Indiana Bat Section 7 and Section 10 Guidance for Wind Energy Projects
Revised: 26 October 2011

Background

In response to a growing number of--and the anticipated potential for--wind energy projects across the range of Indiana bat, a quorum of biologists have raised questions regarding effects analyses and the HCP process with respect to wind energy. Specifically, staff has expressed a desire for practical and enforceable methods to: 1) determine anticipated take levels, 2) to develop monitoring plans, 3) to track take, and 4) to develop appropriate adaptive management plans. To assist these biologists and to improve consistency within and among Regions, a small group convened in March 2010 to identify critical issues (questions).

To discern the list of critical issues, we worked through the analytical framework typically applied in conducting section 7 effects analyses. Although the impetus for this effort is the impending wind projects, we anticipate any guidance forthcoming would also apply not only to wind energy projects but also to any Indiana bat related project. From this initiative and subsequent discussions, we identified 84 questions.

The questions and responses described below are those critical questions for which we were able to develop responses through internal deliberation and elicitation of expert opinion. The remaining questions either require further internal discussion or expert review. As those issues are resolved, the responses will be provided. The purpose of this document is to provide guidelines for Field Offices (FO) to use in reviewing wind energy projects. **The information is rapidly evolving in this arena, thus it is appropriate to view the responses as interim guidelines that will be updated periodically.**

The questions and responses are organized by subject. There are 7 subjects: 1) mist-netting, 2) summer biology, 3) migration biology, 4) swarming biology, 5) wind specific impacts topics, 6) section 10(a)(1)(B) issues, and 7) jeopardy and adverse modification analyses.

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Contents

Mist-netting

1. **Is the current protocol for mist-netting appropriate for determining likely presence of Indiana bats during the summer?**
   Response: First, note that the protocol is applicable for determining Indiana bat presence during the summer period; it is not applicable for determining Indiana bat presence during the migration period. The answer to the question is yes, but with caveats. Several studies have been conducted to investigate the efficiency of mist netting to determine Indiana bat presence and several other studies have been conducted to directly compare mist netting and acoustical monitoring (Kuenzi and Morrison 1998, Murray et al. 1999, Robbins et al. 2008). Not surprisingly, neither mist netting nor acoustic surveys by themselves consistently achieve 100% detection of Indiana bats even when deployed in known occupied summer habitat. However, the detection rate for Indiana bats can be significantly increased when both mist netting and acoustic surveys are used in tandem. For example, Robbins et al. 2008 found that capture/detection rates were highest when both mist nets and ultrasonic detectors were used. Murray et al. 1999 stated that "the combination of both survey methods provides the most effective means of determining bat species composition in an area." Other studies have found similar results (Flaquer et al. 2007, Kalko and Handley 2001, Sampaio et al. 2003).

   These studies strongly indicate that we should compile and analyze the available data and revise the Service's current summer survey protocol accordingly. To facilitate this effort, we have formed an inter-regional team to undertake the task of compiling the empirical data and devising a set of survey protocols for Service managers to consider. In the interim, biologists should use the current protocol but adapt them--including incorporating acoustic monitoring—as deemed appropriate by the Field Office. Over the past few years, the Service's Kentucky Field Office has successfully developed and 'field tested' an Indiana bat survey protocol incorporating the range of sampling techniques. Field offices with little experience with acoustic monitoring should seek out assistance from the KYFO and other stations.

2. **For how long are negative summer survey results valid?**
   Response: The current Indiana bat mist netting guidelines state "Survey results are valid for at least two years." The guidelines do not specify a maximum timeframe, nor do they account for different take scenarios (namely, whether ongoing take is anticipated). As indicated above, we anticipate that the current survey protocol will be revised shortly (by the 2012 field season). We also anticipate that the forthcoming protocol will have better power than the existing survey protocol, and thus, the timeframe for which survey results are valid can be extended. To provide consistency among FO recommendations, we developed standard minimum and maximum timeframes for both the current and forthcoming survey protocols (see Table 1 below). Note, it is generally our policy across species to apply positive survey results (i.e., assume presence) indefinitely or until evidence suggest otherwise (e.g., subsequent negative survey results, habitat destruction). Thus, this discussion and the timeframes established within are germane only to negative survey results.

   Table 1. Standard expectations for presence/probable absence surveys that follow FWS' Indiana bat summer survey guidelines[1, 2]

Survey Protocol Used	FWS will consider negative survey results valid for at least…(Min. # Yrs)	FWS will consider negative survey results valid for no more than…(Max. # Yrs)[4]
Current mist netting protocol[3]	2	5+
Forthcoming revised mist netting & acoustic protocol	5	10+

[1]All timeframes assume that significant forest habitat alterations have not occurred in adjacent areas outside of the project area as determined/defined by the local FO.
[2]Note, this matrix applies to surveys conducted to determine presence/probably absence of bats during the summer period. FWS has yet to develop or approve standard survey guidelines for determining presence/probable absence of migratory Indiana bats.
[3] The current protocol is included as an appendix to the Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision (USFWS 2007), which may be accessed at http://www.fws.gov/midwest/Endangered/mammals/inba
[4]The maximum timeframe may be extended when we believe it is highly unlikely that colonization of the habitat can occur within 5 to 10 years (e.g., if the unoccupied habitat is isolated from occupied habitat)

A rationale for the 2-year minimum timeframe is not provided in the current survey guidelines nor is a maximum timeframe specified. Information pertinent to establishing periods of time for which survey results can be confidently applied is scant. Nonetheless, such timeframes must be defined. The basis for developing minimum and maximum timeframes rests upon the behavior of Indiana bats and our confidence in the survey results. Indiana bats are strongly philopatric, remaining in a more or less fixed geographic area year-to-year (USFWS 2007). For this reason, we believe it is highly unlikely for Indiana bats to colonize unoccupied areas over a short period of time. The period of time for which we believe this would be true is influenced by the degree of confidence we have in the survey results. The greater our confidence in the findings, the longer period of time for which we are comfortable concluding probable absence of Indiana bats. We assume this was the basis for the 2 -year minimum timeframe defined in the current mist netting guidance. That is, FWS agreed that, given negative survey results stemming from applying the adopted mist netting protocol, we would not reasonably expect Indiana bats to colonize the search area over the next 2 years. The forthcoming survey protocol is anticipated to have substantially better power than the current protocol, and thus extending the minimum timeframe is appropriate. Given a higher degree of confidence that Indiana bats are not likely present when survey results are negative, we believe a 5-year minimum timeframe is reasonable. Presuming that the chances of a false negative will be greatly reduced under the revised survey protocol coupled with the species' strong fidelity to their traditional summer habitat areas, we can be sufficiently confident that an area will remain unoccupied for at least 5 years. An exception to this is that if currently occupied nearby habitat (e.g., within 2.5 miles) is substantially degraded or removed, then it is plausible that the resident bat colony may abruptly relocate into suitable, previously unoccupied areas. In these situations, the previously unoccupied habitat should be resurveyed to confirm Indiana bat absence.

Although highly philopatric, maternity colonies shift their use over time as natural-caused changes to their habitat occur. Thus, a maximum timeframe beyond which negative survey results are no longer applicable is warranted. This is particularly pertinent for projects that have the potential to cause take into the future (e.g., operation of some wind turbines and construction of some roadways). There are little data to glean insights regarding the timescale of maternity colony movement across a landscape. Kurta and Murray 2002 and Kurta et al. 2002 documented shifts in the focal point of Indiana bat roosting activity by 2 km (1.2mi) over a 3-year period. Similarly, the centers of activity for two colonies shifted 1.6 and 4.8 km (1 and 3 mi), respectively, in a decade (T. Carter, Ball State University, pers. comm. *in* Stantec et al. 2010). Drawing from this data, it is reasonable to assume that maternity colonies may shift notable distances over a 10-year period as they exploit ephemeral roost tree resources within and adjacent to their traditional summer home ranges. Therefore, assuming we have high confidence in the validity of the survey results, it is reasonable to anticipate that within a 10-year period neighboring maternity colonies could move/shift their summer range into previously unoccupied areas. Assuming that the forthcoming survey protocol will sufficiently guard against false negatives, we believe applying survey results for a maximum of 10 years is reasonable. Under our current mist netting survey protocol (without an acoustic survey component), however, we have less confidence in the results. Thus, using our current protocol, the maximum number of years for which negative survey results can be applied should be 5 years. Both of these maximum standards can be extended, however, if the FO determines it is appropriate to do so (e.g., when future take is not anticipated or when the presently unoccupied habitat is isolated--more than 10 miles--from occupied areas).

3. **Is it acceptable to reduce the number of net nights for large projects?**
   Response: Generally speaking, the current protocol provides for this flexibility. However, Field Offices should, particularly for projects that pose ongoing threats, carefully assess the level of effort required to achieve confidence in the survey results. It is possible that for some projects more, not fewer, net nights may be warranted. For most project areas, a site-specific analysis of the juxtaposition of suitable habitat elements (i.e., suitable roosting, foraging, and commuting areas) is necessary to adequately adapt the survey protocol. Given the information to date, Field Offices may encourage project proponents—especially for projects affecting large areas--to use acoustic detectors to direct netting efforts to particular areas within large project sites.

Summer Biology

4. **How do we delineate an Indiana bat maternity colony home range?**
   Response: Delineation methodology depends upon the data available.

   A. Capture Data Only - If through mist-net surveys associated with the project, or any other effort, a reproductive (i.e., pregnant, lactating, or post-lactating) female or juvenile is captured within the standard window (i.e., May 15 to August 15) but no other information (e.g., radio telemetry) is available for the area. We assume the maternity colony home range may include all suitable habitat within <u>5 miles</u> of the capture location.

B. Capture and Roost Trees - If roost tree(s) have been documented (through telemetry associated with the project or any other effort) but no foraging data are available, we assume the maternity colony home range includes:
   1. all suitable habitat within <u>2.5 miles</u> of the single documented maternity roost tree unless the distance between the capture location and roost tree is larger. In that case, use the longer distance to create the polygon (see Figure 1).
   2. all suitable habitat within <u>2.5 miles</u> of the line drawn between the two documented roost trees unless the distance between the capture location(s) and roost trees is larger. In that case, use the longer distance to create the polygon (see Figure 2).
   3. all suitable habitat within <u>2.5 miles</u> of the center of the polygon created by connecting three or more documented roost trees unless the distance between the capture location(s) and roost trees is larger. In that case, use the longer distance to create the polygon (see Figure 3).

C. Capture, Roost Trees, and Foraging Points or Acoustic Data - If roost tree(s) have been documented <u>and</u> foraging points and/or acoustic data are available, do as follows:
   1. Map the potential home range following steps for "capture and roost trees".
   2. Determine whether all telemetry points are included within the polygon.
      a. If yes, continue to consider that all suitable habitat within 2.5 miles of documented roosts is part of home range.
      b. If no, reconfigure the polygon to include telemetry points.

   Note, the distance of 2.5 miles from roost trees is the standard threshold used to delineate the typical foraging distance of Indiana bats. The standard was based on analysis of data available at that time (see footnote 1 and references cited in Question below). The distance of 5 miles from capture points is selected because the capture location could be at the edge of the home range and we do not know which direction(s) the bat may fly.

Figure 1. Scenario a: Single roost tree – home range includes all suitable habitat within 2.5 miles of the roost tree.

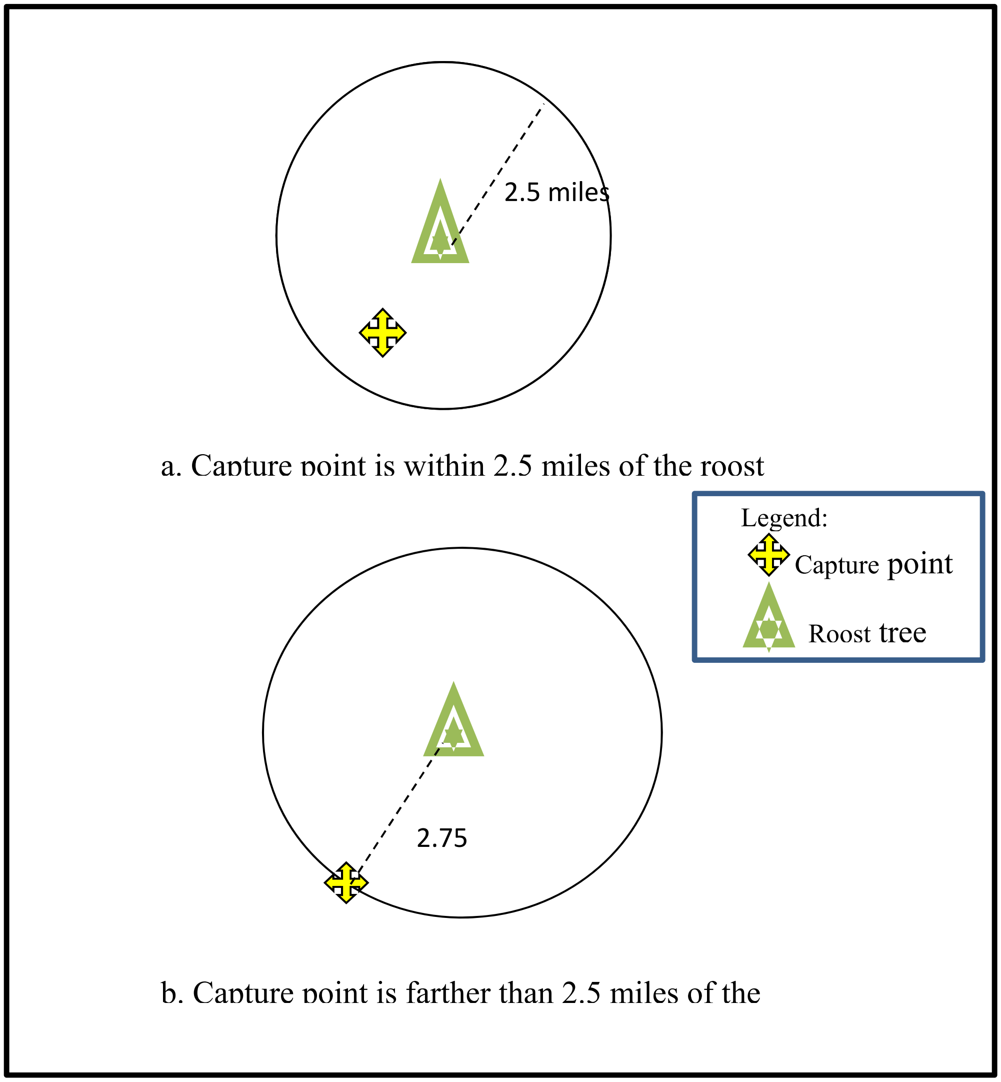


Figure 2: Scenario b: Two roost trees – home range includes all suitable habitat within 2.5 miles of the center point between the roost trees.

