GUIDELINES FOR ASSESSING AND MINIMIZING IMPACTS TO BATS AT WIND ENERGY DEVELOPMENT SITES IN CALIFORNIA

California Bat Working Group (September 2006)

This document was prepared by members of the California Bat Working Group (CBWG). The CBWG is one of 13 working groups from western U.S. states and the Canadian provinces of Alberta and British Columbia that comprise the Western Bat Working Group (WBWG). The WBWG (http://www.wbwg.org) is a partner in the Coalition of North American Bat Working Groups, and consists of agencies organizations and individuals interested in bat research, management, and conservation.

Washington was the first state in the nation to develop guidelines (http://wdfw.wa.gov/hab/engineer/windpower/index.htm), and Vermont is currently drafting some (http://www.anr.state.vt.us/site/html/RMAR.htm). The USFWS has also published interim guidelines to avoid and minimize wildlife impacts from turbines (http://www.fws.gov/habitatconservation/wind). In Alberta, Canada, draft guidelines are also being developed cooperatively by the Alberta Fish and Wildlife Division, bat researchers and the Alberta Bat Action Team (http://www.srd.gov.ab.ca/fw/bats/abat.html) (Lausen et al. 2006).

Our guidelines should not be considered static. The relationship between bat occurrence and mortality at wind turbine sites is currently poorly understood. Our recommendations may need revision as new information becomes available. We encourage the California Energy Commission (CEC) to update their recommended guidelines as necessary, as well.

INTRODUCTION

The purpose of this document is to 1) provide a brief summary of bat-related issues associated with wind power development, 2) suggest criteria for wind farm site selection, 3) describe techniques for and timing of recommended pre-and post-construction surveys, 4) provide a wind power project reviewer checklist, and 5) provide suggestions for mitigation and future research.

Wind power is widely regarded as a source of renewable, pollution-free energy and the U.S. wind industry is growing rapidly. California was the site of the first wind turbines to generate electricity, 25 years ago. Turbines are now found in 32 states, and wind power capacity nationwide more than doubled from 2000 to 2004 (Johnson 2005, Lipman 2005).

Avian mortalities due to wind turbine collisions have been documented for some time (e.g., Howell 1997, Anderson et al., 2000); the Avian Workgroup of the National Wind Coordinating Committee (http://www.nationalwind.org) has been meeting since 1997. The 2000 National Avian Wind Power Planning Meeting Summary (http://www.nationalwind.org/events/avian/summary.htm) states “our knowledge regarding bats and wind-turbines is roughly equivalent to where we were ten years ago with birds.” The summary also states “a need for standard metrics and methods specifically for research on bats” and that “experts in bat ecology and statistics are needed to develop this guidance”. Additionally, the summary states “a need to learn more about the intensity of site utilization by bats in order to get a sense of the actual significance of bat collisions to their populations”.

Mortality of bats from wind turbines was first documented in Australia (Hall and Richards 1972). Bat mortality at wind farms in the U.S. was first reported in Minnesota (Johnson et al. 2003, Osborn et al. 1996), and fatalities now have been documented at wind farms in 10 other states (Johnson 2004 and 2005). Of these fatalities, most (83%) were migratory tree bats (hoary, red and silver-haired bats). Johnson (2004) provides a bibliography of information about wind energy and bat interactions and Johnson (2005) summarized bat mortality associated with U.S. wind energy sites. The most recent (2004) National Wind Coordinating Committee meeting provided an overview of current issues and research needs, as well as a summary of current knowledge and necessary next steps (POWIWD-V 2005).

In 2003, the Bats and Wind Energy Cooperative (BWEC) (Tuttle 2004) was formed to develop and coordinate research opportunities and identify solutions to prevent or minimize threats to bats. Partners in the effort are Bat Conservation International (BCI), the U.S. Fish and Wildlife Service (USFWS), the American Wind Energy Association (AWEA) and the U.S. Department of Energy’s National Renewable Energy Laboratory (NREL).

