Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia:

An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines

A Summary of Findings from the Bats and Wind Energy Cooperative's 2004 Field Season

The Bats and Wind Energy Cooperative (BWEC) was formed in 2003 by Bat Conservation International (BCI), the US Fish and Wildlife Service, the American Wind Energy Association (AWEA), and the National Renewable Energy Laboratory of the US Department of Energy (NREL). The BWEC is an alliance of state and federal agencies, private industry, academic institutions, and non-governmental organizations interested in cooperating to develop and coordinate research opportunities and identify solutions to prevent or minimize threats to bats.

The BWEC implemented research to improve fatality search protocols for bats and to evaluate interactions between bats and wind turbines from 31 July through 13 September 2004, the period when bat fatalities have most often been reported at wind facilities. The goal was to establish a basis for developing solutions to prevent or minimize threats to bats at wind energy facilities.

Specific Objectives of the 2004 Research:

- ***Compare results of daily versus weekly carcass searches, quantify bias corrections needed to more accurately estimate fatality, and recommend improved search protocols for bats.***
- ***Correlate bat fatalities detected during daily searches with the previous nights' weather and turbine conditions.***
- ***Observe and quantify behavior of bats encountering moving and non-moving blades at turbines with and without FAA lights.***
- ***Evaluate the use of trained dogs to detect bat fatalities beneath turbines.***

Study Areas and General Approach:

- ***Studies were conducted at the Mountaineer and Meyersdale Wind Energy Centers located along the Appalachian plateau in West Virginia and Pennsylvania, respectively. The Mountaineer site has 44 and the Meyersdale site has 20 NEG Micon 1.5 MW turbines. Mountaineer began operation in December 2002, Meyersdale exactly one year later.***
- ***Fatality searches were conducted at both sites between 31 July and 13 September, 2004. Half of the turbines at each site were searched daily and the other half weekly. Search time per turbine was 30-60 minutes depending on terrain, vegetative cover, and weather.***
- ***Thermal imaging cameras were used to assess bat, bird, and insect activity at turbines only at Mountaineer (2-27 August). Thermal images were downloaded through laptop computers onto external hardrives and later analyzed by viewing and quantifying objects in "real time."***


Eastern Pipistrelle

Characteristics of Bat Fatalities:

- *Six species were killed at Mountaineer and 7 at Meyersdale: hoary bats, eastern red bats, eastern pipistrelles, little brown bats, silver-haired bats, big brown bats, and northern long-eared bats (only found at Meyersdale) were discovered(from highest to lowest number found).*
- *More adult and more male bats were found than juvenile and female bats, respectively.*

Patterns of Bat Fatality:

- *Bat fatalities were highly variable and periodic throughout the study.*
- *At both sites, bat fatalities were evenly distributed within each cardinal direction around the turbines for all days and turbines combined.*
- *Ninety-three and 84% of all fatalities were found within 40 m from turbines at Mountaineer and Meyersdale, respectively.*
- *Fatality was distributed across all turbines, although higher than average numbers of bats generally were found at turbines located near an end or center of the string at both sites.*
- *Of the 64 turbines studied, one (turbine 11 at Mountaineer) was non-operational throughout the study period and this was the only turbine where no fatalities were found.*
- *Although we found more male than female bat fatalities, the timing by sex was similar at both sites.*
- *Fatalities of hoary and eastern red bats were distributed throughout the study period and there was a positive correlation in the timing of fatality for these two species at both sites.*
- *Timing of bat fatalities at Mountaineer and Meyersdale was highly correlated, providing evidence that broader landscape, perhaps regional, patterns dictated by weather and prey abundance/availability or other factors.*
- *FAA lighting had no detectable impact on bat fatality.*
- *At both locations, the majority of bats were killed on low wind nights when power production appeared insubstantial, but turbine blades were still spinning and often at or close to full operational speed (17 rpm).*