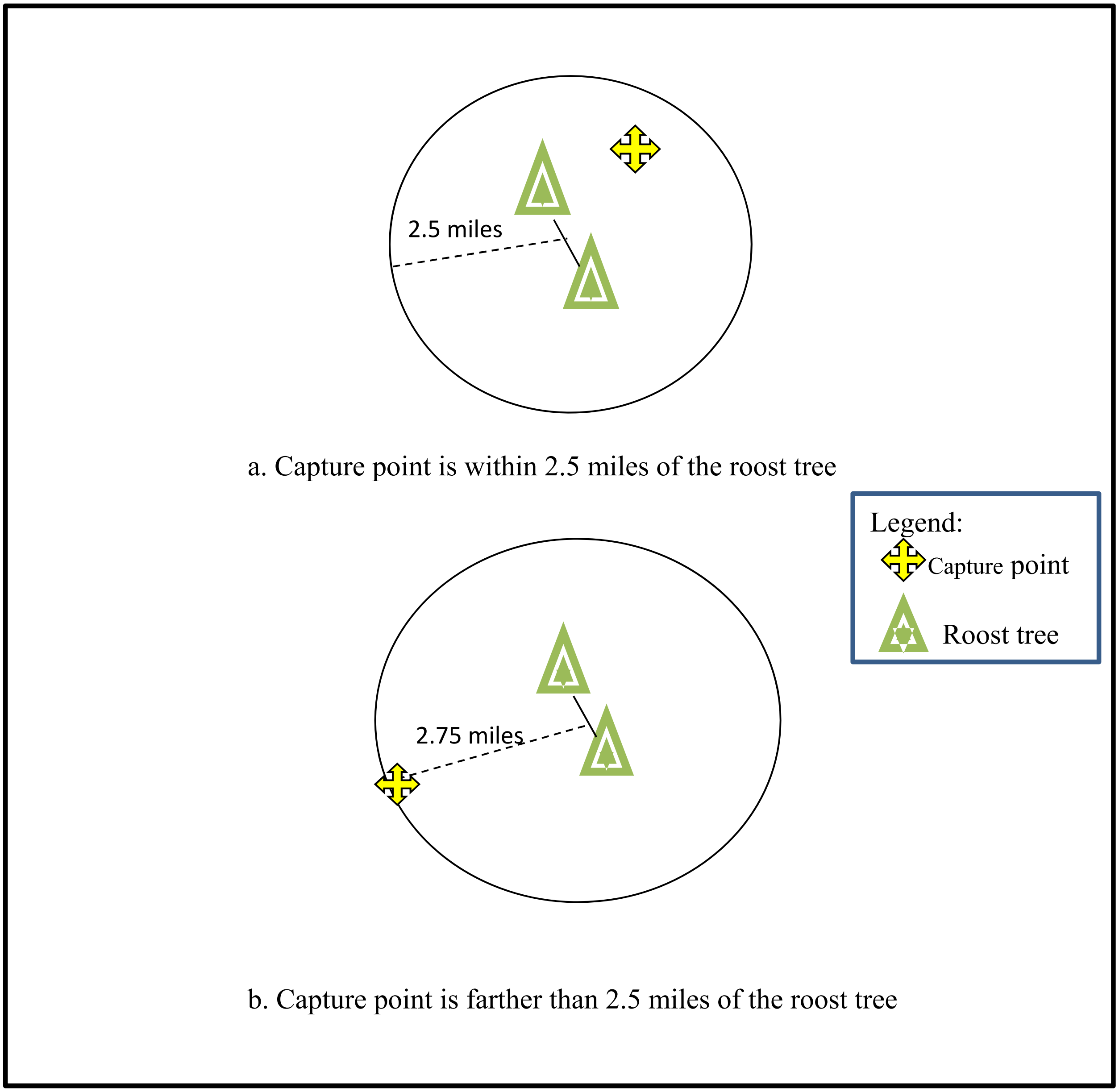
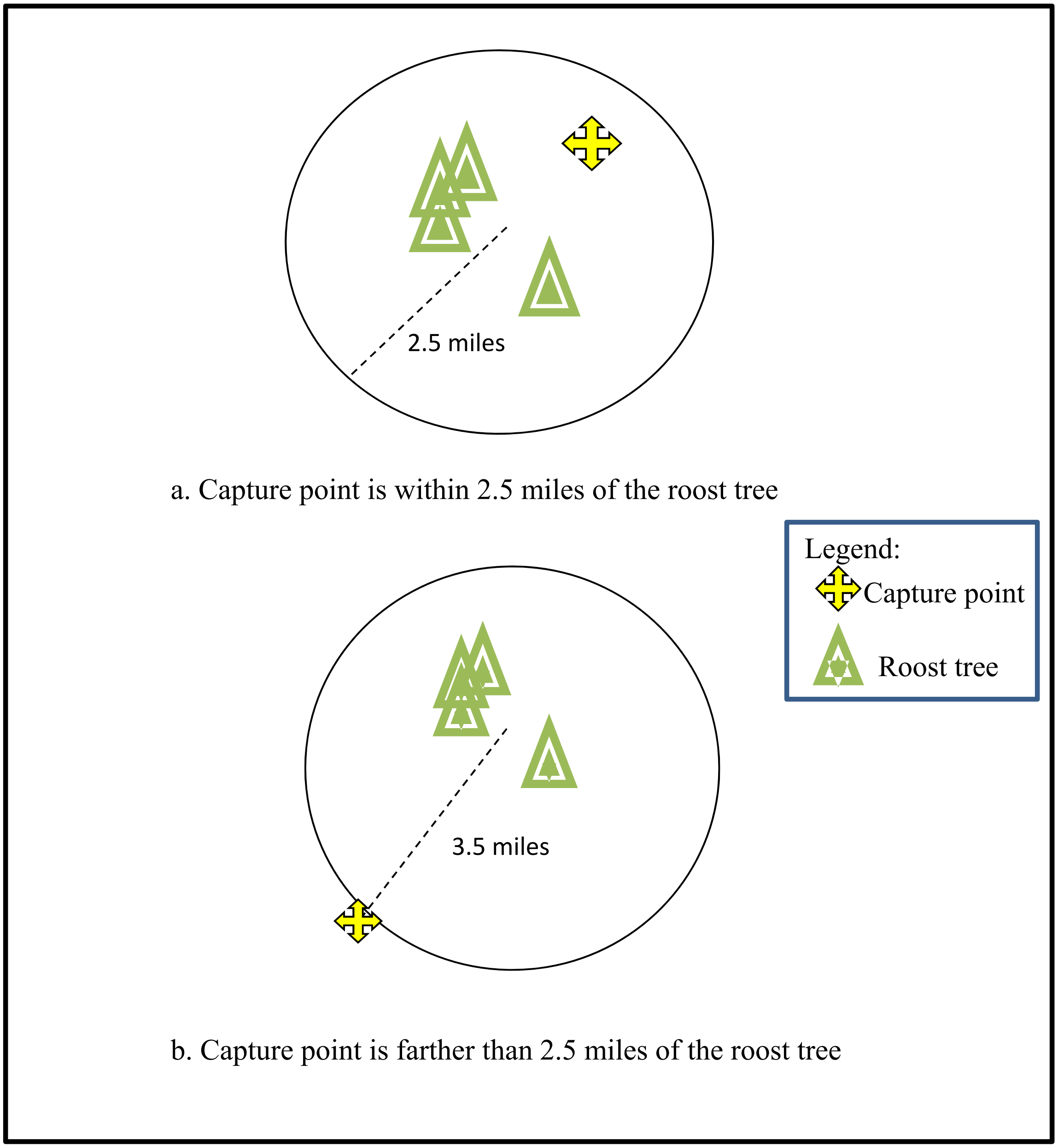


Figure 3: Scenario c: Three or more roost trees – home range includes all suitable habitat within 2.5 miles of the center point between all roosts.



5. **Do we delineate home range differently based on different landscape scenarios?**
Response: At this time, the weight of the evidence does not support adopting different home range methodologies. Thus, we recommend that the home range guidelines are appropriate for delineating home ranges across the entire summer range of Indiana bat.

Data pertaining to home range sizes and foraging patterns for Indiana bats are primarily from "fragmented" landscapes (e.g., Indiana, Illinois, Ohio, and Michigan). Some have suggested (e.g., Murray and Kurta 2004) based on limited data from forested regions that Indiana bats may not forage as far from their roosts in more contiguous, forested landscapes and thereby may occupy smaller home ranges. For example, Butchkoski and Hassinger (2002) found that

Indiana bats foraged 2.4-4.5 km (1.5-2.8 mi.) and averaged 3.4 km (2.1 mi) in a 78% forested landscape in Pennsylvania. At this time, however, the information is too limited to confidently conclude that foraging ranges in forested landscapes are on average are smaller than in fragmented areas. Therefore, we recommend that, delineation of a home range should follow the guidance provided in answering "How should we delineate an Indiana bat maternity colony home range?"

6. **What is the typical height that Indiana bats fly while foraging during the summer period?**
   Response: Based on published data (see below), we believe that Indiana bats typically forage and fly within an air space from 2 to 30 m. Furthermore, all experts agreed that based on the information available, 2 to 30 m is a reasonable assumption. Some noted that there isn't a way to exactly measure flight height, and others stated that 30 m may err a bit on the high side. A few experts responded that periodic higher elevation flights may occur. Personal observations associated with the assumption include capturing Indiana bats at these heights in mist-nets, visual monitoring of radio-tagged foraging Indiana bats (around tree canopies), and height distribution of myotid calls detected during acoustic surveys were provided.

   A sample of literature: LaVal and LaVal (1980) conducted light-tagging experiments using helicopter observations of Indiana bats in Missouri and all tracked bats foraged below tree-top level. Brack et al. (unpublished data) conducted ground tracking of light-tagged Indiana bats in Indiana and found most foraging within or along the edge of wooded areas (above and around foliage surfaces rather than within foliage clutter). He also noted that flight height associated with commuting was higher than when foraging. Humphrey et al. (1977) found Indiana bats foraging heights of 2-30 m using a combination of visual observations of bats with reflective tape on their bands and ultrasonic detectors. Ford et al. (2005) conducted acoustic sampling at the Fernow Experimental Forest in West Virginia at 63 sites under a closed forest, within a forest canopy gap or forest harvest area, or along a stream and recorded below-canopy activity of Indiana bats.

   Acoustic data collected at 19 proposed wind power projects (96 Anabat detectors) in 6 states (ME, NH, NY,OH, VT and WV) from 2005-09 indicate that myotids fly at low heights (Meinke et al. 2010): Ninety-five percent of myotid activity was recorded at detectors placed at or below a height of 10 m, 99.9% of myotid activity was below 47m regardless of season, and myotid activity recorded at 50 m was approximately 3% of that recorded at 2 m. Low flying height of myotids during summer foraging and traveling activities is supported by information from summer foraging observations (Russell et al. 2008), aircraft bat strike data (Peurach et al. 2000), and acoustic studies at proposed wind power sites. These data collectively present fairly strong support for the assumption that myotid bats fly at low heights during the maternity season but their reliability is uncertain because acoustic studies my not detect higher flying bats.

7. **What is the typical height that Indiana bats fly while traveling between roosts or between roosts and foraging areas?**

Response: Experts generally agreed that Indiana bats likely travel at the same heights (2-30 m above ground) as when they are foraging. This belief is also consistent with the findings of Ford and colleagues (2005). Although Brack et al. (unpublished data) noted that bats flew higher while commuting than when foraging.

8. **Do summering Indiana bats fly at certain times of night during the summer period?**
Response: Indiana bats are active shortly (20-30 minutes) after sunset and forage most of the night, with short bouts of asynchronous resting throughout the night, until shortly (10-40 minutes) before sunrise (Murray and Kurta 2004).

9. **Are there weather conditions under which Indiana bat activity during the summer period will be greatly reduced?**
Response: Positive correlations of bat activity and temperatures are common in bat literature, both over an annual time period (O'Farrell and Bradley 1970, Avery 1985, Rydell 1991), and on a nightly basis (Lacki 1984, Hayes 1997, Vaughan et al. 1997, Gaisler et al. 1998, Shiel and Fairley 1998, Fieldler 2004, Reynolds 2006). For example, Reynolds (2006) found no detectable bat activity on spring nights when the daily mean temp was below 10.5 C (50.9 F). Bat activity at the Buffalo Mountain wind project in Tennessee from 2000 to 2003 was most closely correlated with average nightly temp (Fiedler 2004). The experts consistently pointed to similar responses among all bat species that activity declines in heavy rain, high wind, and cold (some specifically mentioned temperatures below 50-55 F) - conditions that impair flight or ability to thermoregulate, or reduce insect activity. Heavy fog was also mentioned as causing reduced bat activity. However, it is important to note that with precipitation events, bats are likely active intermittently. Murray and Kurta (2004) reported, for example, that the only time a pregnant Indiana bat returned to the day roost before dawn was on a night with periods of heavy rain; this individual returned twice to the day roost (once for 10 min and once for 20 min). Furthermore, extensive netting at gray bat caves in Missouri indicated that gray bats (and other species of bats using those caves, including male Indiana bats) are indeed active in virtually all kinds of summer weather (excluding extreme cold). On rainy nights, bat activity was greater between bouts of rain but was essentially never entirely interrupted (Virgil Brack, Env. Solutions & Innovations, pers. comm. 2011).

10. **Is it reasonable to assume that pups are less skilled at flying than adults, and therefore, will forage closer to their roosting sites?**
Response: Although not empirically tested, most experts believe pups are less skilled with echolocation than adults, and hence, forage closer to the roost than adults. This behavior has been documented for red bat (French and Whitaker 2002) and little brown bats (Buchler 1980) and assumed for bats in general (Tuttle and Stevenson 1982). Young bats have also been observed making "test flights" in the immediate vicinity of roosts when recently volant (Allen Kurta, Eastern Michigan University, pers. comm. 2011). However, it is believed that pups learn and begin to forage farther out in short amount of time (within a couple weeks).

11. **Is it reasonable to assume that bats will shift their habitat use in response to anthropogenic disturbances, or is it likely that competition with other bats would preclude them from making such shifts?**

Response: All 10 of the experts that responded to this question believed it was reasonable to assume that bats would shift away from human disturbances (e.g., habitat modifications; novel, loud activities, etc.). Most respondents agreed that interspecific competition for prey is not likely to hinder shifts/movements as prey items seldom appear to be in short supply and different bat species eat different types of insects. Interspecific competition for prey may be an issue in rapidly developing landscapes where bats of all species are forced into a relatively small/narrow remnant of habitat (e.g., riparian corridor).

In most areas, however, a shortage of suitable roosting habitat is presumed to be more limiting than prey and more likely to influence range shifts. Based largely on long-term field studies at the Indianapolis Airport in Indiana, Sparks (Env. Solutions & Innovations, pers. comm. 2010) suspects that Indiana bats are competitively inferior to little brown, big brown, and evening bats and superior to northern long-eared bats. Similarly, data collected by Carter (2001, 2002) showed Indiana bats apparently being excluded from an artificial roost by *M. lucifugus* over a 3-year period. Others have found niche separation in roost selection between northern and Indiana bats. Foster and Kurta (1999) found that northern long-eared bats (*M. septentrionalis*) in southern Michigan had a distinctly broader roosting niche, utilizing maples, cavities, living trees, and sites with higher canopy cover more often than its congener, the Indiana bat and moved greater distances between roosts than *M. sodalis*. Timpone et al. (2010), for example, studied the overlap in roosting habits of Indiana bats and northern long-eared bats in Missouri. Their results suggested that niche separation in roost selection exists between the two species, although they noted that differences in roost selection may result from inherent differences in natural history, or may be the result of competition. Similarly, Lacki et al. (2009) compared roost site characteristics of the Indiana bat and the northern long-eared bat using published data from 28 studies completed where the distributions of the two species overlap. Their analysis suggested that the two species partition available roosting resources, with northern long-eared bats exhibiting greater variation in choice of roosting sites than Indiana bats. They concluded that the greater flexibility in choice of roosts in northern long-eared bats may explain, in part, why this species is more widely distributed and more common compared to Indiana bats. Whether interspecific competition is in play, it is likely that Indiana bats will shift their habitat use when confronted with anthropogenic disturbances. The question becomes whether they will successfully shift. The answer to this question depends upon the scale of the shift and surrounding landscape; these issues are addressed below.

12. **Is it reasonable to expect a colony to shift its use to newly created habitat? If so, how large of a shift (e.g., within <1, 5, or 10 miles of existing habitat) is reasonable to expect?**
Response: The maximum reasonable distance at which the experts believed a colony may move to exploit newly created summer habitat ranged from 2 to 10 miles. All seven experts thought it was reasonable to assume that a colony could successfully shift its range to exploit newly created habitat when they have lost only a portion of their traditionally occupied habitat (but see discussion regarding loss of a primary roost tree below) and it is created within their traditional maternity range (i.e., approximately within 2.5 miles). Brack et al. (2009) presented the well-studied maternity colony at the Indianapolis Airport as an example of how Indiana bats have been observed to shift their focal roosting and foraging areas over time in direct response to anthropogenic disturbances and losses and creation of foraging and

roosting habitat within their traditional maternity range. This maternity colony shifted its use of primary roost trees nearly 3 miles over a 6 to 7-year period and began utilizing a large bat conservation area that had been reforested as mitigation for an airport-related HCP.

Although less certain, most experts also presume that Indiana bats are capable of successfully exploiting newly created habitat that is farther from their traditional maternity area. But as neither the mechanism nor circumstances under which Indiana bats pioneer maternity colonies is known, we do not know whether and to what extent Indiana bats would rely on this newly created habitat. Clearly, the farther away and the more disjunct from the traditional maternity area, the less likely it is that bats will use both the newly created and traditional maternity areas.

13. Will removing a primary roost tree during the inactive season affect the fitness of the colony?

Response: Loss of a primary roost tree (i.e., a tree sheltering 30+ Ibats on one or more occasions) is a natural phenomenon that all colonial tree-roosting bats are well adapted to address; mostly by having alternates available (i.e., both in terms of sufficient number and in terms of knowledge of their location). Although ephemeral, primary roost trees are a critical resource for reproductive success. For a tree to serve as a suitable primary maternity roost, it must possess particular characteristics (e.g., a minimum size, sloughing bark, high solar exposure, etc.) and remain free of predators (e.g, owls and raccoons), and hence their abundance varies and may be limited in some areas. Given their importance and uniqueness, it is understandable why Indiana bats remain faithful to individual maternity trees while they remain suitable (Gardner et al. 1991b; Whitaker et al. 2004; Barclay and Kurta 2007; K. Watrous, University of Vermont, pers. comm. 2005).

The implications of losing a maternity roost tree can vary from little consequence to severe. In forests, where large trees with sloughing bark are abundant, the loss of a single maternity roost tree may have not affect reproductive effort to any noticeable degree. However, loss of a primary maternity roost tree when other suitable maternity trees are not readily available could lead to reproductive consequences over multiple years. Kurta (2005) suggested that the magnitude of impact will vary greatly depending on the scale of roost loss (i.e., how many roosts are lost, how many alternate roosts vs. primary roosts, and how much alternative habitat is left for the bats in the immediate vicinity of the traditional roost sites). Racey and Entwistle (2003) noted that traditionally managers have assumed that bats excluded from a roost would simply relocate with conspecifics in another roost. However, they cautioned that there is little evidence of this from molecular or banding studies of bats. Sparks et al. (2003), for example, observed a breakdown of an Indiana bat colony (bats used more roosts and congregated less) for several years following the natural loss of a single primary maternity tree. Brigham and Fenton (1986) demonstrated that a colony of big brown bats (*Eptesicus fuscus*) excluded from their maternity roost in a building experienced a 56 percent decline in reproductive success. Humphrey and Cope (1976) evaluated changes in population size of little brown bats relative to “destructive” activity (ranging from DDT poisoning to re-roofing structures housing the colony). They studied 23 maternity colonies, totaling 15,450 bats and found that the disturbed bats clearly sought out alternate roosting sites after exclusion, but “there is no evidence of successful or even attempted group reestablishment at a new roost.

Perhaps a few females (each several years old) relocated in previously established nurseries. Thus virtually all bats eliminated from an established colony site seem to disappear." Given the above, we believe it is not valid to assume that removing a maternity roost tree will not incur fitness consequences. Instead, we must analyze whether the anticipated habitat alternation will alter the quantity or character of the site in terms of Indiana bat habitat suitability. In particular, our analysis should evaluate whether other suitable roost trees, particularly potential primary roost trees, within the homerange are available to the colony. If suitable roosting trees are limiting, adverse fitness consequences are likely.

14. **If Indiana bats abandon an area, what is the fate of the affected maternity colony in the short and long-term?**
Response: If a relatively small number of bats abandoned an area/colony, most experts responded that an affected maternity colony would experience either no impacts or only a short-term reduction in reproductive output. However, if individual losses were sustained over time, then the probability of a colony's continued survival would be proportionally diminished. The majority (5 of 7) of experts believed that the magnitude of negative effects was dependent upon the proximity of unoccupied suitable habitat with longer distances leading to more negative effects.

15. **Will Indiana bats continue to occupy a traditional summer area that remains suitable in terms of habitat characteristics but presents a perpetual external source of mortality (e.g., wind turbines)?**
Response: Experts agree that there is no information exists that would suggest that bats would shift their home range to avoid an external source of mortality.

16. **How do we account for changes in habitat use, and thus changes in exposure potential, over time?**
Response: Indiana bats exhibit strong fidelity to their roost trees, roosting and foraging areas, and commuting corridors. But, we also know that roost trees are ephemeral, and hence, bats must shift their habitat use over time. Kurta and colleagues, for example, documented movement of the focal point of roosting activity by 2 km across the landscape over a 3-year period but these bats continued to use the same commuting corridors and foraging grounds (Kurta and Murray 2002, Kurta et al. 2002). Based on these data, it is reasonable to anticipate that Indiana bat use of an area will shift over time, and hence, Indiana bat exposure to wind facility operations may shift over time as well.