ASSESSING AND MINIMIZING IMPACTS OF WIND TURBINES ON BATS

Overview

The greatest difficulty in assessing impacts of proposed wind turbines on bats is the lack of baseline data for California, particularly for specific wind energy sites. While it is clear that wind turbines can have significant effects on bats, the potential for bat collisions varies among locations (Johnson et al. 2003 and 2004, Johnson 2004), and the reasons for the collisions are poorly understood (Kunz 2004). Data gathered in other geographic areas such as Pennsylvania or West Virginia may not predict what will happen in California, since the topography, vegetation, climate and many of the bat species are different. Some attempts are being made to model and predict effects on bats, primarily at sites where new turbines are being installed adjacent to existing facilities with documented bat mortalities (Mistry and Hatfield 2004).

Risk by Species

Wind turbines are concentrated in places like ridgelines with predictable winds that may aid migrating bats. Migratory tree-roosting species, such as hoary bats (*Lasiurus cinereus)*, eastern red bats (*L. borealis*) and silver-haired bats (*Lasionycteris noctivagans*), account for the greatest numbers of assessed mortalities (83.2%) nationwide (Johnson 2005). Johnson's 2005 synthesis of mortality data from four areas of the U.S. found that hoary bats account for 45.5%, red bats 26.3%, and silver-haired bats 11.4% of all bat fatalities at wind farms. Of the 27 dead bats found during a monitoring study in Oregon, all were either silver-haired (15) or hoary (12). (The absence of red bats in this study is not surprising as there is currently no evidence that this species occurs in Washington or Oregon.) Twenty of the fatalities were found from August through October, and seven were found from May through July (Erickson et al. 2003). This agrees with data gathered on eastern bats, where most mortality has been observed in late summer and early fall during periods that coincide with bat migrations (Johnson 2004, Kunz 2004). A recently released monitoring report for the High Winds project in Solano County has documented 279 bat fatalities between 2004 and 2005 (Kerlinger et al, 2006). Based on carcass removal surveys (done mostly with small birds, not bat carcasses) Kerlinger et al. estimated an adjusted total of 612 bats killed at turbines in the High Winds project over the two years. Hoary bats were the most numerous bat species fatality, followed closely by Mexican free-tailed bats. A much smaller number of western red bats and silver-haired bats completed the species list of bat fatalities.

In California, those bat species known to be migratory, and thus, based on patterns observed elsewhere, most likely to be affected by wind farm development are listed in Table 1.

Table 1. California bat species at greatest risk of being impacted by wind farms located along migration routes

North-South Migration Known to Occur in California:	
Lasionycteris noctivagans	Silver-haired bat
Lasiurus blossevillii	Western red bat
Lasiurus cinereus	Hoary bat
Tadarida brasiliensis	Mexican free-tailed bat
Likely Migratory, Migration Patterns in California Poorly Known:	
Eumops perotis	Western mastiff bat
Nyctinomops femorosaccus	Pocketed free-tailed bat
Nyctinomops macrotis	Big free-tailed bat

Silver-haired bat

Silver-haired bats are concentrated primarily in the forested regions of northern California during the breeding season (in the Trinity and Klamath ranges and northern Sierra Nevada), with records suggesting over-wintering (and thus migration) in southern California (Constantine 1998). Silver-haired bats, in low numbers, were one of the four species documented as bat fatalities during 2004 and 2005 at the High Winds project in Solano county, California (Kerlinger et al. 2006).

Western red bat

Western red bats within California are inferred to be migratory based primarily on observed shifts in seasonal occurrence or abundance (Cryan 2003, Pierson et al. 2004). Western red bats show a sexually segregated distribution in the summer, with breeding females concentrated along major river corridors in the Central Valley, adjacent foothills, and southern coast, and males likely dispersed up to relatively high elevation in the Sierra Nevada (Pierson et al. 2004, Stokes et al. 2005). Museum records suggest that both sexes congregate along the central and southern coasts in the winter (Pierson et al. 2004). Long-term acoustic monitoring stations in the Central Valley show marked late summer peaks of red bat activity (not correlated with insect abundance), suggestive of aggregated migration events (Rainey et al. 2006). Red bats, also in low numbers, were one of the four species documented as bat fatalities during 2004 and 2005 at the High Winds project in Solano county, California (Kerlinger et al. 2006).