Hoary Bat

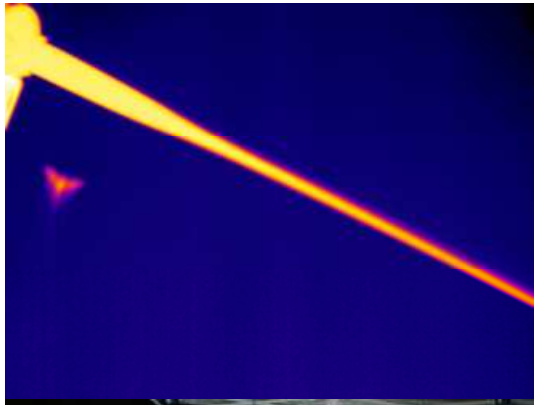

Little brown bat carcass after just 7 days

Searcher Efficiency and Scavenger Removal:

- *The overall, average searcher efficiency for bat carcasses was estimated to be 44 and 25% at Mountaineer and Meyersdale, respectively, for all trials and habitats combined. Searcher efficiency was highest on bare ground and declined rapidly as height and density of vegetation increased.*
- *The highest rates of searcher efficiency were estimated within 10 m of the turbines at both sites (64 and 63% at Mountaineer and Meyersdale, respectively) because much of this area is covered with bare ground. Searcher efficiency was variable >10 m away from turbines, but was lower because this area contained more low visibility habitat.*
- *Searcher efficiency was highest within 1 m of the transect line, and detection of carcasses placed further than 3.0 m from the transect line dropped significantly, with only 17.9% of carcasses placed at distances >4 m from the transect line being found.*
- *Scavenger removal rates were very different between the two study sites. At Mountaineer, 24% of bats that were killed the previous night and then left where they fell for trials were removed on the same day the trial started and 70% of these bats were removed within 24 hr. Bat carcasses placed in high visibility habitats at Mountaineer were removed at nearly twice the rate in the first 24 hr compared to those placed in low visibility habitats.*
- *In contrast, scavenger removal rates were very low at Meyersdale, with only 3% of fresh bat carcasses removed within the first 24 hr and 16% by day 7.*
- *Mountaineer began operation one-year earlier than Meyersdale and it is possible that scavenger had more time to learn of a new food source beneath turbines at Mountaineer. Also, differences could be a function of species composition of bird and mammal scavengers at the different sites.*

Bat Fatality Estimates:

- *Estimates of total fatality were heavily influenced by the periodicity of bat kills and carcass removal by scavengers, particularly at Mountaineer where estimates from weekly searches were nearly 3x lower compared to those from daily estimates because of high scavenging.*
- *Daily searches at Mountaineer yielded an estimated 38 bats killed per turbine for the 6-week study period (90% confidence interval = 31–45) and a daily kill rate of 0.90 bats per turbine. The total number of bats estimated to have been killed by the 44 turbines during this 6-week period was 1,364–1,980.*
- *At Meyersdale, an estimated 25 bats were killed per turbine based on daily searches during the 6-week study (90% confidence interval = 20–33), yielding a daily kill rate of 0.6 and a total of 400–660 bats killed by the 20 turbines during the 6-week study. Because of low scavenging rates, weekly searches at Meyersdale yielded similar results; an estimated 30 bats killed per turbine during the 6-week study (90% confidence interval = 20–46) and a daily kill rate of 0.71 for a total estimated 400–920 bats killed during the 6-week study.*
- *These estimates are among the highest ever reported, and support the contention that forested ridges are locations of especially high risk for bat fatality at wind facilities.*



Observations of Bats and Insects at Turbines:

- ***Thermal imaging observations of bat and insect activity support the conclusion that fatality occurs primarily on low wind nights, but when blades are pitched so as to rotate, which may be at or near their maximum speeds of 17 RPMs.***
- ***Thermal images indicated that bats are attracted to and investigate both moving and non-moving blades.***
- ***Thermal images of bats attempting to land or actually landing on stationary blades and turbine masts suggest possible curiosity about potential roosts or use for gleaning insects. Images of bats chasing turbine blades rotating at slow speeds suggest possible attraction to movement that may be confused with prey or perhaps other bats.***
- ***Most bat activity was observed within 2-hours after sunset. Nightly numbers of bat passes observed at a single turbine were highly variable, with as few as 9 per night, and as many as 291.***
- ***There was a significant positive correlation between insect passes and bat passes observed across all nights.***
- ***Although insect activity was somewhat higher at turbines with FAA lights, aviation lighting did not appear to affect the incidence of foraging bats around turbines and there was no difference between numbers of bat passes at lit and unlit turbines.***
- ***Most of the observed collisions (7 of 8) were between bats and fast-moving (17 rpm) turbine blades.***

Use of Trained Dogs to Recover Bat Fatalities:

- ***Dog-handler team searcher efficiency trials were performed on 3 different days at 4–6 turbines each day at Mountaineer, using a total of 45 trial bats. At Meyersdale, trials were performed on 5 different days at 4–6 turbines each day, with 52 trial bats.***
- ***Dogs found 71% of the bats randomly placed in searcher efficiency trials at Mountaineer and 81% of those at Meyersdale, compared to 42% and 14% for human searches, respectively.***
- ***Both the dog-handler team and humans found a high proportion of trial bats within 10 m of the turbine, usually on open ground (88 and 75%, respectively). However, human search efficiency declined as vegetation height and density increased while dog-handler efficiency remained high.***
- ***The dog-human team consistently found higher proportions (65-100%) of trial carcasses in high, medium, and low visibility habitats at both sites, and 40-50% in extremely low visibility habitats.***

Scope:

- ***This study only covered 6 weeks (31 July to September 13) in just one year and is not a measure of full season bat activity, behavior, or fatality. Estimated fatality rates from the 6-week period appeared to be as high during the first site visits in mid-July and likely continued at least through September.***

- ***Unusually cool summer temperatures and passage of 4 major hurricanes in August may have influenced these findings because such weather conditions are known to suppress bat and insect activity, particularly at higher elevations.***

- ***Until a full season of fatality searches is gathered (April through October), it should not be assumed that: 1) fatalities do not occur and/or are biologically insignificant during other periods; 2) the 6-week period we studied includes the peak of fall migration; and 3) that other species of bats, such as Indiana bats, are not being killed at wind facilities during different times of the year.***

- ***Scavenging rates should not be assumed similar between sites even in close proximity and in similar habitat conditions. Scavenging could be expected to change over time as well.***

- ***Our study was conducted in two areas located on forested ridges in the Appalachian Mountains and statistical inferences are limited to these sites. However, we believe that our findings reflect an emerging pattern of bat fatality associated with wind turbines located on forested ridges and suggest that similar fatality rates could be expected at sites with comparable forest composition and topography, especially in the eastern U.S.***

Future Research Needs:

Results from this study suggest the following research needs:

- ***Conduct extensive post-construction fatality searches for a "full season" of bat movement and activity (April-October) to fully elucidate temporal patterns of fatality..***

- ***Experimentally compare fatality at moving versus "feathered" (i.e., blades parallel to the wind and free-wheeling) turbine blades during periods of low wind speeds to quantify reductions in bat fatality relative to economic costs of curtailment.***

- ***Further investigate the relationship between passage of storm fronts, weather conditions (e.g., wind speed, barometric pressure), turbine blade movement, and bat fatality.***

- ***Conduct post-construction fatality searches at existing wind facilities that encompass a broad range of habitat types and topographic features to further understand patterns of fatality in relation to surrounding landscape context. These data are essential for assessing potential risks at future developments.***

- ***Investigate approaches for making turbines less attractive to bats or for deterring bats.***

- ***Demonstrate synergy of complimentary technologies, such as acoustics, radar, and thermal imaging, used simultaneously to describe use at proposed and existing wind facilities.***

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