If Indiana bats are documented within an action area, monitoring of the colony over time should be part of the HCP or terms and conditions of the biological opinion. We should apply the monitoring data in an adaptive management framework (e.g., delineate all suitable habitats within the project action area and consider and monitor its potential use in the future when developing measures to avoid exposure potential; consider and monitor for both the potential for movement towards and away from turbines and shifts in home range use as a result of changes in forest/openings from the project or targeted planting of high-quality habitat).

Migratory Biology

17. If a project is located outside of the currently documented summer and winter range, is it also outside of migratory range?

Response: Yes, if a project is located completely outside the range as delineated by the Recovery Unit boundaries in Figure 14 (page 119) in the draft recovery plan, we can reasonably assume that no use (for summer or migration purposes) by Indiana bats will occur near the project area. The exception being, of course, if the range of Indiana bats relative to that documented in the draft recovery plan has expanded. [Note: an updated RU boundary map will be posted on the R3 IBat webpage when available: http://www.fws.gov/midwest/Endangered/mammals/inba/index.html]

18. How far do Indiana bats migrate from their hibernacula?

Response: Migration distances vary inter-regionally as well as intra-regionally. Twelve female Indiana bats (the majority of which were reproductive females) from maternity colonies in Michigan migrated an average of 477 km (296 mi) to their hibernacula in Indiana and Kentucky, with a maximum migration of 575 km (357 mi) (Winhold and Kurta 2006). Gardner and Cook (2002) also reported on long-distance migrations for Indiana bats traveling between their summer ranges and hibernacula. Shorter migration distances are also known to occur. Twenty-seven Indiana bats banded, during summer, at multiple locations in Indiana have subsequently been relocated in hibernacula (26 were in hibernacula in Indiana, and one in Kentucky). For these bats, the distance between summer capture to the hibernacula ranged from 8 to 209 km (5 to 130 mi); the average distance was 84 km (52 mi) (L. Pruitt, USFWS, pers. comm. 2008). Recent radio-telemetry studies of 130 spring emerging Indiana bats (primarily females) from six New York hibernacula found that 75 percent of these bats were later detected and all migrated less than 68 km (42 mi) to their summer habitat (Butchkoski et al. 2008). Some banded female Indiana bats from maternity colonies in Mammoth Cave National Park have been found hibernating in nearby caves (J. MacGregor, USFS, pers. comm. 2006).

19. What are the windows for fall and spring migration?

Response: Fall Migration: Review of the literature suggests that most fall migration of *Myotis sodalis* occurs between August 15 and October 15; however, a small number of bats will be migrating outside this window. Pre-migratory movements associated with disbanding of maternity colonies begin in early August.

August 15 as the start of the migration window is supported by the USFWS mist-netting guidelines which state that: "May 15-August 15 are acceptable limits for documenting the presence of summer populations of Indiana bats, especially maternity colonies." This timeframe for surveys was developed by the Indiana bat recovery team. This suggests that most female Indiana bats and their young be on the summer range through August 15. Note, however, that Kiser and MacGregor (2005) suggest that late-season surveys between August 1 and August 15 are not ideal for presence/absence surveys because some bats begin to leave summer habitat during these dates.

Maternity colonies begin disbanding at various times with a report as early as late July (Chris Dobony, Fort Drum, NY, US Army, pers. comm. 2011); most other reports indicate disbanding occurs during the first two weeks in August, although some large colonies may maintain a steadily declining number of bats into mid-September (Humphrey et al. 1977, Kurta et al. 1993). Note, however, because the maternity colony disbands does not necessarily mean that bats have begun to migrate (Kurta, pers. comm. 2011). At any given time some individual bats may be migrating while others are still on the summer range and still others are hibernating (Sparks, pers. comm. 2011); consider the behavior of the bat (versus the date of capture) when determining if a bat is migrating or resident (Sparks, pers. comm. 2011). Even in northern areas, such as Michigan, a few Indiana bats may remain into late September and early October; these late migrants may be young-of-the-year (Kurta and Rice 2002). Members of a maternity colony do not necessarily migrate to the same hibernacula, and may migrate to hibernacula that are over 300 km (190 mi) apart (Kurta and Murray 2002, Winhold and Kurta 2006).

Timing of migration may vary by sex, age, and reproductive condition. Indiana bats arrive at their hibernacula in preparation for mating and hibernation as early as late July; usually adult males or nonreproductive females make up most of the early arrivals (Brack et al., 2005, Brack 1983). The number of Indiana bats active at hibernacula increases through August and peaks in September and early October (Cope and Humphrey 1977, Hawkins and Brack 2004, Rodrigue 2004, Hawkins et al. 2005). At Pilot Knob Mine in Missouri, the number of females active at the cave peaked in late August; compared to females, peak activity of males was later (LaVal and LaVal 1980).

<u>Spring Migration</u>: March 15 – May 15 is a window that encompasses most known records of spring migrants; however, there will be small numbers of bats migrating outside this window.

The dates of spring migration are less well established in the literature compared to fall migration, in part because there has been more trapping conducted at hibernacula in fall compared to spring (producing more information on when bats arrive at the hibernacula in the fall). May 15 as the end of the spring migration window is supported by the USFWS mist-netting guidelines which state that: "May 15-August 15 are acceptable limits for documenting the presence of summer populations of Indiana bats, especially maternity colonies." This timeframe for surveys was developed by the Indiana bat recovery team. This implies that the majority of Indiana bats are expected to be on their summer range by May 15.

The timing of annual spring emergence of Indiana bats from their hibernacula varies across the range, depending on latitude, and between years, depending on weather (Hall 1962, John Chenger, Bat Conservation and Management, Inc., pers. comm. 2011). Based on trapping conducted at the entrances of caves in Indiana and Kentucky, Cope and Humphrey (1977) observed that peak spring emergence of female Indiana bats was in mid-April, while most males were still hibernating. The proportion of females active at the entrance of hibernacula decreased through April, and by early May none remained. Peak emergence of males occurred in early May, and few were left hibernating by mid-May. LaVal and LaVal (1980) made similar observations at Missouri hibernacula; females started emerging in late March to early April, and outnumbered males active at hibernacula entrance during that period. By the end of April, few females remained, and males dominated the sample of bats captured at hibernacula entrances. At the Mt. Hope Mine complex in New Jersey, peak spring emergence of females was in early April, and emergence of males peaked at the end of April (Scherer 2000). Exit counts from several hibernacula in southern Pennsylvania and Big Springs Cave in Tucker County, West Virginia, suggest that peak emergence from hibernation is mid-April for these two areas (Butchkoski and Hassinger 2002, Rodrigue 2004). Spring surveys of the interior of Barton Hill Mine in New York documented substantial numbers of Indiana bats through April and into mid-May; however, by the end of May, about one-tenth of the population remained (Al Hicks, New York State Department of Environmental Conservation, pers. comm. 2005). Spring migration surveys conducted in Pennsylvania, New Jersey, and New York indicate that Indiana bats typically emerge from hibernacula on the first unseasonably warm night in mid-April (Chenger, pers. comm. 2011).

Spring emergence from hibernacula varies by sex. Based on trapping conducted at the entrances of caves in Indiana and Kentucky, Cope and Humphrey (1977) observed that peak spring emergence of female Indiana bats was in mid-April, while most males were still hibernating. The proportion of females active at the entrance of hibernacula decreased through April, and by early May none remained. Peak emergence of males occurred in early May, and few were left hibernating by mid-May. LaVal and LaVal (1980) made similar observations at Missouri hibernacula; females started emerging in late March to early April, and outnumbered males active at hibernacula entrance during that period. By the end of April, few females remained, and males dominated the sample of bats captured at hibernacula entrances. At the Mt. Hope Mine complex in New Jersey, peak spring emergence of females was in early April, and emergence of males peaked at the end of April (Scherer 2000).

Female Indiana bats may leave immediately for summer habitat (Hicks, pers. comm. 2011; Greg Turner, PA Game Commission, pers. comm. 2011; Humphrey and Cope 1976) or linger for a few days near the hibernaculum. Turner (pers. comm. 2011) indicated that fitness upon emergence from hibernacula may play a role in the timing of departure. Once en route to their summer destination, females move quickly across the landscape, at least in the few studies that have tracked spring migrating Indiana bats. One female released in southeastern New York moved 56 km (35 mi) in approximately 85 minutes (Sanders et al. 2001). Radiotelemetry studies in New York documented females flying between 16 and 48 km (10 and 30 mi) in one night after release from their hibernaculum, arriving at their maternity sites within one night (Sanders et al. 2001; Hicks 2004; S. vonOettingen, USFWS, unpublished data, 2005). One radiotagged female bat released from Canoe Creek Mine in Pennsylvania traveled approximately 97 km (60 mi) in one evening (Cal Butchkoski, PA Game Commission, pers. comm. 2005). A female Indiana bat from a hibernaculum in Luzerne County, Pennsylvania, traveled 90 km (56 mi) to her summer habitat in Berks County, Pennsylvania, in two nights (Butchkoski and Turner 2006).

20. Do Indiana bats – and other myotids – migrate in inter-specific groups?
Response: There are no data available to infer that Indiana bats do or do not actively form inter-species groups for the purposes of migration.

21. **Do Indiana bats--and other myotids--migrate independently or in intra-specific groups?** Response: Unknown, but data collected thus far provide some insights. Different information is provided for spring and fall migration, as it is unknown if these events are similar in duration, route, stopover locations, or other ways.

Spring migration: Some New York and Vermont work with radio-tagged migrating Indiana bats indicates that they migrate individually, although on a few occasions, two Indiana bats appeared to be very close, perhaps traveling to the same colony site (Scott Darling, Vermont Dept. of Fish and Wildlife, pers. comm. 2010). Radio telemetry of spring migrating Indiana bats in Pennsylvania indicated that radio-tagged individuals hand-released one at a time typically begin migration immediately, and do not remain near the hibernacula (Turner, pers. comm. 2011). This may indicate individual migration. However, other work in Pennsylvania, New Jersey, and New York indicates that on the first unseasonably warm night in mid-April multiple ("pulses" or "trickles") Indiana bats are detected leaving the hibernacula (Chenger, pers. comm. 2011). It is reasonable to suggest that these Indiana bats may be migrating together in small groups (Chenger, pers. comm. 2011), or to suggest that they are relying on similar migratory cues and therefore are often migrating simultaneously, though perhaps independently (Rick Reynolds, Virginia Dept. of Game and Inland Fisheries, pers. comm. 2010). Brack (pers. comm. 2010) contends that several species of bats, including myotids, may migrate in groups. He described an incident in which a small group of gray bats (*Myotis grisescens*) showed up at the same cave on the same day, remained together for 2 days, and then departed on the same day. Similarly, he recited a situation where the only record of gray bats in WV is in Hell Hole. Two bats were hibernating side-by-side at the same time in a cave with 100's thousands of bats. He believes they ended up there by mistake—together.

Fall migration: There is little telemetry data for fall migrating Indiana bats, however there is data from roost tree exit counts and fall swarming surveys that may provide some insights into fall migration behavior. Data from the eastern U.S. show that adult males, adult females, and young migrate separately, with adult males arriving at the hibernaculum first, followed by adult females and lastly juveniles (Brack et al., 2005; Brack 1983, Kurta and Rice 2002). Further, we know that females and juveniles do not usually congregate with males during the summer and that males are frequently solitary during the summer (USFWS 2007). This may indicate that at least some males migrate independently. It is further known that females depart from maternity colonies at different times (though because the maternity colony disbands does not necessarily mean that bats have begun to migrate (Kurta, pers. comm. 2011)) and that females from the same maternity colony do not all hibernate in the same hibernacula, (though some do) (Kurta and Murray 2002, Winhold and Kurta 2006). This information suggests at least some females may migrate independently. However, data from the Indianapolis airport indicates that maternity colony dispersal occurs fairly quickly, indicating it is possible that individuals may be departing together (Pruitt, pers. comm. 2011). Similar to spring migration, during fall Indiana bats are likely cued into the same stimuli with similar migratory phenology so there may be migratory pulses moving through an area rather than a syncopated movement and it is reasonable to assume that individual bats may leave together (Pruitt, pers. comm. 2011; Reynolds, pers. comm. 2010).

22. Do migratory Indiana bats fly at certain times of night while migrating?

Response: Only a few studies in a discrete portion of the range (New York, Pennsylvania, and Maryland) have been conducted during the spring migration period. During these studies, Indiana bats typically flew at sunset for 2 to 3 hours, with a maximum of 5.5 hours (Butchkoski and Turner 2005). Most of these bats, however, migrated a total of only 30–50 km between winter and summer habitat; distances that could be completely covered in only a few hours. Consequently, the durations of their nightly flights may underestimate the typical flying time of the species elsewhere in its range. For example, Turner (2006) tracked one female Indiana bat in Maryland emerging from a hibernacula for 4 hours over a distance of 91 km (57 mi) the first night, and then 56 km (35 mi) the next day, arriving at the maternity colony. Recent information from Stantec (2010) shows that myotid activity is the greatest in the early hours of the evening, while Reynolds (pers. comm. 2010) indicated that activity diminishes markedly after 5:00 a.m. Given the above observations, it is reasonable to assume Indiana bat activity throughout the night with the greatest peak of activity early in the evening.

23. At what height do Indiana bats fly when migrating?

Response: Data regarding the height Indiana bats fly during migration are severely lacking, but there are two emerging viewpoints: they fly at/below tree canopy height or they fly considerably higher than tree canopy height. Most of the migration data to date have been collected in the northeast portion of the bat's range. It is uncertain if these flight heights would be similar in central and western portions of the range, particularly in areas with little tree cover. Further, it is unknown whether flight heights during spring and fall migration are similar.

The documented mortality of two Indiana bats at the Fowler Ridge wind facility in Benton County, Indiana (WEST 2011), and the documented mortality of many other myotids at other wind facilities primarily during late summer and fall (USFWS unpublished data) indicate that at least a portion of myotid bats are flying at rotor-swept height (well above the tree canopy) during migration. However, of all bat mortalities detected at wind power facilities, myotids and tri-color bats comprise only about 10% of total bat fatalities within the range of the Indiana bat (USFWS unpublished data) , indicating that these species are probably not occurring within the rotor-swept zone of turbines as frequently as the long-distance migrating tree bats.

Conversely, anecdotal and empirical data suggest that Indiana bats migrate at the tree canopy level. Robbins (Missouri State Univ., pers comm. 2010) argues that detection of Indiana bats above 10 m is rare at any season. Butchkoski (pers comm. 2010) and Turner (2006) reported canopy level or lower flight behaviors using radio telemetry. Using stationary Anabat acoustic detectors across several sites and several states Meinke et al. (2010) found that Myotis activity at 50 meters was about 3% of activity at ground level. Similarly, at a study in Indiana, of the 1284 high frequency calls (July 15-Oct 18), 95% were at the ground level (0.5 m), and 5% were at 80 m. Myotis comprised 15% of these HF calls (the remaining being red and tri-colored bats) (WEST 2011). Chenger and Turner (pers. comm. 2011) both indicate that Indiana bats migrating in the northeast closely follow topographic features including meandering stream corridors and utility right-of-ways for miles, and over multiple different years. Similar findings exist in Tennessee (Gumbert et al. 2011). This close following of land features indicates that Indiana bats may be flying near canopy height (Gumbert et al. 2011). Further, Chenger (pers. comm. 2011) and Herzog (NY Dept. fo Env. Conserv., pers. comm. 2011) believe that if radio-tracked Indiana bats in the northeast were flying higher, ground-based radio telemetry would detect them at further ranges, but instead bats tracked from the ground quickly fly out of range probably because they fly so low that obstacles (trees, terrain, etc.) between the transmitter and receiver attenuate the signal greatly.

The reliability of the acoustic data to assess height of migration, however, is in question because: acoustic detectors have a limited field of detection (Larson and Hayes 2000); calls of high frequency bats including myotids attenuate over less distance than calls of medium or low frequency bats (Lawrence and Simmons 1982); acoustic detectors mounted on meterological towers are not typically placed much higher than 50 m in the air column, so bats flying much above 50 m are not detected; and bats are not equally detectable in all habitat types (Patriquin et al. 2003). Furthermore, Sparks (pers. comm. 2011) by evaluating the quality of telemetry signals, believed bats were flying 200-300 feet above ground.

24. Does weather influence the behavior of migratory bats?
Response: Positive correlations of bat activity and temperatures are common in bat literature, both over an annual time period (O'Farrell and Bradley 1970, Avery 1985, Rydell 1991) and on a nightly basis (Lacki 1984, Hayes 1997, Vaughan et al. 1997, Gaisler et al. 1998, Shiel and Fairley 1998). The experts also pointed to similar responses among all bat species (nothing specific to Indiana bats) that activity declines in heavy rain, high wind, heavy fog, and cold (some specifically mentioned temperatures below 50-55 F); essentially any condition that impairs flight or ability to thermoregulate or reduces insect activity is expected to reduce bat activity. For these reasons, our mist-netting guidelines stipulate the acceptable environmental conditions in which sampling may be conducted. The data obtained from monitoring at wind farms also suggests correlations between weather events (namely, temperature, wind speeds, and storm fronts) and bat activity. Although general patterns have been established, the specific environmental thresholds are not yet known.

We anticipate that subsequent data gathered from wind facilities will provide specific insights on the behavior of myotids relative to environmental conditions. Further, it may prove helpful to analyze existing data submitted through section 10(a)(1)(A) permit reports to garner whether there are distinct environmental conditions in which Indiana bats curtail activity.

25. Are Indiana bat migratory pathways associated with or do they orient to landscape features?
Response: The migratory behavior of Indiana bats appears to differ among the RUs. Generally speaking, the routes in the Northeast and Appalachian RUs are multi-directional and short (100 miles or less), while the migrations in the Midwest RU and Ozark-Central RUs are mostly south to north and can be short or long (ranging between 8-575 km (5-357 mi) (Winhold and Kurta 2006, Gardner and Cook 2002, Pruitt pers. comm. 2008).

