	15	0.19	0.43	0.54	0.91
COMBINE 3	100	100	20	0.44	0.68	0.69	0.975
COMBINE 3	135	170	10	0.12	0.34	0.46	0.905
COMBINE 3	135	170	13	0.17	0.51	0.62	0.96
COMBINE 3	135	170	15	0.32	0.65	0.76	0.975
COMBINE 3	135	170	20	0.55	0.86	0.89	1
COMBINE 3	150	250	10	0.17	0.48	0.63	0.975
COMBINE 3	150	250	13	0.30	0.67	0.77	0.995
COMBINE 3	150	250	15	0.43	0.79	0.84	0.995
COMBINE 3	150	250	20	0.62	0.90	0.94	1
COMBINE 3	200	200	10	0.13	0.41	0.60	0.965
COMBINE 3	200	200	13	0.22	0.55	0.69	0.995
COMBINE 3	200	200	15	0.33	0.775	0.86	1
COMBINE 3	200	200	20	0.55	0.875	0.935	1
COMBINE 3	250	150	10	0.075	0.32	0.46	0.885
COMBINE 3	250	150	13	0.12	0.51	0.645	0.97
COMBINE 3	250	150	15	0.24	0.63	0.765	1
COMBINE 3	250	150	20	0.48	0.84	0.885	0.99

Table 5. Probability of finding a statistically significant reduction in **AMKE** fatalities in the data, given that a reduction of 10%, 25%, 30%, or 50% actually occurred. Simulations were **based on all turbines shutdown during Nov-Feb**. Powers greater than 0.80 are highlighted.

species	# control turbines	# painted turbines	overdispersion	actual reduction			
				10%	25%	30%	50%
AMKE	80	80	10	0.03	0.08	0.10	0.33
AMKE	80	80	13	0.02	0.11	0.15	0.45
AMKE	80	80	15	0.07	0.18	0.24	0.575
AMKE	80	80	20	0.23	0.39	0.47	0.8
AMKE	100	100	10	0.03	0.08	0.12	0.395
AMKE	100	100	13	0.05	0.15	0.19	0.595
AMKE	100	100	15	0.08	0.19	0.27	0.68
AMKE	100	100	20	0.28	0.46	0.54	0.87
AMKE	135	170	10	0.04	0.11	0.19	0.575
AMKE	135	170	13	0.07	0.21	0.31	0.8
AMKE	135	170	15	0.12	0.32	0.40	0.855
AMKE	135	170	20	0.33	0.58	0.67	0.945
AMKE	150	250	10	0.06	0.24	0.33	0.755
AMKE	150	250	13	0.12	0.29	0.39	0.905
AMKE	150	250	15	0.17	0.46	0.55	0.94
AMKE	150	250	20	0.41	0.70	0.79	0.975
AMKE	200	200	10	0.06	0.17	0.24	0.72
AMKE	200	200	13	0.05	0.29	0.37	0.855
AMKE	200	200	15	0.14	0.375	0.515	0.925
AMKE	200	200	20	0.295	0.655	0.735	0.98
AMKE	250	150	10	0.035	0.09	0.15	0.595
AMKE	250	150	13	0.03	0.2	0.315	0.79
AMKE	250	150	15	0.1	0.27	0.38	0.9
AMKE	250	150	20	0.255	0.595	0.65	0.98

Table 6. Probability of finding a statistically significant reduction in **BUOW** fatalities in the data, given that a reduction of 10%, 25%, 30%, or 50% actually occurred. Simulations were **based on all turbines shutdown during Nov-Feb**. Powers greater than 0.80 are highlighted.

species	# control turbines	# painted turbines	overdispersion	actual reduction			
				10%	25%	30%	50%
BUOW	80	80	10	0.54	0.80	0.84	0.995
BUOW	80	80	13	0.60	0.90	0.94	1
BUOW	80	80	15	0.79	0.97	0.99	1
BUOW	80	80	20	0.80	0.94	0.96	0.985
BUOW	100	100	10	0.68	0.90	0.93	1
BUOW	100	100	13	0.77	0.96	0.97	1
BUOW	100	100	15	0.88	0.99	1.00	1
BUOW	100	100	20	0.87	0.97	0.97	0.995
BUOW	135	170	10	0.90	0.99	1.00	1
BUOW	135	170	13	0.98	1.00	1.00	1
BUOW	135	170	15	0.98	1.00	1.00	1
BUOW	135	170	20	0.97	1.00	1.00	1
BUOW	150	250	10	0.97	1.00	1.00	1
BUOW	150	250	13	1.00	1.00	1.00	1
BUOW	150	250	15	1.00	1.00	1.00	1
BUOW	150	250	20	0.99	1.00	1.00	1
BUOW	200	200	10	0.97	1.00	1.00	1
BUOW	200	200	13	1.00	1.00	1.00	1
BUOW	200	200	15	0.985	1	1	1
BUOW	200	200	20	0.99	1	1	1
BUOW	250	150	10	0.935	0.995	1	1
BUOW	250	150	13	0.995	1	1	1
BUOW	250	150	15	0.975	1	1	1
BUOW	250	150	20	0.96	0.99	0.995	1