Hoary bat

In California, hoary bats are widely distributed in California, but exhibit spring and fall shifts in abundance. They are virtually absent from southern California in the summer, yet occur there from fall to spring (Stokes et al. 2005). There is evidence of elevated fall activity in the Pit River drainage (Pierson et al. 2001), along the coast (Dalquest 1943, Tenaza 1966) and in the Central Valley (Pierson et al. 1998, 2004; Rainey et al. 2006), and over-wintering in southern California (Vaughan 1953, Vaughan and Krutzsch 1954). Pierson et al. (2004) observed an apparent mass migration of hoary bats along the Sacramento River near Chico in September 1999. A three-year study at low elevation on the Cosumnes River showed spring and fall pulses of elevated acoustic activity consistent with migration events (Rainey et al. 2006). Hoary bats were the most numerous bat fatalities documented at the High Winds project in Solano county, California, during 2004 and 2005 (Kerlinger et al. 2006).

Mexican free-tailed bat and other molossids

Molossids (free-tailed and mastiff bats) generally do not occur in the geographic areas included in Johnson's (2005) review of U.S. wind farm bat mortality, and no molossid deaths were noted. However, one of the first papers documenting bat turbine mortality dealt with white-lined mastiffs (*Tadarida australis*) in Australia (Hall and Richards 1972). This species is a large molossid with an audible echolocation call, similar to large western North American free-tailed species.

Four species of molossids occur in California (Mexican free-tailed [*Tadarida brasiliensis*], pocketed free-tailed [*Nyctinomops femorosaccus*], big free-tailed [*Nyctinomops macrotis*], and Western mastiff [*Eumops perotis*]). Mexican free-tailed bats were the second largest group of bat fatalities at the High Winds project in Solano county, California, in 2004 and 2005.

The Mexican free-tailed bat is known to undergo long distance migration (e.g., Leitner 2005, Wilkins 1989), While seasonal movement patterns are not well understood in California, it is known that large populations which have breeding colonies in caves in northern California (e.g., Lava Beds National Monument) leave this area in the winter, and that this species appears to be more abundant along the coast in the winter than during the summer. Recent work in the Sierra Nevada suggests that the Western mastiff bat may move relatively short distances seasonally, with this species being more abundant at lower elevations in the winter (Pierson et al. 1998). The pocketed and big free-tailed bats have limited distributions in southern California. Recent surveys conducted in San Diego County documented pocketed free-tails as occurring year round, with records for the big free-tailed bat being limited to the months of October through March (Stokes et al. 2005).

All bat species

While it appears, based on data collected outside California, that priority consideration should be given to migratory species during migration (when animals potentially travel together in large numbers – e.g., Mearns 1898), it should not be presumed that impacts do not occur to these and other species outside the migratory season, and under other circumstances, such as routine foraging (Kerns et al. 2005). California has 25 bat species, many of which do not occur in the areas where wind turbine impacts have been reviewed. For example, all the molossid species are aerial flock foragers, and active year round, and thus potentially at risk of impacts from wind turbines throughout the year in areas where they occur.

While a number of other species are thought to forage primarily close to the ground or close to foliage, a recent study that investigated foraging at canopy level in a giant sequoia grove found some *Myotis* species, presumed to forage close to the ground, foraging at >80 m (Pierson et al. 2006). Other studies have shown differences in activity with height and changes in height of peak activity with time of night (Hayes and Gruver 2000, Kalcounis et al. 1999). Because the foraging habits are so poorly known for many California species, caution is warranted in making *a priori* inferences regarding potential for impacts from wind turbines to foraging bats.

Wind turbine site selection

New wind farm sites should be located in areas where impacts to bats would be minimal or nonexistent. Existing information about bat migration and habitat use is limited for California; new information should be incorporated into siting decisions as it becomes available.

Site selection and approval should be based on:
- An evaluation of existing information about bat use in the area.
- Pre-construction survey data if bat use information is unavailable or inadequate.
- Avoidance of turbine locations along bat movement and possible migration routes, i.e., forest edges, ridge tops, streams and rivers.
- Avoidance of turbine locations within 500 m of still or flowing water bodies, riparian and forest edges and known bat hibernacula.

Pre-Construction Surveys

Before a site is selected and construction approved, a bat inventory, including long-term acoustic monitoring, should be conducted for at least two years to establish baseline bat occurrence and activity data in both the proposed site and control areas. These data should be combined with other available post-construction monitoring information for a better understanding of landscape scale patterns of bat activity.