Observations regarding whether Indiana bats orient to landscape features are mixed. It is unknown whether spring and fall migratory pathways are similar. Tuttle (1976) discussed migration in gray bat (*M. grisescens*) and noted plasticity relative to following landscape features in this species -- while they may orient along river systems, they will deviate from such features "when there is an advantage to doing otherwise." Barbour et al. (1966) demonstrated that Indiana bats likely use vision to migrate long distances, which may indicate that they are orienting to landscape features to some degree.

Northeast & Appalachian RUs: Spring migration studies in NY and PA (Butchkoski and Turner 2006, Hicks and Herzog 2006, Turner 2006) indicate a generally straight line migration, with some variation around large cities and following tree lines to avoid open areas. They also observed multiple Indiana bats deviating from straight line flights to go several miles south to avoid crossing a 2-mile wide extent of open water over Lake Champlain, and instead crossing at a narrow area, possibly where a bridge was present (Hicks, pers. comm. 2011). Based on a combination of aerial and ground tracking, Indiana bats tracked from a hibernaculum in Pennsylvania took several nights and flew almost straight lines to their roost trees 135 to 148 km (83 to 92 mi) away in Maryland (Butchkoski and Turner 2006). However, there is some evidence that bats follow landscape features while migrating. Based on observations of 22 bats tracked during spring telemetry studies in Pennsylvania from 2000 to 2006, bats appeared to go out of their way to follow tree lines, including riparian buffers along streams through otherwise developed areas, and avoided open areas (Turner 2006). Similarly, 12 bats tracked in western Virginia during spring migration generally followed ridges in the area, which run northeast-southwest, with only one bat flying east (i.e., into the Shenandoah Valley) and none flying west (i.e., over the higher mountain ridges into West Virginia) (McShea and Lessig 2005). The authors think that these movement patterns suggest that bats were using these corridors as migration flyways. Whether Indiana bats are using pathways remains unknown, but data compiled in the Northeast and northern Appalachian RUs suggest that Indiana bats tend to follow forested areas and avoid open areas if possible.

Unlike populations in the northern portion of Appalachian RU, the direction of migration and distances traveled between hibernacula and summer roosting grounds has not been well documented in populations of the southern portion of Appalachian RU. McShea and Lessig (2005) while tracking 12 bats in Virginia observed "rather indirect paths to their summer ranges" but also noted some bats covered relatively large distances quickly (e.g., one bat moved 80 km south in four days and another moved 40 km north in two days).

Midwest RU: Although there is anecdotal evidence to support the landscape feature concept going back to John Hall's (Hall 1962) original work based on banding (Kurta pers. comm. 2011), there is very limited recent data from the northern portion of this RU pertaining to migratory behavior. As noted above, Indiana bats within the Midwest RU appear to primarily migrate north from hibernacula in Indiana and Kentucky to summer ranges in the north (Whitaker and Brack 2002, Gardner and Cook 2002, and Winhold and Kurta 2006). Recent Indiana bat fall mortalities at a wind turbine facility in northern Indiana occurred over an agricultural field, indicating that Indiana bats will migrate through non-forested areas (WEST 2011). Judy et al. (2010) found a single adult female Indiana bat in Indiana flying in a straight line away from the capture and roost point and well beyond the home range of the maternity colony through open areas in May. Whether there are migratory pathways is unknown.

Gumbert et al. 2011 looked at Indiana bat spring migration corridors from several hibernacula in Tennessee (in the southern portion of the Midwest RU) and found that bat flight azimuths depended on the original trajectory the bat exited the staging area around the caves. Bats did not appear to be following one another along concentrated flyways; however, bats did follow some landscape features. Over half (n = 55.1%) of the linear distance traveled by focal bats while actively migrating was flown along features such as creeks.

Ozark-Central RU: Very little empirical data are available for this RU. Robbins (pers. comm. 2010) data suggest that activity is highly correlated with landscape features in all seasons.

Swarming Biology

26. Does the density of "migrating" bats increase as they get closer to swarming areas (i.e., is there a funnel effect as Indiana bats approach a hibernaculum)?

Response: Yes, most certainly. Although precisely on-point data are lacking, intuitively this pattern must be true. For humans, this phenomenon is analogous to encountering an increase in vehicular traffic congestion as one nears a popular tourist destination or metropolis. Because large numbers of bats typically come from different areas/directions and converge upon a specific geographic location to mate and hibernate together, it follows that they become more densely concentrated as you move closer to hibernacula areas during the swarming period. Brack (2006) has suggested that insectivorous bats likely experience increased competition for prey while foraging near densely populated hibernacula, which may explain why some bats have been observed making relatively long-distance movements away from hibernacula during the fall swarming period. The frequency at which these potential density-dependent, long-distance movements occur in nature is unknown, but they could reduce the overall density of swarming bats at some hibernacula. Because Indiana bats arrive, swarm and enter into hibernation asynchronously (e.g., males typically arrive at hibernacula first and females typically enter hibernation before males) (USFWS 2007), local bat density levels vary over the course of the swarming period and at no time during this period is the entire winter population of a given hibernaculum likely to be present and actively swarming in mass. Hibernacula typically have one or two brief periods in the late summer/fall when swarming activity and bat density levels rise and peak and then decline until all bats have entered hibernation (Cope and Humphrey 1977, La Val et al. 1977).

Wind Specific Impacts Topics

27. Most wind-bat data collected thus far pertains to migratory tree bats. Is it valid to use data garnered from tree bats to infer how likely and to what extent Indiana bats will be exposed to wind turbines?

Response: As post-construction mortality studies at wind energy facilities detected both myotids and tree bats (lasiurines) during the late summer and early fall, we know that the guilds migrate through the same areas and are both at risk from wind turbines. However, the causes of exposure between the two groups are likely very different, and experts generally believe that myotid and tree bat migratory patterns are different, occurring at different heights, and with peak migration activity at different times. Myotids and lasiurines greatly differ in roosting habits (Barbour and Davis 1969), wing morphology (Norberg and Rayner 1987), migratory behavior (Cryan 2008), and flight and mating behavior (e.g., lasiurines may form leks at tall landmarks during fall migration) (Cryan 2008), which generally precludes them from being used as valid surrogates for one another in respect to vulnerability to wind turbines. These differences are reflected in how resident and migratory myotids and lasiurines utilize the aerosphere and presumably explain why Indiana bats and other myotids appear to be less likely than lasiurines to suffer wind turbine fatalities (Kalko et al. 2008, see excerpt below).

> Excerpt from Kalko et al. (2008): "Adaptations in morphology (wingshape, body size), physiology, and sensory systems (vision, olfaction, passive listening, echolocation), as well as behavioral characteristics (i.e., foraging strategies), permit differential use of the aerosphere in time and space (Arita and Fenton 1997; Schnitzler and Kalko 2001; Schnitzler et al. 2003). Access to the aerosphere is constrained along vertical and horizontal axes by the ability of bats to cope with obstacles, i.e., vegetation clutter (Schnitzler and Kalko 2001; Schnitzler et al. 2003), and by their capability to navigate large, open spaces with few or no landmarks."

28. Is it valid to use data garnered from other Myotis species to infer mortality rates of Indiana bats at wind facilities?

Response: Generally, expert opinion is mixed as whether it is valid to use other *Myotis* species as a surrogate to infer exposure/effect to Ibats from wind energy projects. Although more similar to one another than the relationship between lasiurines and myotids, there are a number of differences in foraging behavior, habitat use, population numbers, echolocation, flying abilities, home ranges, and migration habits among *Myotis* species that make such assumptions problematic. Trying to estimate effects to Indiana bats by using a ratio based on presence of *Myotis* species alone would be extremely speculative if little is known about the regional population sizes of the proposed surrogate. However, it is generally agreed and understood that information on myotids (*M. lucifugus*, in particular) can be insightful and is typically the only information we have. Thus, the guidance is to use myotid information as appropriate and with due consideration and evaluation.

29. Does proximity to a hibernaculum increase exposure potential of Indiana bats to wind turbines?

Response: Theoretically, we would expect a "funnel effect" as large numbers of widely dispersed bats move across the landscape from different areas and converge upon a hibernaculum or a hibernacula complex each fall. This funnel effect can lead to substantial mortality when wind turbines intersect areas where migrating bats begin converging as they approach their hibernacula. Thus, it seems reasonable to assume that the closer to a hibernaculum a facility is sited, the greater the number and density of bats that could be exposed.

Further, there is preliminary information that suggests that bats may be killed in higher numbers when wind facilities are located near hibernacula. This evidence is based on little brown bats, and lacking specific data on Indiana bats, it is reasonable to assume that Indiana bats would be similarly affected. At the Blue Sky Green Field Wind Farm (BSGF) in Fond du Lac County, Wisconsin, Gruver et al. (2009) observed higher mortalities of little brown bats (28.7% of all bat fatalities) than observed elsewhere in the eastern U.S. They concluded that the existence of a large hibernaculum (the largest bat hibernaculum in the State of Wisconsin, and one of the largest known little brown bat hibernacula in the Midwest) approximately 30 miles from BSGF may play a role in concentrating little brown bats.

30. Does proximity to summer concentrations increase exposure potential of Indiana bats to wind turbines during the fall?

Response: Higher fatalities of bats in late summer and fall may be observed at wind facilities located near summer concentrations of bats. Little brown bats comprised 24% (18/75) of the bat fatalities at the northern Iowa windfarm studied by Jain (2005); all of the dead little brown bats were found from June through October, with most found in July and August (searches were conducted from April through mid-December). This is much higher than the proportion of little brown bat fatalities typically recorded. Jain (2005) reported that acoustic surveys during both spring and summer at the Iowa site revealed that little brown bats were the most commonly recorded species and it was concluded that the local abundance of this species (in summer) may have contributed to the high mortality at this site. Although little brown bats were summer residents on the study area, most mortality was not experienced until July and August. The onset of mortality may have been associated with movements associated with the breakup of maternity colonies and pre-migratory movements in late summer. Arnett et al. (2008) concluded that peak of fatalities during late summer and early fall may be related to increased bat activity before and during migration.

31. Are there situations in which it is valid to conclude that Indiana bat exposure to wind turbines is highly unlikely during the migration period?

Response: Studies to date suggest that that fatalities of myotids (little brown bats, in particular) during the pre-migratory or migratory period may be higher near hibernacula or summer maternity colonies, and it is reasonable to assume the same is true for Indiana bats. The evidence supporting this supposition is as follows.

Near hibernacula: At the Blue Sky Green Field Wind Farm (BSGF) in Fond du Lac County, Wisconsin, Gruver et al. (2009) observed higher mortalities of little brown bats (28.7% of all bat fatalities) than observed elsewhere in the eastern U.S. They concluded that the existence of a large hibernaculum (a mine that is the largest bat hibernaculum in the State of

Wisconsin, and one of the largest known little brown bat hibernacula in the Midwest) approximately 30 miles from BSGF may play a role in concentrating little brown bats. Fatality data from recently constructed wind farms, that are even closer to the mine (closest turbines are two miles east of the mine) may further elucidate this issue (David Redell, WI Department of Natural Resources, pers. comm. 2010).

Near summer concentrations: Higher fatalities of bats in late summer and fall may also be observed at wind facilities located near summer concentrations of bats. Little brown bats comprised 24% (18/75) of the bat fatalities at the northern Iowa wind farm studied by Jain (2005); all of the dead little brown bats were found from June through October, with most found in July and August (searches were conducted from April through mid-December). This is much higher than the proportion of little brown bat fatalities typically recorded. Kunz et al.(2007) summarized the species composition of annual bat fatalities reported for wind energy facilities in the United States and reported that across the country little brown bats made up 5.8% of the fatalities recorded, and in the upper Midwest 3.3%. Jain (2005) reported that acoustic surveys during both spring and summer at the Iowa site revealed that little brown bats were the most commonly recorded species and it was concluded that the local abundance of this species (in summer) may have contributed to the high mortality at this site. Although little brown bats were summer residents on the study area, most mortality was not experienced until July and August. The onset of mortality may have been associated with movements associated with the breakup of maternity colonies and pre-migratory movements in late summer. Arnett et al. (2008) synthesized available information on bat fatalities from 21 studies conducted at 19 wind energy facilities in 5 regions of the United States and one province in Canada, based on these studies they concluded that peak of fatalities during late summer and early fall may be related to increased bat activity before and during migration.

While the above studies lead us to conclude that fatalities of Indiana bats during the pre-migratory or migratory period may be higher near hibernacula or summer maternity colonies, the question remains on whether or not we can predict the exposure of Indiana bats to wind turbines that are not located near either winter or summer concentrations. Limited data suggests that this may be possible for migratory tree bats. Baerwald and Barclay (2009) examined variation in activity levels and fatality rates of hoary bats (*Lasiurus cinereus*) and silver-haired bats (*Lasionycteris noctivagans*) at wind energy installations across southern Alberta, Canada. Based on their study of these species, they concluded: "During fall migration, activity of migratory bats varied among sites in southern Alberta, suggesting that, rather than being dispersed randomly or evenly over a wide east-west area, bats concentrated along select routes." This result suggests that it may be possible to minimize fatalities of these species by siting wind energy facilities to avoid migratory routes of these species.

However, unlike the migratory tree bats (see Baerwald and Barclay 2009), evidence suggesting that myotids (or Indiana bats, specifically) follow specific migratory pathways is lacking. As described below, both of the species studied by Baerwald and Barclay (2009) are long-distance migrants (compared to myotids), and have very different life history strategies. Experts cautioned against using data from migratory tree bats to evaluate exposure of myotids to fatalities at wind facilities.

Although we have information linking regional summer and winter populations of Indiana bats, the pathways use by Indiana bats migrating between these summer and winter populations are not well known. Further confounding the issue, it is uncertain whether Indiana bats across its range use landscape features (e.g., rivers, tree-lines). Given this, we cannot reasonably predict where, within the range of the species, Indiana bats will be migrating. Therefore presently, we must assume that migratory Indiana bats are vulnerable to potential strikes with wind turbines anywhere throughout the range of the species. The exceptions to this are: 1) where we have sufficient evidence that Indiana bats do not occupy a specific project area anytime of the year, or 2) where specific aspects of the project (i.e., located outside suitable habitat and involve only a small number of turbines) make the likelihood of take extremely unlikely. Further guidance relation to these exceptions will be forthcoming.

32. **At what distance from an Indiana bat hibernaculum should a wind farm be sited in order for us to conclude that take of swarming bats is extremely unlikely to occur?**
Response: The task before the group was to identify a threshold distance (i.e., a buffer zone) from hibernacula beyond which exposure of **swarming** Indiana bats to wind turbines is extremely unlikely. Swarming in this context refers to bats that are engaged in foraging, roosting, and mating activity near hibernacula in the fall. Available data indicate bats predominately swarm at hibernacula they overwinter in, but individuals will also visit and swarm at other hibernacula, as well as, at non-hibernacula sites such as caves, mines, rock crevices/shelters and cliff faces (LaVal et al. 1976, Cope and Humphrey 1977). Thus, swarming activity also refers to bats moving between and among nearby hibernacula and/or swarming sites. These buffer zones are, therefore, intended to delineate areas where bats are foraging, roosting, and mating near their hibernacula and to capture local movements among nearby hibernacula and swarming sites. So, the intent of this question is to identify situations for which we are able to conclude that exposure potential of **swarming** Indiana bats to wind turbines is extremely unlikely. Note, that this does not imply that wind projects that fall within this boundary will adversely affect swarming bats. Rather, it means that the project requires further site-specific review. It must be noted that these buffer zones are guidelines and should be modified if site-specific data indicate greater or smaller distances are warranted.

Additionally, we fully acknowledge that **migrating** bats may be exposed to wind turbines at distances beyond the typical foraging range of swarming bats, and that this exposure can be substantial near large hibernacula. Hibernacula with larger bat populations are more likely to exhibit a significant "funnel effect" as large numbers of widely dispersed bats move across the landscape from different areas and converge upon a single large hibernaculum or a hibernacula complex each fall. Thus, as you approach a large hibernaculum, the greater the bat numbers and densities. This funnel effect can lead to substantial mortality when wind turbines intersect areas where migrating bats begin converging as they approach their hibernacula. This exposure risk is not captured in the swarming analysis, but rather is evaluated in the previous question, which addresses exposure risk during migration.

In recent years, we have typically applied a 5-mile buffer around Priority 3 (P3) and Priority (P4) hibernacula, and a 10-mile buffer around Priority 1 (P1) and Priority 2 (P2) hibernacula. However, based on a recent review of fall radio-telemetry studies, we believe increasing these buffer zones is appropriate and warranted. Table 1 summarizes the maximum distance that marked bats have been observed from hibernacula.

Table 1: Summary of swarming distance data obtained from fall radio-telemetry studies of Indiana bats.

Hib. Priority Ranking	**Max. Distance (mi) from the Hibernaculum**	**Hibernaculum Location & Source**
1A	19	Indiana (Hawkins et al. 2005)(2 adult females)
1B	4.4	Missouri (Rommé et al. 2002)
2	8	New York (Pfeffer et al. 2008)
3	1.8	Kentucky (Kiser & Elliot 1996)
3	2.6	Kentucky (Gumbert 2001)
3	9.1	Pennsylvania (Butchkoski and Turner 2007)
3	11.1	Pennsylvania (Chenger and Sanders 2007)
3	2.0	Virginia (Brack 2006, Fig. 1)
4	6.9	Arkansas (Risch and Brandebura 2007)
4	2.1	Michigan (Kurta 2000)

We used the maximum distance traveled to establish buffer zones for the following reasons. Radio-telemetry studies provide us with a range of distances that a small number of bats traveled during short, variable tracking period; therefore, it is reasonable to assume that bats forage and roost beyond the reported maximum distances. Some bat researchers have explicitly noted that their maximum reported distances/activity areas would have been greater/larger had their tracking efforts not been constrained by rugged terrain, short detection ranges of the small radio-transmitters and other logistical problems (Rommé et al. 2002, Brack et al. 2006). Furthermore, the observed swarming season movements were derived from very small sample sizes over a relatively short period of time, thus it is reasonable to assume that larger sample sizes studied over a longer time period also would have increased the maximum reported travel distances. Lastly, based on a recent analysis of the Indiana bat winter population data over time, we determined that positive changes in population size (N) at some hibernacula could not be solely explained by high survival and recruitment. Thus, immigration and emigration of bats from other hibernacula likely played a role in some of the observed population changes. When population data from multiple hibernacula that were located within 10 miles of one another were combined (i.e., hibernacula complexes were examined together), a majority of unaccounted for change/variability in N was explained (Wayne Thogmartin, USGS, pers. comm. 2011). Thus, to capture bat movements among nearby hibernacula our swarming buffer zones must be at least 10 miles.