Table 7. Probability of finding a statistically significant reduction in **GOEA** fatalities in the data, given that a reduction of 10%, 25%, 30%, or 50% actually occurred. Simulations were **based on all turbines shutdown during Nov-Feb**. Powers greater than 0.80 are highlighted.

species	# control turbines	# painted turbines	overdispersion	actual reduction			
				10%	25%	30%	50%
GOEA	80	80	10	0.00	0.00	0.01	0.015
GOEA	80	80	13	0.01	0.03	0.03	0.03
GOEA	80	80	15	0.05	0.05	0.07	0.135
GOEA	80	80	20	0.17	0.31	0.38	0.525
GOEA	100	100	10	0.00	0.01	0.01	0.02
GOEA	100	100	13	0.03	0.05	0.05	0.105
GOEA	100	100	15	0.07	0.12	0.14	0.225
GOEA	100	100	20	0.22	0.40	0.46	0.655
GOEA	135	170	10	0.05	0.07	0.08	0.135
GOEA	135	170	13	0.11	0.14	0.15	0.34
GOEA	135	170	15	0.13	0.29	0.29	0.45
GOEA	135	170	20	0.36	0.53	0.61	0.865
GOEA	150	250	10	0.13	0.18	0.20	0.34
GOEA	150	250	13	0.16	0.25	0.32	0.49
GOEA	150	250	15	0.21	0.36	0.39	0.615
GOEA	150	250	20	0.44	0.70	0.71	0.905
GOEA	200	200	10	0.08	0.11	0.13	0.205
GOEA	200	200	13	0.12	0.20	0.23	0.39
GOEA	200	200	15	0.14	0.29	0.345	0.61
GOEA	200	200	20	0.39	0.61	0.7	0.895
GOEA	250	150	10	0.015	0.03	0.035	0.075
GOEA	250	150	13	0.075	0.11	0.12	0.24
GOEA	250	150	15	0.135	0.24	0.255	0.41
GOEA	250	150	20	0.35	0.56	0.64	0.87

Table 8. Probability of finding a statistically significant reduction in **RTHA** fatalities in the data, given that a reduction of 10%, 25%, 30%, or 50% actually occurred. Simulations were **based on all turbines shutdown during Nov-Feb**. Powers greater than 0.80 are highlighted.

species	# control turbines	# painted turbines	overdispersion	actual reduction			
				10%	25%	30%	50%
RTHA	80	80	10	0.04	0.07	0.08	0.145
RTHA	80	80	13	0.07	0.10	0.15	0.31
RTHA	80	80	15	0.08	0.18	0.22	0.375
RTHA	80	80	20	0.19	0.37	0.43	0.715
RTHA	100	100	10	0.07	0.10	0.12	0.235
RTHA	100	100	13	0.08	0.14	0.18	0.425
RTHA	100	100	15	0.10	0.22	0.26	0.45
RTHA	100	100	20	0.28	0.47	0.54	0.81
RTHA	135	170	10	0.07	0.17	0.21	0.475
RTHA	135	170	13	0.13	0.28	0.34	0.61
RTHA	135	170	15	0.19	0.31	0.35	0.755
RTHA	135	170	20	0.41	0.67	0.73	0.945
RTHA	150	250	10	0.13	0.23	0.29	0.62
RTHA	150	250	13	0.19	0.36	0.45	0.775
RTHA	150	250	15	0.26	0.46	0.53	0.865
RTHA	150	250	20	0.50	0.77	0.85	0.985
RTHA	200	200	10	0.09	0.19	0.24	0.575
RTHA	200	200	13	0.13	0.32	0.41	0.72
RTHA	200	200	15	0.205	0.41	0.45	0.835
RTHA	200	200	20	0.45	0.72	0.8	0.98
RTHA	250	150	10	0.055	0.14	0.175	0.42
RTHA	250	150	13	0.075	0.215	0.27	0.62
RTHA	250	150	15	0.145	0.335	0.41	0.75
RTHA	250	150	20	0.355	0.67	0.735	0.97