The recommended surveys should be designed to determine:
- Species occurrence and diversity
- Activity levels (e.g., relative abundance, seasonal and daily timing)
- Potential migration routes

Deposition of all bat locality data with the California Department of Fish and Game California Natural Diversity Data Base (CNDDB; for species on the Special Animals List http://www.dfg.ca.gov/whdab/html/animals.html) or Biogeographic Information and Observation System (BIOS; for all other species http://bios.dfg.ca.gov) would provide a centralized repository for data of this type.

Post-Construction Monitoring

The purpose of post-construction monitoring is to 1) compare pre- and post-construction survey data, 2) evaluate the effectiveness of mitigation measures, and 3) assess unintended impacts.

Post-construction monitoring should:
- Provide species mortality data in the context of relative abundance
- Characterize flight behavior, species composition, changes in site use
- Assess seasonal/annual changes
- Provide data in sufficient detail to allow reviewer evaluation of methods and data

Post-construction surveys must include carcass surveys, acoustic surveys, and in places where bat mortalities are occurring, thermal imaging or radar surveys.

Carcass surveys are particularly important in assessing the impacts turbines might be having on bats at a wind farm.

SURVEY TECHNIQUES

Overview

In 2002, the WBWG developed a recommended survey methods matrix for western bats (http://www.wbwg.org/survey_matrix.htm). The effort is designed to help determine the presence of individual species and characterize species composition in a particular area. Survey techniques commonly used at wind farm sites (Keeley 2002, Davy et al. 2004, Reynolds 2004) such as mist-netting (during windless nights), acoustic monitoring and roost searches assist in determining species composition, seasonal trends (e.g., migratory peaks) and relative species abundance at a particular site. Year-round passive acoustic surveys are now feasible, and should be performed to obtain a minimum baseline pattern of bat activity, and for identification of some migratory species. During peak migratory periods (August-October), use of image intensifiers, thermal infrared imagers and/or radar is desirable (Horn et al. 2004, Arnett 2005, Desholm 2005,2006, Larkin 2006). Obtaining accurate estimates of bat populations is very difficult, unless a colonial roost is discovered (O'Shea and Bogan 2003). Carcass surveys provide a way to assess mortality post-construction.

When considering factors that can influence survey results, weather (i.e., temperature, wind speed, and precipitation) affects bat activity, and must be considered, especially when comparing surveys at different times of night or seasons. Time of year may also play a role in determining bat activity at a site, particularly if the project is situated in a migratory corridor.

All of these surveys must be conducted by persons who are adequately trained in equipment use, bat identification, and interpretation of data for the various survey techniques. Permits to capture and handle bats for scientific purposes must be obtained from the Department of Fish and Game.

Pre-construction Surveys

Mist-netting and Roost Surveys

Mist-netting and roost surveys, both standard bat survey techniques, should be used when feasible to aid in assessing a species assemblage at a site. Both have the advantage that they allow direct observation/ in-hand examination of bat species, and complement acoustic data (Kuenzi and Morrison 1999), providing ready identification of species (along with information on age, gender and reproductive condition). While these techniques will assist in establishing a species list for an area, they will not provide an assessment of what species are active in the impact zone of rotating turbine blades. Mist-netting must be conducted on low or no wind nights, since bat readily detect and avoid moving nets. This can be difficult at proposed wind power sites. Both these techniques should be used only in conjunction with other survey methods.

Acoustic Surveys

Acoustic surveys (monitoring bat echolocation calls) provide one means of assessing bat activity in the zone swept by turbine rotors. There are, however, several important considerations in designing acoustic surveys (see Hayes 2000). First, attenuation of ultrasound in air means that acoustic detectors have limited detection volumes (maximum detection distances in the tens of meters for most species). As a consequence, acoustic monitors on the ground will not detect bats in the rotor swept volume. Therefore, the typical solution to placing detector microphones at an appropriate height above the ground is to attach them to towers used for meteorological site evaluation. Second, bat activity at a point typically varies greatly night to night (Hayes 1997), and the limited available evidence suggests migration passage events may be highly pulsed. Thus, it is important that acoustic activity be monitored over long time intervals, preferably at multiple points simultaneous with meteorological sampling. While a variety of acoustic detection systems are available, a system currently designed to collect data passively (storing bat calls on compact flash cards for later analysis) and run unattended for long periods of time (using solar power) employs a frequency division system with low power demand (Anabat, Titley Electronics, adapted by EME Systems). See Rainey et al. 2006 for more complete description.