Very few fall telemetry studies have been conducted, but those available indicate that Indiana bats may move up to 19 miles from their hibernacula during the fall swarming season (Hawkins et al. 2005). A review of the literature pertaining to Indiana bats captured at P3 and P4 hibernacula found that these bats foraged and/or roosted a maximum distance of 1.8 to 11.1 miles from their hibernacula during the fall. Based on these data, it is reasonable to assume that swarming Indiana bats may be exposed to wind turbines that are sited within 10 miles of most P3 or P4 hibernacula. We believe it is highly unlikely that swarming bats will forage and roost beyond this 10-mile zone. Thus, it is appropriate to conclude that the risk of exposure of swarming bats to wind turbines is discountable beyond the 10-mile zone. Again, site-specific information should be considered if available and the buffer zone readjusted as warranted by the data.

Data from P1 and P2 hibernacula are limited to three studies. During the study conducted at Wyandotte Cave (P1), Indiana bats generally foraged/moved farther than observed elsewhere, with one light-tagged bat observed 19 miles from the hibernaculum on the same night it was released at the cave entrance (Hawkins et al. 2005). The authors noted that several radio-tagged bats were not relocated near or in the hibernacula where they were captured after their release suggesting that bats moved too far from the hibernaculum to be located using ground-tracking techniques. This could suggest that 1) the bats were roosting and foraging farther than 19 miles, or 2) the bats that were radio-tagged and/or light-tagged at Wyandotte Cave moved among hibernacula (and possibly over-winter at a hibernaculum elsewhere). Similarly, in Virginia, although not a P1 or P2 (there were 16,000 bats of various species in the cluster of caves), 70% of tagged bats left the project area one or more times for one or more days (some bats were tracked as they left the study area) (Brack 2006). They were not found during nocturnal activity studies or in diurnal roosts. These long-distance movements are in stark contrast to the clustering of day roosts in close proximity to hibernacula ($\bar{X}$ = 0.8 km).

Based on these data, it is reasonable to assume that swarming Indiana bats may be exposed to wind turbines that are sited within 20 miles of a P1 or P2 hibernaculum. Although drawing conclusions from three studies is not ideal, it seems reasonable that bats occupying large hibernacula may need to forage out greater distances. The carrying capacity of an area is a fundamental principle affecting all biological communities and may influence the swarming behavior of bats at some hibernacula. The fall swarm is a critical period in Indiana bat's annual life cycle when they must build up their fat reserves to sustain them through the winter (Cope and Humphrey 1977). Thus, it is expected that individual bats may move farther from the cave to minimize competition for food and roost sites. Bats may visit a cave to meet, mate, and ultimately hibernate, but roost and forage in more distant areas. Brack (2006) suggests, for example, that competition for foraging resources may force bats to leave the immediate vicinity of the hibernacula. Hawkins et al. (2005) stated that the long distances traveled by bats at Wyandotte Cave (IN) suggest that use of habitat near hibernacula during swarming may differ between caves that support large vs. small populations of bats. Nearly a million bats of multiple species have been estimated to migrate through, swarm and/or hibernate in the general vicinity of Wyandotte Cave (Hawkins et al. 2005). It is expected that the foraging area needed to support this number of bats is greater than areas needed at smaller caves. For these reasons, we believe it is valid to establish a larger buffer zone for P1 and P2 hibernacula.

Hibernacula priority rankings (P rankings) may not always be a good indicator of how far Indiana bats will forage and roost from their hibernacula. Their choice of habitat may be based as much on habitat quality, site fidelity, and commuting distance (between the hibernaculum and foraging/roosting habitat) as on the size of the hibernating population. There are instances, for example, where forest habitat is abundant and hibernating populations are relatively small, yet Indiana bats associated with those hibernacula forage and roost several miles from the hibernacula. Such is the case for the two P3 hibernacula studied in Pennsylvania (Butchkoski and Turner 2007; Chenger and Sanders 2007). Also, the P rankings may not reflect actual bat population numbers because they are based on current or historic population sizes. Some P1 hibernacula currently have very few (or no) Indiana bats, and WNS may very shortly reduce P1 and P2 hibernacula to population numbers typically associated with P3 and P4 hibernacula. Again, these buffer zones are guidelines and should be modified if site-specific data indicate greater distances are warranted.

In summary, we believe a 10 mile buffer around P3-P4 hibernacula and a 20 mile for P1-P2 hibernacula are appropriate for delineating the space beyond which exposure to wind turbines by **swarming** bats is unlikely. These distances may be modified based on site-specific information. Wind facilities sited within these buffer zones require further evaluation to ascertain whether exposure of swarming bats is likely.

33. How far away from suitable habitat should we recommend siting a wind facility to avoid potential exposure of Indiana bats during the summer?

Response: Suitable habitat includes roosting, foraging, and commuting areas. Suitable summer roosting habitat is characterized by trees (dead, dying, or alive) or snags with exfoliating or defoliating bark, or containing cracks or crevices that can be used as a roost. Foraging habitat is forested patches, wooded riparian corridors, and natural vegetation adjacent to these habitats. Commuting habitat includes wooded tracts, tree-lines, wooded hedgerows or other such pathways that are connected to roosting or foraging areas.

Information to date indicates that Indiana bats predominately forage, roost, and travel within wooded habitats or along their edges (Cope et al. 1974, Humphrey et. al., 1977, LaVal et al., 1977, LaVal and LaVal 1980, Gardner et. al., 1991a and b, Hobson and Holland 1995, Kiser and Elliot 1996, Butchkosi and Hassigner 2002, Rommé et al. 2002, Murray and Kurta 2004, Menzel et al. 2005, Sparks et al., 2005). Although other habitat types are used, use of these habitat types appears to be infrequent relative to their availability (Garner and Gardner 1992, Menzel et al., 2005, Sparks et al. 2005). The observations of Murray and Kurta (2004) indicate that Indiana bats will avoid traveling in open areas; of the 34 transmitter nights (= a single bat monitored through one night), no bats were detected crossing open areas but rather predictably, over 5 years, used a single tree-lined corridor to move from their roosting to foraging areas. Avoiding these open areas increased the distance bats needed fly by up to 55 percent (=0.2 to 3.4 km extra distance flown) more than if they had taken a straight-line flight from their day roosts to their foraging areas. Similarly, investigators in Missouri (Ecology and Environment, Inc. 2009) found that the areas of activity for five radio-tagged bats were in heavily forested areas and along riparian corridors and forest edges. No bats were recorded in the open areas that are interspersed throughout the research area.

Conversely, research has shown that Indiana bats will cross open areas to travel between roosting and foraging habitat (Brack and Sparks, pers. comm. 2011). Brack and Whitaker 2006 documented a maternity roost in an isolated 0.7 ha woodlot where the closest woody habitat was a brushy fencerow of small trees 160 m (525 ft) away. Similarly, three years of radiotelemetry study on a maternity colony of Indiana bats in an agricultural landscape of Ohio documented Indiana bats often crossing open areas greater than 1 km in length (Kniowski 2011).

Given this information, it is reasonable to assume that Indiana bats may use edge habitat and seemingly isolated tracts in close proximity to occupied habitat, but will rarely fly over large open areas. The distance from the forest edge (i.e., the area of non-wooded habitat) that Indiana bats are likely to travel through is unknown. We are aware of few studies that provide specific data on "capture distances from the forest edge." Data garnered thus far by Stantec et al. (2010) show that of the 1124 foraging telemetry points from 21 radio-tagged Indiana bats, the vast majority (75 percent) of points were within 400 feet of forest edge and 97 percent were within 1000 ft of forest edge. Drawing from all existing data, it reasonable to conclude that Indiana bats are unlikely to occur within projects areas located more than 1000 feet from wooded areas.

Indiana bats use commuting habitats to travel between roosting and foraging areas. As such, the use of commuting habitat is only likely if roosting and foraging habitat are positioned near or adjacent to the potential travel corridor. Thus, if suitable commuting habitat is not connected to and not within 2.5 miles of foraging and roosting habitat, it is unlikely that Indiana bats will use it.

In summary, if both of the following conditions are true, Indiana bat presence is unlikely within and near the project area during the summer period, and it is unlikely that Indiana bats will be exposed to wind facility operations during the summer.

1. No suitable foraging or roosting habitat is in the project area or within **1,000 feet** of the project area boundary
2. Commuting habitat, if occurs in or within **1,000 feet** of the project area boundary, is, more than 1000 feet, or if connected more than 2.5 miles, from suitable roosting or foraging habitat.

If both of these conditions are <u>not</u> met, further analysis is required to determine whether Indiana bat exposure is likely. In making this assessment, it is important to properly define the project area boundary. At a minimum, a polygon should be drawn around <u>all</u> of the temporary and permanent wind facility structures (e.g., turbines, roads, staging areas), and expanded out if environmental impacts (e.g., water quality effects) are anticipated beyond this footprint.

Figure 1: Condition 1 and 2 met: commuting habitat within 1000 feet but isolated from roosting and foraging habitat. Appropriate conclusion: Indiana bats not present. (not-to-scale)

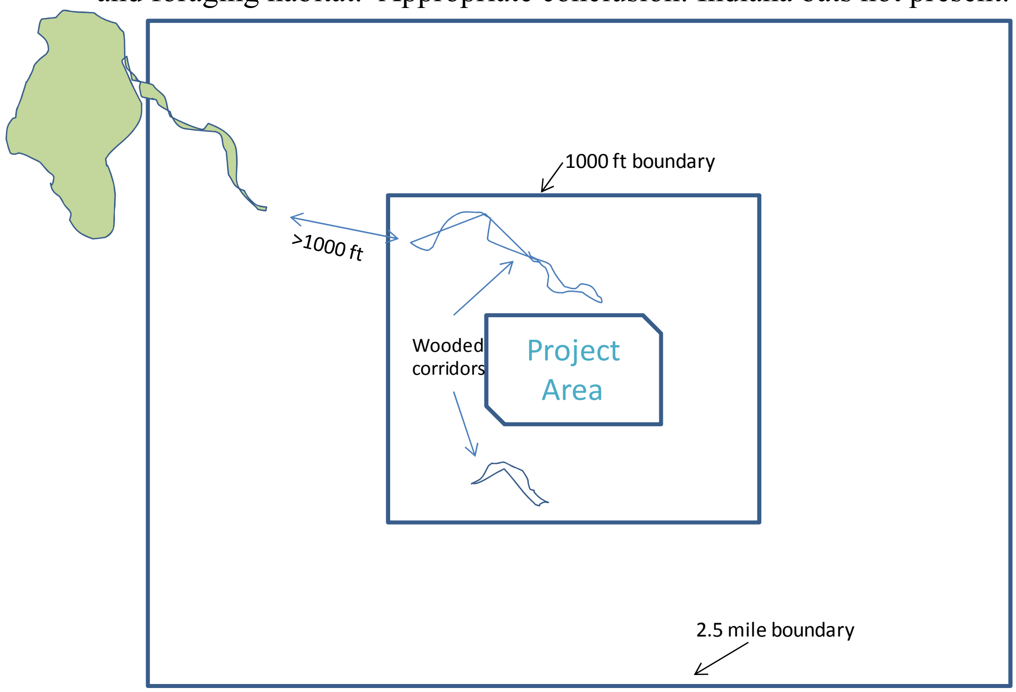
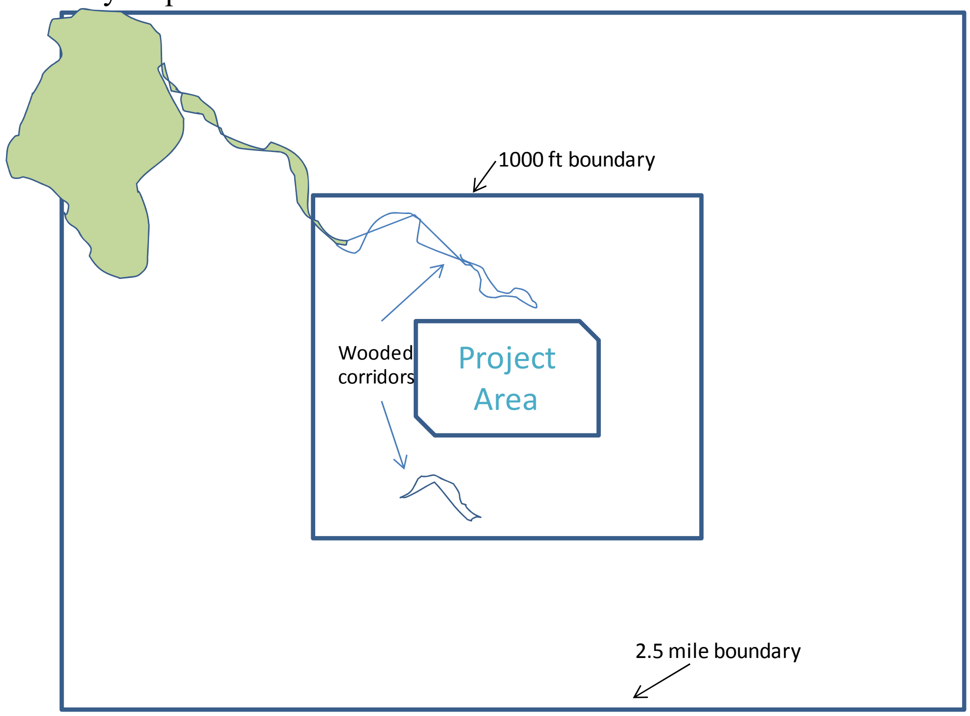


Figure 2: Condition 1 met but Condition 2 not met: commuting habitat within 1000ft and connected to roosting or foraging habitat within 2.5 miles. Appropriate conclusion: Indiana

bats may be present.



34. Should we recommend removing suitable maternity habitat to reduce potential exposure to Indiana bats near wind turbines when no further siting modifications are possible?

Response: During project planning and development (preconstruction), removal of occupied or unoccupied suitable (when adjacent to occupied habitat) summer habitat is not, for reasons discussed below, currently a valid minimization measure. Similarly, removal of unoccupied habitat at already constructed wind facilities is not a valid minimization measure. In cases where occupied maternity habitat is discovered/delineated after a project has been constructed, removal of that habitat may be a valid minimization measure if all the following conditions are met:

A. documented mortality level is unacceptable (e.g., exceeds any authorized amount);
B. all feasible operational measures have been implemented to reduce mortality;
C. loss of such habitat will not result in long-term negative fitness consequences for the colony; and
D. there is a high degree of confidence that Indiana bat exposure potential will be reduced as a result of habitat removal.

Indiana bats exhibit strong site fidelity to both roosting and foraging areas, and as such, removing occupied summer habitat may cause harm rather than minimizing adverse effects. Loss of such habitat, for example, could lead to increases in the energy demands of pregnant females as they search for new roosts, travel corridors, and/or foraging areas. As we are uncertain of risk posed to Indiana bats from wind turbine operation, it would be illogical to recommend destroying or otherwise rendering occupied habitat unsuitable at this time. If future site-specific data indicate that unacceptable mortality is still anticipated despite operational modifications (e.g., feathering or curtailment), discussions of habitat modifications may occur. Similarly, destroying or rendering currently suitable but unoccupied habitat unsuitable is not advisable. Removing suitable habitat in the vicinity of occupied habitat will preclude use of this area by the colony in the future. Given that we do not know at this time whether the effects of removing the habitat would be less than the effects from the proposed turbines, recommending preemptive removal of habitat is unsupportable.

The exception to this is when mortality levels at operating facilities are unacceptably high after all feasible and prudent operational measures to minimize effects have been implemented. Removal of habitat may be warranted under this scenario if the loss of habitat will not result in the long-term negative fitness of colony and we are confident such removal will reduce Indiana bat exposure to the impacts from turbines. Note, that any removal of habitat will need to be included as part of the project description and fully evaluated to determine whether adverse effects or take is anticipated. If so, authorization is needed through section 7 or section 10 of the ESA.

35. Is there a correlation between mortality rates and storm events or temperature?
Response: The answer seems intuitive given that it is generally accepted that bat activity is influenced by environmental conditions. As indicated previously, positive correlations of bat activity and temperatures are common in bat literature. Yet, the data pertaining to bat fatalities at wind facilities are inconclusive, and hence, the experts are divided on the issue. Several experts indicated bat activity is likely to decrease during storms and colder temperatures, and thus, a corresponding reduction in exposure to wind turbines is expected. Kerns et al. (2005) data from studies at two sites appear to both comport and contradict this statement. As expected, they found a negative relationship between bat fatalities and percentage of the night that rain occurred (an index to presence of storm fronts) at two sites but did not detect a relationship between temperature and mortality at one of the two sites. Fiedler and colleagues (2007), unlike Kerns et al., did not observe a correlation between storm events and mortality but found a positive relationship with average nightly temperature at a site in Tennessee. To confound the issue further, while there is a great deal of information on influences of weather on bat activity during the summer period, very little is known about the effects of weather on the behavior (e.g., flight patterns) of migrating bats (Cryan and Brown 2007). As data is garnered and analyzed, the effect of weather events on exposure potential of bats to wind turbines will be better understood.

36. Does wind speed influence exposure potential to wind turbines?
Response: Data from several studies show a negative correlation between wind speed and bat fatalities (e.g., Fiedler 2004, Kerns et al. 2005, Baerwald et al. 2008, Arnett et al. 2009 and 2010). Kerns et al. (2005) cautioned that wind speeds are typically variable throughout any given night, and therefore it is difficult to characterize "threshold wind speed" associated with bat fatalities. However, they found an inverse relationship between wind speed and bat fatalities. Specifically, wind speed <4 m/sec was positively related to bat fatalities, whereas the reverse was true for the proportion of the night when winds were >6 m/sec.

37. Does wind direction influence exposure potential to wind turbines?

Response: Most experts indicated that either they did not believe that mortality is related to wind direction, or that they were not aware of any data to suggest such a relationship. The lone exception is from a study at Buffalo Mountain wind facility in Tennessee. A positive association with wind direction was noted during a study conducted from 2000 to 2003; the greater the difference between wind direction and the predominant wind direction (SW), the greater the chance of a fatality event (Jenny Davenport, DeTect, Inc., pers. comm. 2010). However, this relationship was not substantiated in subsequent years at the site. Thus, until further evidence suggests otherwise, it is reasonable to assume that wind direction is not likely to affect exposure potential.

38. Does the number of turbines influence exposure potential to wind turbines?

Response: Yes, the number of turbines does affect the likelihood of exposure for birds and bats. As the number (up to some unknown dilution threshold) of turbines increase in an area, so too does the probability of a collision (Davenport, Manville, Redell, and Thresher pers. comm. 2010).

39. Does the configuration (rows vs. irregular pattern vs. following landscape features) affect the likelihood of exposure to wind turbines?

Response: With respect to the extent that configuration influences exposure, data are limited and expert opinion varied. Configuration appears to be relevant for birds and could be for bats if they follow landscape features, such as ridgelines or corridors, and wind turbines intersect such features.

40. Does turbine height or the diameter of the rotor-swept area influence likelihood of exposure?

Response: There is general agreement that turbine height is positively correlated to bat fatality. That is, taller turbines result in higher bat fatalities. Barclay et al. (2007) analyzed data from North American wind energy facilities (33 sites) to look at the effects of rotor size and tower height on bird and bat fatalities. They summarized that "… increasing tower height, regardless of rotor swept area, resulted in higher bat fatalities." The experts that we queried also agreed that for the species that dominate fatalities at wind facilities (hoary bat, eastern red bat, silver-haired bat), the available data suggest that turbine height is positively related to mortality. However, they cautioned that there are insufficient data on fatality of other species, particularly myotids, to draw any conclusions about susceptibility as a function of turbine height. Several experts suggested that it is likely that vulnerability relative to turbine height likely does vary among species.

Increasing fatality with increasing turbine height may simply reflect that the height of the turbine blades is overlapping with the height of migrating bats. Barclay et al. (2007) cited numerous radar and other studies which indicated that most nocturnally migrating bats fly more than 100 m above the ground. Alternatively, it may be that bats are disproportionately attracted to the taller turbines compared to shorter structures, at least for some species (Horn et al. 2008, Cryan and Barclay 2009).

Turbine height and rotor-swept area are related, that is, taller turbines generally have larger rotor-swept areas. Therefore, one might infer that rotor-swept area would also be correlated to bat fatality, but there is conflicting evidence and opinion on this point.
Barclay et al. (2007), based on their analysis of data from North American wind energy facilities (33 sites) to look at the effects of rotor size and tower height on bird and bat fatalities, concluded: "Diameter of the turbine rotor did not influence the rate of bird or bat fatality." However, a recent study at the Fowler Ridge Wind Energy Facility in Indiana showed a relationship between rotor diameter and bat fatalities (Good et al. 2011). At Fowler Ridge fatality rates at three types of turbines were measured; all three types had the same nacelle height (80m), but different rotor diameters. Higher bat casualty rates were observed at turbines with greater rotor diameters. Note that the greater rotor diameter would result in greater overall height of those turbines (given that nacelle height was the same for all turbines), as well as greater rotor-swept areas. Based on data from 37 wind farms in Europe, Rydell et al. (2010) also concluded that bat mortality was significantly correlated with turbine tower height and rotor diameter.

Experts that we queried were divided on the issue of the influence of rotor-swept area. Four of nine experts who responded expected that mortality would be positively associated with the size of the rotor-swept area because a larger sweep equates to a greater "area of potential interaction" with bats. Two indicated that they did not expect rotor-swept area to be a major factor in predicting mortality. One expert explained that he did not expect that rotor-swept area would be correlated with fatality, noting that bats are apparently attracted to turbine blades, and therefore the size of the rotor sweep will not matter (because bats will be attracted to the turbines and thus at a collision risk, regardless of size).

There are several explanations for why rotor-swept area may be positively related to bat fatality. As noted above: 1) generally larger rotor sweep also equates to overall taller structures; and 2) larger rotor sweep equates to a greater "area of potential interaction" with bats. Additionally, taller turbines and their wider and longer blades also produce far greater blade-tip vortices and blade wake turbulence compared to smaller turbines; the potential influence on barotrauma to bats is uncertain (and may also be contributing to higher fatalities).

Two experts cautioned that differences in fatality rates relative to turbine heights and rotor sweep will vary depending on how those rates are measured. At their study sites, per turbine mortality was greater at taller turbines, but was lower when turbines where standardized by turbine generating capacity (bats killed/MW). One of these experts noted that "…several factors such as blade length, blade speed, rotor swept area, turbine density, turbine configuration, or other factors such as surrounding habitat which may affect insect distributions, must all be carefully considered along with tower height before we can say how turbine type or height truly affects bat fatality rates since the effects of all these factors are difficult to tease apart."

In summary, existing data indicate general correlation between tower height and mortalities of migrating tree bats. We note, however, a number of factors appear to play a role and more study is needed to fully understand the relationship. Until new information suggest otherwise, we will assume that there is a correlation between tower height and mortality. At this time, we are uncertain of relationship between rotor-swept area and exposure potential, although limited data as well as expert opinion suggest that there may be a positive relationship between rotor sweep and bat fatality at some sites. Regardless, we must exercise caution in measuring the fatality rates given the potential that bat fatalities/turbine may be higher for larger turbines (taller and/or with larger rotor sweep), but not necessarily if we standardize for generating capacity (bat fatalities/MW).

41. Is it likely that insects and consequently foraging bats are attracted to heat emitted from nacelles?

Response: At this time, there are no data suggesting that bats are being attracted to the turbine nacelle as a result of insects being attracted to the nacelles.

42. Is it likely that insects and consequently foraging bats are attracted to turbine lighting?

Response: Experts responded that data indicate that this effect is unlikely. Data do not show differences in fatality rates at lit and unlit turbines. Arnett et al. (2008) synthesized available information on bat fatalities from 21 studies conducted at 19 wind energy facilities in 5 regions of the United States and one province in Canada. None of the studies reviewed demonstrated statistically significant differences in fatality between turbines equipped with FAA lights and those that were unlit. Further, Arnett et al. (2005) studied bat fatalities at one site in West Virginia and one site in Pennsylvania. In total, their study included 64 turbines. They noted that: "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." Bat fatalities were not different between turbines equipped with FAA lights and those that were unlit. Finally, Horn et al. (2008) used thermal infrared cameras to study behavioral responses of bats to operating wind turbines. They concluded that aviation lighting did not appear to affect the incidence of foraging bats around turbines.

43. Is it likely that bats are attracted to sounds created by moving turbines?

Response: Although some of the experts contacted indicated that it is possible, most agreed it is unlikely. One expert provided the opinion that "if bats were attracted to sounds I would suspect that resident bats present during summer would be killed more frequently."

Szewczak and Arnett (2006) studied ultrasound emissions from wind turbines as a potential attractant to bats. They concluded: "Although audible acoustic emission from wind turbines has been extensively characterized (i.e., frequencies below 20kHz), the ultrasound emissions remain uncharacterized for most wind turbines. We performed a basic characterization of ultrasound emission from a variety of wind turbines to determine whether ultrasound emissions may contribute to attracting bats toward wind turbines with consequential fatalities from rotor strikes… We conclude that ultrasound emissions, as measured from the ground-level, from these wind turbines do not likely play a significant role in attracting bats."

However, they cautioned that ultrasound could be emitted from turbines not tested during their investigation, or from the nacelle of turbines.

44. Does installation of acoustic deterrents influence exposure potential to wind turbines?
Response: Many experts felt that initial results are promising but that it is not currently shown to be effective. There are concerns about the units having a small range of use given high attenuation of ultrasonic waves and about bats acclimating to the disturbance. There are also concerns that such deterrents could create an acoustic barrier given the fact that in some areas these turbines will literally form a nearly continuous line across the landscape for tens of miles.

Szewczak and Arnett (2008) monitored foraging activity at 6 different ponds during August and September 2007 in Arizona, California, and Oregon for at least two nights to establish baseline activity levels, and then for 5 to 7 days of continuous treatment with ultrasound broadcast. The median activity rate/hour when the ultrasound was broadcast was estimated to be between 2.5 and 10.4% of the activity rate when no ultrasound was broadcast indicating that ultrasound deterred bats and that they did not habituate or accommodate to continued broadcast of ultrasound for the period of time studied. The airspace affected was 12-15 meters.

45. Is it likely that myotid bats are attracted to the turbine poles?
Response: One of the hypotheses put forth to explain the high mortality rates of tree bats at wind turbines is that these bats congregate at tallest trees on the landscape for mating. The turbine poles may then attract tree bats. This behavior, however, does not occur in the myotid guild. So, although myotid bats may "check the poles out," most experts indicated that it is unlikely that they would be attracted to turbine poles for roosting. Based on the data available, it is reasonable to conclude that it is unlikely that Indiana bats are attracted to poles for roosting.

46. Is collision with turbine towers a major cause of bat fatalities?
Response: Available literature suggests that bats occasionally collide with buildings and communication towers in small numbers (Cryan and Brown 2007 and citations therein), but there is no evidence that bats consistently have fatal collisions with stationary structures. The experts agreed that there is no evidence that bats routinely collide with nonmoving turbine blades or towers. Several cited data from specific wind facilities, noting that while dead bats are routinely found at operational turbines, they are not found at non-operational turbines or at meteorological towers associated with the sites. For example, Arnett et al. (2005) studied bat fatalities at one site in West Virginia and one site in Pennsylvania. Of the 64 turbines studies, one was non-operational throughout the study period and was the only turbine where no fatalities were found. Similarly, Jain (2005) found no bat fatalities at meteorological towers associated with a wind facility in Iowa.

47. Is collision with turning blades a major cause of bat fatalities?
Response: Traumatic injuries (sheared off wings, headless bodies, head injuries, gashes on the body, etc.) are consistently reported by researchers. At the Buffalo Mountain, Tennessee wind farm, for example, 43.3% of the 522 bodies had evidence of a major injury (Davenport

pers. comm. 2011). Thus, data indicate that collision with moving turbine blades is a major contributor of bat fatalities.

48. **Does barotrauma make up a large percentage of mortalities?**
Response: Most experts believe this is the case, but with the exception of a few studies, more evidence is needed to be sure of this and to have a better understanding of the percentage of deaths caused by barotraumas. Baerwald et al. (2008) found internal hemorrhaging in 92% of bats that were necropsied, indicating that internal injury is common at wind facilities.

49. **At what distance from a turbine blade would you expect see a barotrauma effect?**
Response: One leading proximate cause of bat fatality is believed to be barotraumas. Barotrauma is damage to air-containing structures due to a rapid and excessive change in air pressure (Baerwald et al. 2008). The distance at which this occurs is debated. There was diversity on this response, with many experts indicating that they were speculating. It varies depending on the rotation speed, but several indicated that the zone of risk is very small (i.e., less than a meter).

50. **Is permanent impairment of hearing or echolocation likely upon exposure to wind turbines?**
Response: Currently there are no conclusive data to answer this question. However, several of the experts speculated that it is certainly possible to have sub-lethal impacts (e.g., impaired hearing) from barotrauma. If this does occur, it seems likely that the impaired hearing would have a direct impact on the survival of a bat. As indicated previously, Baerwald et al. (2008) found that internal injury is common at wind facilities. However, data specific to hearing or echolocation effects are lacking. Thus, there is insufficient information to include impaired hearing in our analyses at this time.

51. **Will bats avoid or abandon an area due to the presence of the turbines?**
Response: Scant empirical data exist on this topic. If avoidance does occur, it may be limited to a few species that utilize insect sounds to aid in foraging. Given that there are many deaths documented from encounters with wind turbines, it does not appear that there is active avoidance. Most experts indicated that the continued high number of fatalities found at wind facilities further supports the contention that avoidance is not occurring in most situations.

52. **Are there differences in exposure potential to wind turbines among seasons?**
Response: Throughout North America, an overwhelming majority of bat mortalities occur during the fall migration period. For example, based on data summarized by Arnett et al. (2008) from 21 studies conducted at 19 wind energy facilities in 5 regions of the United States and one province in Canada) indicate that bats are most vulnerable during the late summer and early fall. Although only a few studies (Fiedler 2004, Jain 2005, Brown and Hamilton 2006) spanned the entire active season, those that did have reinforced the finding that most mortality occurs during the migratory period.

Depending on the species in reference, this period is generally described as occurring between the end of July through October. More minute temporal patterns of mortality are not clearly evident, although most studies indicate a peak in mortalities during the late summer (Johnson 2005, Kunz et al. 2007, Arnett et al. 2008, and others). Even so, a considerable number of bats are routinely found dead into the early fall making it difficult to determine the exact causes (i.e., foraging behavior, courtship behavior, weather patterns) behind the minor fluxes of causalities found throughout the migration period. Several experts indicated that sheer number of bats, their increased foraging activity in uplands and along ridge tops, and their somewhat long distances traveled in search of mates, may render bats more susceptible to turbine-related deaths during the fall swarming period than other times of the year.

Given that the vast majority of the fatalities recorded are during the fall, it is reasonable to conclude that the mortality rates are reasonable estimates for fall exposure. However, it is unclear as to whether the same is true during the summer. While experts agreed that migratory bats are at highest risk, they cautioned that a disproportionate amount of fatality searches occur during the migratory period, and that at some sites high fatalities of resident bats may be missed during times when no (or limited) searching occurs. Cryan (2008b) noted that fatality searches consistently are dominated by long-distance migratory, non-hibernating bats, and other affected species may show different seasonal fatality patterns. Based on an ongoing review of data from several sites across the range of Indiana bat, it appears that summer exposure potential for myotids is nearly equal to the fall period. Similar to previously published accounts, exposure potential during the spring period is substantially less. Thus, information available to date indicates that exposure potential for myotids is high during fall and summer.

53. Are there differences in exposure potential to wind turbines between the sexes?

Response: Mortality statistics (see Arnett et al. 2008) are skewed toward males of the four most commonly killed species at wind energy facilities -- the hoary bat, the eastern red bat, the silver-haired bat, and the tri-colored bat (formerly the eastern pipistrelle). Cryan (2008a) reported that observations to date suggest differences in exposure vulnerability between the sexes, with males dominating the reported fatalities. Such trends suggest nonrandom interactions between bats and wind turbines. However, patterns are inconsistent among species and among study sites. Brown and Hamilton (2006), for example, studied fatalities at a wind facility in Alberta and found of those sexed and aged, 9% of the sexed and aged silver-haired bat carcasses were adult males and 46% were adult females, and the remainder were juveniles. Of the aged and sexed hoary bats, 51% were adult males and 24% were adult females, and the remainder juveniles.

Most experts agreed that there is a general lack of information to definitely state what the differences between the sexes may be. Cryan (2008a) hypothesized that long-distance migratory, non-hibernating tree bats, specifically hoary bats and eastern red bats, collide with turbines while engaging in mating behaviors that center on the tallest trees in the landscape. He noted: “Bats use vision to move across the landscapes and might react to the visual stimulus of turbines as they do tall trees.” He further hypothesized that males may be congregating around turbines during autumn in an effort to attract females, which could contribute to the adult male bias observed in bat fatalities at wind facilities. Cryan and Barclay (2009) provide three general hypotheses regarding the causes of bat fatalities at wind projects (random, coincidental- based on species distribution or behavior, and attraction). If the causes are random the composition of fatalities in terms of timing, sex, age, and reproductive condition should match the composition of bats in the area.

There are no data that suggest that male *Myotis* species may be more vulnerable to wind turbine mortality, however. At a facility in Wisconsin, Gruver et al. (2009) found approximately equal numbers of females and males; this pattern of fatalities was found both for all bats combined, and when *Myotis* spp. and big brown bats were considered separately from long-distance migratory tree bats. Another post-construction mortality monitoring study in Wisconsin recorded higher female than male *Myotis lucifugus* carcasses (BHE Environmental 2010). Based on data available, it is most reasonable to assume equal vulnerability to collisions exist for males and females.

54. Are there differences in exposure potential to wind turbines among the life stages?

Response: Data pertaining to age differences are scarce. Cryan and Barclay (2009) provide three general hypotheses regarding the causes of bat fatalities at wind projects (random, coincidental- based on species distribution or behavior, and attraction). A coincidental hypothesis is that the late-summer and autumn peak in fatalities is attributable to introduction of inexperienced young into bat populations, and that juveniles lack the flight skills to avoid turbine blades. However, existing data on the age composition of fatalities do not support this hypothesis (Arnett et al. 2008) and none of the experts suggested this was the case. An exception was Buffalo Mountain in 2005 where juveniles were killed at equal or higher rates than adults for red bats, silver-haired bats, and eastern pipistrelles (Fiedler et al. 2007).

Despite a lack of data, we can make reasonable inferences about age-specific vulnerabilities by examining the life history of Indiana bats. If a wind facility is cited within the home range of a maternity colony, for example, we would expect all members of a maternity colony to be exposed to wind turbines, but rate of exposure would differ among the life stages. The adult females would be exposed for longer periods of time than the young and thereby have a greater exposure risk. Similarly, post-lactating females and older juveniles likely travel longer distances than newly volant young and pregnant and lactating females. Presumably, the farther out individuals forage the more likely they are to be exposed to wind turbines. Drawing from these inferences, it is likely adult females will be more vulnerable to exposure but if the turbines are closely situated to occupied habitat, all individuals, young or old, will be vulnerable to collisions.

55. Is it likely that migratory bats respond (e.g., no response, reduction in reproductive success, death, and so) differently than summer resident bats upon exposure to wind turbines?

Response: Although exposure potential may certainly differ, we would not expect bats once exposed to turbines to exhibit different physiological and biological responses. If barotrauma occurs within 1 meter of an operating turbine, for example, we would expect this physiological response to occur regardless of whether exposure occurs during the summer or fall period.