While not all species can currently be identified by their echolocation calls alone, most of the migratory species (i.e., hoary bats, red bats and all the molossids) provide some species diagnostic echolocation calls in open air flight, making it possible to both monitor temporal patterns of community activity and assign a subset of calls to species.

Guidelines for detector placement and use are provided by a protocol under development in Alberta (Lausen et al. 2006).

Image Intensifiers

Handheld or head mounted night vision devices relying on electronic intensification of both ambient and artificial, ‘white’, red or infrared light have been used as a supplemental observation/’ground truth’ method in several recent predominantly marine radar based surveys of bird and bat activity conducted by ABR (e.g., Mabee et al. 2005). They estimate the effective observation range with supplemental light as <150m above ground level (thus adequate to reach the outer edge of the swept rotor zone for most current projects).

Thermal Imaging

Thermal (passive infrared) imagers can detect flying bats and birds at substantial distances (e.g., 3000 m per Leichti et al. *In* Larkin 2006) if a long telephoto lens is used. A primary technical constraint of current equipment is the limited optical resolution of commercially available imagers so that detection at long distances imposes a very small a field of view and thus typically a small sample (see Desholm et al. 2005 for an extended discussion). With wider angle lenses, this technique can provide information about bats close to or interacting with wind turbines, such as in the Mountaineer study (Horn et al*.* 2004, Arnett 2005).

The greater range of thermal imagers permits monitoring for bats that are flying outside of acoustic detector range. At one survey in the Mojave Desert, bats were documented with a thermal imaging camera flying several hundred feet above the desert, while concurrent acoustic surveys were recording no or few bats (P. Brown pers comm). In this case, only the thermal imaging camera enabled researchers to observe bat activity in the area.

Radar

Marine surveillance radars are relatively frequently employed to identify and monitor avian foraging movements or migration, including assessing activity near wind development sites (Larkin 2006, Desholm et al. 2006) Both these papers and site specific contract reports emphasize a number of caveats. This type of radar can locate bats and birds in three dimensions at ranges and heights considerably greater than other available tools, but cannot currently differentiate similarly-sized bats and birds. Individuals and flocks cannot be reliably differentiated. Bat species cannot be differentiated (though tracking radars allow this, see Bruderer and Popa-Lisseanu 2005). Radar equipment and the expertise to operate and interpret the data are currently limited; but driven in part by the need to improve migration monitoring, technical development in this arena is advancing (Desholm et al. 2005). Sampling regimes for surveillance radars typically involve extended intervals at a site operating each night in both horizontal and vertical mode for several hours. As with acoustic data, total and mean numbers of detections per night and per sampling-hour (excluding nights with measurable rainfall) should be calculated. In addition, the proportion of targets flying within the rotor-swept height is calculated.

Post-construction Surveys

Carcass surveys

Carcass surveys are an important tool for assessing mortality caused by rotating turbines. Morrison (2002) summarized information known at the time about searcher efficiency and scavenging rates. Searcher efficiency rates ranged from 35-85%. Searcher trials should be conducted throughout the post-construction monitoring period to correct for variability. The use of dog carcass detection teams significantly increases search efficiency, especially where the vegetation is taller and/or denser (Arnett 2005).

Because bat carcasses are readily scavenged and easily overlooked (Keeley et al. 2001, Keeley 2002, Arnett and Tuttle 2004), 1/3 to ½ of turbines at any site should be searched daily for full “bat activity” seasons (April through October) to establish the patterns and relationships needed to understand the problems across varying landscapes (Arnett 2005). Searches done at weekly intervals at the Mountaineer wind energy center underestimated the fatality rate by nearly a factor of 3, compared to the results of daily searches. When it is not possible to survey all turbines every day, surveys should be done in a staggered pattern so that some turbines are searched each day over a longer time period (Arnett 2005). Scavenging rates should be determined using bat carcasses (not birds, as has been done in some studies).

Other sources of bias to be aware of in removal estimates include background mortality (i.e., natural mortality of bats), scavenger learning, seasonal change in scavenger abundance, overabundance of carcasses, and duration of carcass presence.

MITIGATION

[Our guidelines predate a CEC workshop scheduled for August 27-28 2006. The workshop will address impacts of wind energy development on bats and birds and ways to mitigate those impacts. CBWG may revise these guidelines and re-submit them to the CEC if information from the workshop warrants it.]