56. What measure(s) has the greatest potential to prevent bat mortalities at wind farms?

Response: Implementation of several measures provides the greatest opportunity to minimize bat mortality at wind farms based on personal communications from the experts. First, siting should be coordinated to avoid bat concentration areas. Preemptive siting of wind turbines away from known bat habitat may decrease the amount of fatalities seen at wind facilities during summer and swarming periods. However, as little is known regarding the behaviors and pathways of migrating bats, it is difficult to determine whether this measure alone would have an effect on the number of mortalities observed during migration. Thus, curtailing blade movement during peak bat activity (i.e., in the evening hours on warm, low wind nights) is likely a necessary measure. Completely curtailing during the active period will avoid fatalities, but studies have shown that curtailing only during specific wind conditions will also substantially reduce fatalities (Baerwald et al. 2008, Arnett et al. 2009, Arnett et al. 2010, WEST, Inc.). This is done by reducing or terminating the rotation of the turbine blades until a pre-determined minimum wind speed, via either increasing the "cut-in" speed, feathering the blades, or a combination of both. Arnett et al. (2010) noted that recent studies have shown that changing the turbine cut-in speed to 5.5 m/sec resulted in at least a 50 percent reduction in bat fatalities. Kerns et al. (2005) cautioned that wind speeds are typically variable throughout any given night, and therefore it is difficult to characterize "threshold wind speed" associated with bat fatalities. However, they too found an inverse relationship between wind speed and bat fatalities. Specifically, wind speed <4 m/sec was positively related to bat fatalities, whereas the reverse was true for the proportion of the night when winds were >6 m/sec. Several other studies looked at the effect of various cut-in speeds on mortality of bats. The general pattern is consistent—increases in cut-in speeds yield reductions in bat fatalities.

These studies, however, primarily apply to tree bats. Given the behavioral differences between the "tree bats" and myotids, the applicability of the results to Indiana bat is uncertain. Currently, there are several ongoing studies looking at myotid-specific responses to various cut-in and/or feathering speeds. As the data from these studies come in, myotid specific fatality reductions will be posted to the wind share point site. In the interim, pursuing an adaptive management approach that incorporates aspects of cut-in speeds and feathering is prudent given the apparent effectiveness at reducing fatalities. It would also be prudent to analyze existing data to garner a better understanding under what wind conditions Indiana bats would likely curtail activity and integrate this information with the curtailment data to define optimal operational conditions (i.e., establish general cut-in speeds and/or feathering options).

Lastly, acoustic deterrents may also prove effective as several studies have indicated a reduction in bat activity at areas treated with acoustic deterrents (Mackey and Barclay 1989, Szewczak and Arnett 2006, Szewczak and Arnett 2008). As discussed previously, however, further research is needed before we will know whether acoustic deterrents will be helpful in avoiding bat strikes at wind turbines.

57. What specific aspects of exposure (e.g., time of day/night, curtailment options, environmental conditions, etc.) need to be monitored to be able to predict and minimize future mortality?

Response: Among the factors consistently recommended for post-construction monitoring are actual mortalities at the turbines, wind speed and direction, temperature, moon phase, barometric pressure, time of day, season, precipitation, distance of turbine from forest and distance from water source. In addition, post-construction operational changes should also be carefully tested to determine effects of specific cut-in and/or feathering speeds relative to time of day, time of year, hour after sunset, as was done at the Casselman project in PA. Other potentially significant factors to assess would be storm front movement through the study area at multiple time scales, i.e., hours before and after as well as day before and day after. To assess bat behavior post-construction, recommended methods include radar and thermal imaging to understand both far field bat behavior around wind farms (with radar) and near turbine interactions (with thermal imaging), and deducing bat behavior as they approach a wind farm and when flying around and through individual turbines. The monitoring needs are dependent upon the underlying assumptions of the effects analyses and the conservation measures built into the HCP.

Section 10(a)(1)(B) Permit Issues

58. Are we required to issue permits for 30 years if requested?

Response: No. The applicable regulations (50 CFR 17.32) and the Services 5-point policy discuss considerations for permit duration. In determining permit duration, the length of the planned activities, as well as the possible positive and negative effects associated with those activities on the covered species should be considered, including the extent to which the HCP will enhance the habitat and increase the long term survivability of the listed and any additional covered species. The length of time necessary to implement and achieve the benefits of the conservation program should also be considered when determining the duration of the permit. If critical information for the covered species is lacking, a shorter permit duration may be appropriate.

59. What is appropriate permit duration for wind projects?

Response: There is no specific permit duration that would be considered appropriate for wind projects and the permit duration should be determined on a case by case basis. As stated above, the length of the planned activities as well as the length of time to achieve the conservation benefits for the covered species should be considered. If critical information is lacking or uncertainty exists, a detailed adaptive management program should be developed and implemented as part of the HCP. If an applicant is unwilling to provide an adequate adaptive management program that addresses any uncertainty as part of their HCP, a shorter permit duration should be considered.

60. What species are appropriate to include as covered species in a HCP?

Response: Any Federally or State listed, proposed, candidate, species of concern, or those likely to become listed during the term of the proposed permit that could be negatively impacted by the proposed project.

61. **Do we need to consider existing, proposed, and/or reasonably foreseeable wind developments in determining impacts and identifying appropriate minimization and mitigation measures?**
Response: Yes. In order to issue an Incidental Take Permit, Section 7 of the ESA requires a range wide status assessment of the covered species. NEPA, which is also required as part of the Section 10 process, also requires review of all past, present, and future projects that could impact the human environment. The specific minimization and mitigation measures developed as part of an HCP are generally project specific but should be consistent as possible across projects if the impacts to the Covered Species and Covered Lands are similar.

62. **Is monitoring required for the duration of the permit?**
Response: Yes. By regulation, compliance and effectiveness monitoring is required for the life of the permit and in some cases effectiveness monitoring at mitigation sites occurs beyond the duration of the permit.

63. **Do developers have a responsibility to contribute to monitoring the overall status of species?**
Response: No. Monitoring the overall status of a listed species is the Services responsibility.

64. **Is every permittee required to monitor the same elements or can (should) we develop a regional-based monitoring scheme?**
Response: Every HCP must include compliance and effectiveness monitoring for each species covered under the permit. That is, each permittee will need to monitor the level of take authorized and the impact of such taking, their compliance with the permit conditions, and the effectiveness of the minimization and mitigation measures. From this perspective, every permittee will have similar monitoring requirements. However, it is anticipated that as new information is gathered from monitoring activities at new or existing facilities, site-specific monitoring may not be required for future projects in all cases. For example, if a facility proposes curtailing operations during critical periods as a minimization measure, and other facilities have already tested the effectiveness of this measure, we may not require the new facility to monitor the effectiveness of the same conservation measure. Instead, we would apply the information garnered at existing facilities and apply to these new facilities. It is important, however, that the permittee understands that even if monitoring is not required, they may need to modify their operation if new information indicates a particular conservation measure is more effective in minimizing or mitigating impacts to the covered species. The adaptive management program must explicitly address how all such uncertainties will be addressed.

65. **What are the requirements pertaining to adaptive management?**
Response: Adaptive management is not required for every HCP, but we must explicitly assess whether it should be used. Our 5-point policy (65 FR 35242) states that, "The Services will consider adaptive management as a tool to address uncertainty in the conservation of a species covered by an HCP… Not all HCPs or all species covered in an incidental take permit need an adaptive management strategy. However an adaptive management strategy is essential for HCPs that would otherwise pose a significant risk to the species at the time the permit is issued due to significant data or information gaps."

If an adaptive management framework is used, we must according to the 5-point policy: (1) identify the uncertainty and the questions that need to be addressed to resolve the uncertainty; (2) develop alternative strategies and determine which experimental strategies to implement; (3) integrate a monitoring program that is able to detect the necessary information for strategy evaluation; and (4) incorporate feedback loops that link implementation and monitoring to a decision-making process that result in appropriate changes in management.

66. **When there are multiple project proponents within the same general geographic area, how is incidental take allocated? Is it first come, first served?**
    Response: ITPs are processed on a first come-first serve basis.

67. **What does "minimize and mitigate to the maximum extent practicable" mean?**
    Response: This issuance criterion requires us to evaluate the effectiveness of the applicants' proposed minimization and mitigation measures. It is important to understand that in doing so, we must focus solely on measures to be undertaken to reduce the likelihood and extent of the impact of take resulting from the project as proposed, as well as appropriate compensatory measures. We interpret this section to mean that the impacts of the proposed project, including the HCP, which were not *eliminated* through informal negotiation must be minimized to the maximum extent practicable and those remaining impacts that cannot be further minimized must be mitigated to the maximum extent practicable. These standards are based in a *biological determination* of the impacts of the project as proposed, what would further minimize those impacts, and then what would biologically mitigate or compensate for those remaining biological impacts.

    If applicants provide biologically based minimization measures and mitigation measures that are fully commensurate with the level of impacts, they have minimized and mitigated to the maximum extent practicable. It is only where certain constraints may preclude full minimization or full mitigation that the "practicability" issue needs to be addressed more thoroughly. In those circumstances where the applicant cannot fully achieve the minimization and mitigation standards, we must evaluate whether the applicant has still minimized and mitigated to the maximum extent practicable. Note, in issuing the ITP we must not appreciably reducing the likelihood of survival and recovery of the species in the wild. Inability to fully compensate for the impacts of the take may make this criterion difficult to satisfy. Factors to be considered in the practicability analysis may include constraints based on the site itself, availability of mitigation habitat, timing and nature of the project, the financial means of the applicant, costs and time associated with redesign and going through local and state permitting and zoning processes, etc. We must evaluate whether the applicant has provided reasonable explanations concerning constraints and independently review the record of evidence supporting the applicant's assertions. The practicability evaluation is necessarily project specific, and may properly yield different determinations in different situations.

68. **Is it allowable for an applicant to mitigate in lieu of minimization measures, or must the applicant first minimize if possible?**
    Response: An applicant must first minimize to the maximum extent practicable.

69. **How do developers demonstrate "to the maximum extent practicable" when it comes to siting wind projects? How do we evaluate whether their "demonstration" is sufficient?**
Response: In reviewing an applicant's HCP, the Service must analyze the biological impacts of the project on the covered species. If the proposed siting of some or all of the turbines will cause impacts to the species the applicant should minimize those impacts by moving the turbines to more suitable locations. If an applicant is unwilling to move the turbines to further minimize the impacts due to economic reasons, the Service should require them to provide justification why they are unable to do so. An independent analysis or third party should review the information provided by the applicant to verify they have sited the turbines to the maximum extent practicable.

70. **Is it valid to identify high priority recovery actions as mitigation measures?**
Response: Yes, but there are many things to consider. Mitigation means to lessen; thus, section 10 requires project proponents to lessen the impact of take. This can be accomplished by improving the fitness (annual reproductive success and lifetime survivorship) of the unaffected bats belonging to the same population unit (be that a maternity colony, hibernating colony, or recovery unit). Presumably recovery actions, especially priority 1 actions, will improve the fitness of a population of Indiana bats. However, factors such as where on the landscape the recovery action occurs and to what degree the recovery action is achieved greatly influence the degree to which it lessens the impact of the taking. Thus, for a recovery action to serve as legitimate mitigation measure, we must believe that there is a high likelihood that the recovery action will improve the survival or reproductive success of the individuals comprising the population unit from which the taken individuals belong.

71. **Is permanent protection of suitable maternity colony habitat in close proximity (beyond the traditional homerange but within 10 miles) to an impacted colony a valid mitigation strategy?**
Response: Provided that you can demonstrate that such protection will compensate for the impact of the anticipated take, protection is a valid mitigation measure. The requirement is to compensate for the impact of the taking. It is important to recognize that the task is to first minimize the level of take to the maximum extent practicable and then to commensurately compensate for the impact of the residual take to the maximum extent practicable. This requires the applicant to: 1) explicitly describe the impact (i.e., how and to what extent will the fitness of the population to which the impacted individuals belong be affected), and 2) develop measures that will compensate for the impacts to the population fitness.

72. **Is permanent protection of occupied habitat far away from the impacted maternity colony a valid mitigation strategy?**
Response: Yes, provided that you can demonstrate that such protection will compensate for the impact of the anticipated take. For example, demonstrating that such protection will likely improve the survival or reproductive success of Indiana bats within the Recovery Unit in which the affected individuals reside.

73. Is a commitment to adaptive management a valid mitigation measure?

Response: The purpose of adaptive management is to address uncertainties in our analyses; that purpose by itself does not compensate for take that occurs, and therefore, is not a mitigation measure (see 5-point policy for information on use of adaptive management in HCPs). This does not imply, however, that the uncertainties associated with proposed mitigation measures should not be included in an adaptive management program. Indeed, such uncertainties must be addressed. It is important to note that reducing uncertainty is not compensation, but implementing actions that reduce or remove the impact of take is.

74. Is contribution to a conservation fund is a valid mitigation measure?

Response: Yes, but not in all cases. As long as the mitigation, such as a conservation bank, is already in place or at a minimum certain to occur, contribution to a fund can be a valid mitigation measure. However, only providing funds does not compensate for the impacts of a project or the authorized take by itself. The Service must have some assurance that the funds will be used to offset the impacts.

Jeopardy & Adverse Modification Analyses

75. How do we assess the impacts of take of a maternity colony on survival and recovery at regional (recovery unit) scale? Similarly, how do we assess the impacts of take of migratory individuals on survival and recovery at regional scale?

Response: Whether an action will jeopardize the continued existence of Indiana bat is context dependent. The magnitude of impacts is contingent on two points: (1) the demographic segment of the population (i.e., summering males and non-reproductive females vs summering reproductive females vs hibernating populations) affected, and (2) the recovery unit in which the affected individuals reside. Thus, the best way to consistently answer these two questions across the range of Indiana bat is to describe an analytical framework to conduct jeopardy analyses.

The framework described below, although Indiana bat specific, is consistent with the current jeopardy analysis approach for species with established recovery units (Recovery Units and Jeopardy Determinations under Section 7 of Endangered Species Act, policy memorandum issued March 6, 2006).

Prior to describing the analytical framework, a brief discussion of the jeopardy mandate is warranted. The purpose of the Endangered Species Act (ESA) is to conserve listed species and the ecosystems upon which they depend such that their protection under the ESA is no longer needed to ensure their continued survival. In other words, once listed, the purpose the ESA is to recover and remove from the list. Federal agency compliance with sections 7(a)(1) and 7(a)(2) play important roles in achieving the species conservation purposes of the ESA. Section 7(a)(1) directs all Federal agencies to carry out programs for the conservation of listed species, while section 7(a)(2) directs Federal agencies to insure actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of listed species.

Section 7(a)(2) of the Act clearly defines the mandate: "Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency…is not likely to jeopardize the continued existence of any endangered species or threatened species…" The implementing regulations for section 7 define "jeopardize the continued existence of" as "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." To facilitate consistent application of the standard, it is helpful to clarify of a few aspects of this definition.

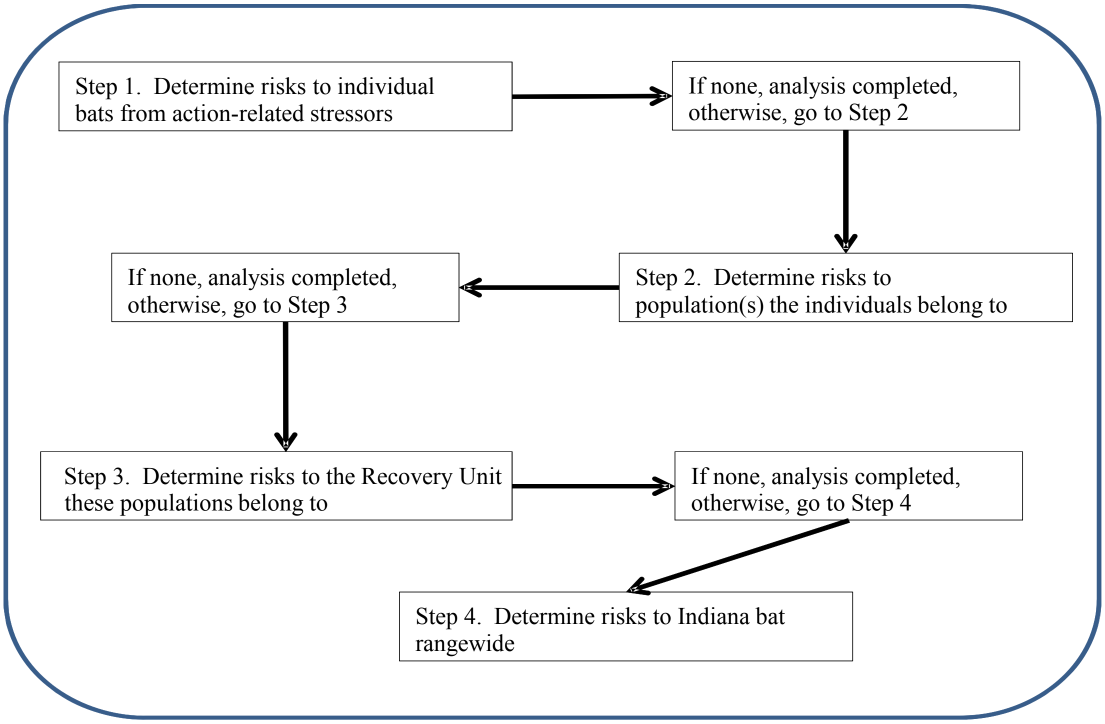
The definition directs us to evaluate whether a reduction in the likelihood of survival and recovery is expected. Reduction embodies the concept of a change, more specifically, a decrease. Likelihood implies a chance or probability of some event. Thus, we are directed to assess whether a decrease in the probability of survival and recovery is expected. Further, it is not just whether any decrease will occur; we must evaluate whether the magnitude of the anticipated decrease is "appreciable." Appreciable means noticeable, perceivable, or measureable. In pulling these three concepts together, our jeopardy analyses is then determining whether the anticipated reductions in the species' reproduction, numbers, or distribution (RND) would reasonably be expected to noticeably, perceivably, or measurably decrease the species' probability of survival and recovery.

Analytical Framework for Jeopardy Analyses

The principal components of the analysis are identified as steps (see schematic below), and a brief description of each step is provided. The framework provides a structure for the analysis; it does not (cannot) do the analysis for the biologist.

The end product of a section 7 effects analysis is a description of the type and magnitude of response bats will exhibit upon exposure to an action and any associated environmental stressors. Among others, biological responses include startle, alarm, flee, avoid, abandon/ displacement, reduced feeding success, reduced growth, reduced reproductive success, reproductive failure, and mortality. Once the anticipated response is determined, we are poised to assess the consequences such responses pose for the species, i.e., complete a jeopardy analysis. The framework below describes a sequential process for conducting jeopardy analyses.