Hötker et al. (2006) summarize measures to reduce the impacts of wind farms to bats and birds. Recommendations they summarize include the topics of site selection, managing habitat within a wind farm, operation of a wind farm, and other site-specific measures. One report not included in their summary is Arnett (2005), which recommends testing of turbine “feathering” – turning the blades parallel to the wind so that they do not spin at full speed. This may be a solution to the problem of bat fatalities associated with low wind nights when the turbines are spinning, but generating little or no power.

CHECKLIST FOR REVIEW AND EVALUATION OF PROPOSED WIND ENERGY SITES – IMPACTS TO BATS

Are both pre- and post-construction monitoring surveys included?

For both pre- and post-construction monitoring:

- Do the surveys encompass the likely period of bat activity?
    - Year round
    - April-October

- Do the surveys include a variety of methods?
    - Mist netting
    - Acoustic
    - Thermal imaging
    - Radar
    - Roost surveys

- Are the survey personnel appropriately qualified and permitted to use the various methods?

For pre-construction monitoring

- Do the surveys account for night to night and seasonal variability in bat activity?
- Are they done over at least one, preferably two, seasons of activity?
- Is acoustic monitoring done at various heights in order to sample the entire height of the turbine-swept area?

For post-construction monitoring

- Do surveys encompass the likely period of bat activity?
- Are mortality surveys included?
    - Did they conduct searcher efficiency trials?
    - Did they conduct scavenging trials with bat carcasses; and is the data corrected accordingly?
    - Did they record data on species, sex, and age (if possible)?
    - Are they searching all turbines, or a statistically valid subset of turbines, on a daily basis?

For mitigation

- Have they done or proposed any statistically valid tests of the mitigation? e.g., feathering experiments, deterrence, etc.

RESEARCH QUESTIONS

We offer the following to help guide research on the bats and wind energy issue.

Many hypotheses have been offered about why bats collide with turbines. Kunz (2004) describes the theories of “sensory failure, roost attraction, acoustic attraction, insect concentration, food resources, reduced maneuverability, decompression and light attraction”. Thermal infrared video recordings at the Mountaineer Wind Energy Facility depict bats actively flying into the turbines as if in pursuit of insects, as well as just flying past (Horn et al. 2004). Why, how and when bats collide with wind turbines is currently poorly understood and “[a]t present, the short- and long-term quantitative environmental effects of existing turbines have not been adequately assessed….” (Kunz 2004). Kunz (2004) also details a number of outstanding questions that need to be addressed regarding the characteristics of wind turbines, which may be summarized as follows:

- Do wind turbines attract bats? If so, how and when?
- If wind turbines attract bats, can the turbines be modified to reduce the chance of collision?
- Do wind turbines attract flying insects? If so, how and when?
- What are the ramifications of locking or shutting down turbines during bat migration?
- Can wind turbines be structurally modified to mitigate impacts on bats?

A number of outstanding questions regarding bats and their behavior need to be answered, including:

- Are ridge lines and other sites conducive to wind energy sites the primary migratory corridors of bats?
- What sensory cues do insectivorous bats use at night, especially migratory species?
- What season and time of night or day are wind turbines killing bats?
- Do bats collide with turbine blades or with the tower poles?
- How many bats are actually killed by wind turbines?
- What is the feeding behavior of bats in the vicinity of turbines?
- What are the ages of bats killed by wind turbines?
- Is bat mortality linked to age, sex, or reproductive condition?
- Is there a technological mechanism that can result in bats’ avoidance of wind turbines?

Arnett et al. (2005) identify eight research needs summarized/paraphrased as follows (see their document for more complete discussion):

1. Conduct extensive post-construction fatality searches to elucidate temporal patters of fatality.

2. Investigate relationships between weather conditions, turbine blade movement, and bat fatality.
3. Experimentally test and compare moving and non-moving turbine blades at multiple sites to quantify reductions in bat fatality relative to economic costs of curtailment.
4. Conduct post-construction fatality searches at existing wind facilities that encompass a broad range of habitat types and topographic features to understand patterns of fatality in relationship to landscape.
5. Evaluate sources of attraction to turbines.
6. Investigate approaches to possible deterrents.
7. Test search efficiency and efficacy of using dogs to recover bat fatalities.
8. Compare different methods and tools (radar, thermal imaging, and acoustic detectors) simultaneously to better understand bat interactions with turbines.

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