First, we evaluate how the individual responses will affect the fitness of those individuals (Step 1 in the schematic below). The fitness of an individual is measured by its annual and lifetime reproductive success and its survival likelihood. For example, if we determined that Indiana bats are likely to abandon a foraging area upon exposure to the proposed action, we must determine how such a response affects the lifetime reproductive success and survival likelihood of the individuals exposed. If no reductions in individual fitness are anticipated, then the analysis is complete and the action agency has insured that its action is not likely to jeopardize the continued existence of the Indiana bat.



If reductions in fitness are anticipated, in the next step (Step 2) we evaluate how changes in the fitness of the individuals affect the fitness of the population to which those individuals belong. The fitness of a population (i.e., its reproductive success and survival probability) is a compilation of the fitness of each of the individuals and the number of individuals comprising the population[1]. For the Indiana bat, a "population" is typically a maternity colony, a congregation of swarming bats, or a congregation of bats in a hibernaculum, and hence, we are evaluating how the fitness of the maternity/swarming/winter colony will be affected by the collective reduction in survivorship and reproduction of the individuals exposed to the proposed action. Specifically, we are analyzing how the reductions in individual fitness affect the population's abundance, reproduction, growth rates, or variance in these measures to make inferences about the population's future reproductive success (if applicable) and its viability. If no reductions in the maternity/swarming/winter colony fitness are anticipated, we conclude that the agency has insured that their action is not likely to jeopardize the continued existence of the Indiana bat and our analysis is completed. If, however, we cannot show that reductions in the population's fitness are unlikely to occur, we evaluate the impact of such reductions in population fitness will reduce the likelihood of both survival and recovery of Indiana bat rangewide by impacting its RND. As the recovery plan designates recovery units (RUs), this next step (Step 3) looks at how the reductions in population fitness affects RND of Indiana bats within the affected RU and how these effects on RND affect the likelihood of both survival and recovery of Indiana bats in the RU.

[1] The long-term viability of many populations is positively correlated with density. For Indiana bats it is generally accepted that below some critical number, the colonial structure will collapse. This critical threshold, however, is unknown.

To understand the consequences of population-level reductions in fitness, we need to identify the RND needs of Indiana bat at the RU level, i.e., what is needed in terms of RND to ensure the species is no longer in danger of extinction or to become endangered within the foreseeable future in the RU (henceforth, referred to as conservation needs). An obvious source for identifying these conservation needs is the recovery plan, specifically the recovery objective, strategy, criteria, and actions. For Indiana bat, we are in the process of revising the 2007 draft recovery plan in response to comments received during the public comment period. Once finalized, the Indiana bat recovery objective, strategy, and actions can inform our analyses of ascertaining whether the population-level risks will or will not cause an appreciable reduction in the likelihood of conserving Indiana bats. Our analysis in this step evaluates how the population-level effects influence the likelihood of progressing towards or maintaining the conservation needs.[2] If the population-level risks do not noticeably, detectably, or perceivably reduce the likelihood of progressing towards or maintaining one or more of the conservation needs, then the action is not likely to appreciably reduce the likelihood of both survival and recovery of Indiana bat within the affected RU(s), and our analysis is completed. If population-level risks appreciably reduce the likelihood of progressing towards or maintaining these conservation needs in the RU, then the likelihood of both survival and recovery of Indiana bats in the RU will likely be appreciably reduced, and we need to complete a fourth and final analysis.

In Step 4, we evaluate whether such reductions in RND within the RU will reduce appreciably the likelihood of both survival and recovery of Indiana bat rangewide. As explained in the recovery plan, the RUs are designed to preserve sufficient representation, redundancy, and resiliency to ensure the long-term persistence of Indiana bat. It then follows that an appreciable reduction in the likelihood of both survival and recovery of Indiana bats in any one RU will reduce the representation, redundancy, and resiliency of the species rangewide and will therefore inherently cause an appreciable reduction in the likelihood of survival and recovery of the Indiana bat rangewide.

76. How do we evaluate the impacts upon critical habitat?

Response: The section 7 mandate pertaining to critical habitat is: "Each Federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency…is not likely to … result in the destruction or adverse modification of habitat…" The regulatory definition of "destroy or adversely modify" has been invalidated by several circuit courts. In response to these legal opinions, we are directed to rely on the statutory language rather the regulatory text. Specifically, our "adverse modification" analyses assess whether the critical habitat is likely to continue to serve its intended conservation function (see the Director's memorandum: Application of the "Destruction or Adverse Modification" Standard under Section 7(a)(2) of the Endangered Species Act, December 9, 2004).

Projects trigger formal consultation if they are likely to adversely affect one or more of the physical or biological features (henceforth referred to as CH features) of the critical habitat.

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[2] This analysis requires us to know the baseline status of the species in the recovery unit. We are developing a process for providing current RU and rangewide baselines for biologists to use in their analyses.

The CH features are those elements of the species' habitat that are essential to its conservation or that may require special management. Critical habitat for the Indiana bat was designated before the concept of CH features was introduced, so only the names of the hibernacula are given. The final recovery plan will identify the CH features associated the designated critical habitat. In the interim, biologists should rely on the Draft 2007 Recovery Plan and their knowledge of Indiana bat biology to identify the CH features for the specific cave or mine affected by the proposed action.

Once the CH features are described, the following analytical framework can be used to evaluate the impacts of wind energy projects on critical habitat. This framework is consistent with Service's policy for conducting critical habitat analysis.

Analytical Framework for Critical Habitat
During our effects analyses we established a spatial (and, depending on the CH features identified, perhaps temporal) overlap between the project area and critical habitat and determined that the quantity, quality, or availability of the CH features will be reduced. Now, we are poised to assess the effects of such impacts on the conservation function of critical habitat, i.e., complete an adverse modification analysis.

In Step 1 of the analytical framework, we assess the effect of the project on the conservation role of critical habitat unit (i.e., a specific cave or mine). That is, we determine how the reduction in the quality, quantity, or availability of the exposed CH features within the action area will affect the intended function (or value) of the specific designated cave or mine. For example, if airflow will be restricted to the cave, we describe how such reduction in this CH feature will affect the ability of the cave to support hibernating bats. If no reduced function is anticipated, then our analysis is completed and the action agency has insured that its action is not likely to destroy or adversely modify critical habitat. If we anticipate that the intended function of the critical habitat unit will be reduced (e.g., no longer able to support a priority 2 population), then a broader analysis is required (Step 2).

Next, we determine whether such impacts to the critical habitat unit (individual cave or mine) will appreciably diminish the ability of the critical habitat as a whole to provide its conservation function. The intent of this analysis is to assess whether the reductions at the critical habitat unit level are likely to appreciably diminish the ability of the designated critical habitat as whole (throughout the range) to provide for the conservation of Indiana bat. If the adverse effects to the critical habitat unit are not likely to noticeably affect the overall function (value) of the critical habitat as whole, no further analysis is needed and the action agency has insured that its action is not likely to destroy or adversely modify critical habitat. If the function (value) of Indiana bat critical habitat will likely be reduced by the impacts to affected critical habitat unit, then the action agency has not insured that their proposed action is not likely to destroy or adversely modify critical habitat.

Literature Cited

Arita, H.T, and M.B. Fenton. 1997. Flight and echolocation in the ecology and evolution of bats. Trends Ecol Evol 12:53–8.

Arnett E.B., W.P. Erickson, J. Kerns, and J. Horn. 2005. 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. 187 pp. Available on BWEC web site: www.batsandwind.org.

Arnett, E.B., J.P. Hayes and M.M.P. Huso. 2006. Patterns of pre-construction bat activity at a proposed wind facility in south-central Pennsylvania. An annual report submitted to the Bats and Wind Energy Co-operative. Bat Conservation International, Austin, Texas, 46 pp.

Arnett, E.B., K. Brown, W.P. Erickson, J. Fiedler, T.H. Henry, G.D. Johnson, J. Kerns, R.R. Kolford, T. Nicholson, T. O'Connell, M. Piorkowski, and R. Tankersly. 2008. Patterns of fatality of bats at wind energy facilities in North America. Journal of Wildlife Management, 72:61–78.

Arnett, E.B., M. M. P. Huso, J. P. Hayes, and M. Schirmacher. 2010. Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA. 57 pp.

Arnett, E.B., M. Schirmacher, M.M.P. Huso, and J.P. Hayes. 2009. Effectiveness of changing wind turbine cut-in speeds to reduce bat fatalities at wind facilities. An annual report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA. 45 pp. Available at: http://www.batsandwind.org/pdf/Curtailment_2008_Final_Report.pdf. Accessed July 7, 2010.

Avery, M.I. 1985. Winter activity of pipistrelle bats. Journal of Animal Ecology: 54(3):721-738.

Baerwald, E.F., J. Edworthy, M. Holder, and R.M.R. Barclay. 2008. A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities. Journal of Wildlife Management 73(7):1077-1081.

Baerwald. E.F. and R.M.R. Barclay. 2009. Geographic Variation in Activity and Fatality of Migratory Bats at Wind Energy Facilities. Journal of Mammalogy 90(6):1341-1349.

Barbour, R.W., and W.H. Davis. 1969. Bats of America. University Press of Kentucky, Lexington, USA.

Barbour, R.W., W.H. Dais, and M.D. Hassell. 1966. The need of vision in homing by Myotis sodalis. Journal of Mammalogy 47(2):356-357.

Barclay, R.M.R. and A. Kurta. 2007. Ecology and behavior of bats roosting in tree cavities and under bark. Pp. 17-59 in M.J. Lacki, J.P. Hayes, and A. Kurta (eds.), Bats in forests: conservation and management. Johns Hopkins University Press, Baltimore, MD. 329 pp.

Barclay, R.M.R., E.F. Baerwald, and J.C. Gruver. 2007. Variation in bat and bird fatalities at wind energy facilities: assessing the effects of rotor size and tower height. Canadian Journal of Zoology 85:381-387.

BHE Environmental 2010. Post-construction bird and bat mortality study. Cedar Ridge Wind Farm Fond Du LaC County, WI. Interim Report prepared for Wisconsin Power and Light, Madison, WI. 10 pp + appendices.

Brack, V., Jr. 1983. The non-hibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, Myotis sodalis. Ph.D. Dissertation. Purdue University, West Lafayette, IN. 280 pp.

Brack, V. Jr., W. Orndoroff, R. J. Reynolds, J. Zokaites, and C. Zokaites. 2005. Bats of Skydusky Hollow, Bland County, Virginia. Virginia Journal of Science 56:93-106.

Brack, V.Jr. 2006. Autumn Activity of Myotis sodalis (Indiana bat) in Bland County, Virginia. Northeastern Naturalist. 13(3):421-434.

Brack, V.Jr., D. Sparks, and J. Whitaker. 2009. Landscape Scale Movements of Maternity Colonies of the Indiana bat Through Time: Examples and Possibilities. Presentation at the National Military Fish and Wildlife Association sessions of the National Wildlife Management Institute meetings. Ppt.

Brigham, R.M. and M.B. Fenton. 1986. The influence of roost closure on the roosting and foraging behaviour of Eptesicus fuscus (Chiroptera: Vespertilionidae). Canadian Journal of Zoology 64:1128-1133.

Brown, W. K., and B. L. Hamilton. 2006. Monitoring of bird and bat collisions with wind turbines at the Summerview Wind Power Project, Alberta, 2005-2006. Report for Vision Quest Windelectric, Inc., Calgary, Alberta, Canada.

Buchler, E.R. 1980. The development of flight, foraging, and echolocation in the little brown bat (Myotis lucifugus). Behav. Ecol. Sociobiol. 6:211-218.

Butchkoski, C., and G. Turner. 2005. Indiana bat (Myotis sodalis) investigations at Canoe Creek, Blair County, Pennsylvania. Unpublished report. Pennsylvania Game Commission, Bureau of Wildlife Management, Research Division. Harrisburg, Pennsylvania.

Butchkoski, C.M. and G. Turner. 2006. Indiana bat (Myotis sodalis) summer roost investigations. Project 06714 Annual Job Report. Pennsylvania Game Commission, Bureau of Wildlife Management, Research Division, Harrisburg, PA. 17 pp.

Butchkoski C. and G. Turner. 2007. Indiana bat (Myotis sodalis) summer roost investigations. Pennsylvania Game Commission, Bureau of Wildlife Management, Research Division – Project Annual Job Report. 21 pp.

Butchkoski, C., J. Chenger, A. Hicks, R. Reynolds. 2008. Spring Indiana bat migration telemetry. Page 12 in Abstracts of the Joint meeting of the Southeastern Bat Diversity Network, Northeast Bat Working Group, and Colloquium on Conservation of Mammals in the Southeastern United States, Blacksburg, VA, February 20-22, 2008.

Butchkoski, C.M. and J.D. Hassinger. 2002. Ecology of a maternity colony roosting in a building. Pp. 130-142 in A. Kurta and J. Kennedy (eds.), The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, TX.

Carter, T.C. 2001. Summer habitat use of roost trees by the endangered Indiana bat (Myotis sodalis) in the Shawnee National Forest of southern Illinois. Unpublished dissertation. Southern Illinois University, Carbondale, Illinois. 96 pp.

Carter, T.C. 2002. Bat houses for conservation of endangered Indiana Myotis. The Bat House Researcher, 10:1-3.

Chenger, J., and C. Sanders. 2007. South Penn Tunnel Fall 2007 Indiana Bat Telemetry. Final Report. Shaffer Mountain Wind, LCC and Airtricity, Inc. Philadelphia, Pennsylvania, and Austin, Texas. 48pp.

Cope, J.B. and S.R. Humphrey. 1977. Spring and autumn swarming behavior in the Indiana bat, Myotis sodalis. Journal of Mammalogy 58:93-95.

Cope, J.B., A.R. Richter, and R.S. Mills. 1974. A summer concentration of the Indiana bat, Myotis sodalis, in Wayne County, Indiana. Proceedings of the Indiana Academy of Sciences 83:482-484.

Cryan, P.M. 2008a. Mating behavior as a possible cause of bat fatalities at wind turbines. Journal of Wildlife Management 72:845-849.

Cryan, P.M. 2008b. Overview of issues related to bats and wind energy: Web version of presentation to the Wind Turbine Guidelines Advisory Committee Technical Workshop & Federal Advisory Committee Meeting, Washington, D.C., 26 February, 2008: U.S. Geological Survey General Information Product. 71 PP.

Cryan, P.M. and A.C. Brown. 2007. Migration of bats past a remote island offers clues toward the problem of bat fatalities at wind turbines. Biological Conservation 139:1-11.

Cryan. P.M. and R. M.R. Barclay. 2009. Causes of Bat Fatalities at Wind Turbines: Hypotheses and Predictions. Journal of Mammalogy 90(6):1330-1340.

Ecology and Environment, Inc. 2009. Draft Report: Indiana Bat (Myotis sodalis) Field Studies at Shuteye Creek Wind Farm Adair and Sullivan Counties, Missouri.

Fiedler, J.K, T.H. Henry, R.D. Tankersley, and C.P. Nicholson. June 28, 2007. Results of bat and bird mortality monitoring at the expanded Buffalo Mountain Windfarm, 2005.

Fiedler, J.K. 2004. Assessment of bat mortality and activity at Buffalo Mountain Windfarm, eastern Tennessee. M.S. Thesis, Univ. of Tennessee, Knoxville, TN.

Flaquer, C., I. Torre, and A. Arrizabalga. 2007. Comparison of sampling methods for inventory of bat communities. Journal of Mammalogy 88:526–533.

Foster, R. and A. Kurta. 1999. Roosting ecology of the northern bat (Myotis septentrionalis) and comparisons with the endangered Indiana bat (Myotis sodalis). Journal of Mammalogy 80:659–672.

Ford, W.M., M.A. Menzel, J.L. Rodrigue, J.M. Menzel and J.B. Johnson. 2005. Relating bat species presence to simple habitat measures in a central Appalachian forest. Biological Conservation 126:528-539.

French, B. and J. O. Whitaker, Jr. 2002. Baby bats can learn to fly, hunt and hide on their own. Bats 20:1-3.

Gaisler, J., Zukal, J., Rehak, Z., and M. Homolka. 1998. Habitat preference and flight activity of bats in a city. Journal of Zoology, 244:439-445.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991a. Summary of Myotis sodalis summer habitat studies in Illinois with recommendations for Impact Assessment. Unpublished Report to the Indiana/Gray bat recovery team. 26 pp.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991b. Summer roost selection and roosting behavior of Myotis sodalis (Indiana bat) in Illinois. Unpublished Report to U.S. Fish and Wildlife Service, 56 pp.

Gardner, J.E. and E.A. Cook. 2002. Seasonal and geographic distribution and quantification of potential summer habitat. Pp. 9-20 in A. Kurta and J. Kennedy (eds.), The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, TX.

Garner, J.D. and J.E. Gardner. 1992. Determination of summer distribution and habitat utilization of the Indiana bat (Myotis sodalis) in Illinois. Final Report: Project E-3. Endangered Species Act Section 6 Report, Illinois Department of Conservation.

Gruver, J.C., M. Sonnenberg, K. Bay, and W.P. Erickson. 2009. Results of a post-construction bat and bird fatality study at Blue Sky Green Field Wind Energy Center, Fond du Lac County, Wisconsin, July 2008-May 2009. Final report prepared for We Energies, Milwaukee, WI. Prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming. Available at: http://psc.wi.gov/apps35/ERF_view/viewdoc.aspx?docid=126370. Accessed May 28, 2010.

Gumbert, M.W., P. Roby, and J. Hawkins. 2011. Spring Migration of Female Indiana bats (Myotis sodalis) from caves in eastern Tennessee. 68 pp.

Gumbert, M.W., J.M. O'Keefe, and J.R. MacGregor. 2001. Roost Fidelity in Kentucky. In The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, Texas. pp143-152.

Hall, J.S. 1962. A life history and taxonomic study of the Indiana bat, Myotis sodalis. Reading Public Museum and Art Gallery, Scientific Publications 12:1-68.

Hawkins, J.A. and V. Brack, Jr. 2004. Habitat Conservation Plan: 2003 telemetry study of autumn swarming behavior of the Indiana bat (Myotis sodalis). Report prepared for the Indiana Department of Natural Resources, Indianapolis, IN. 23 pp.

Hawkins, J.A., J. Jaskula, A. Mann, P. Kudlu, and V. Brack, Jr. 2005. Habitat Conservation Plan: 2004 Telemetry Study of Autumn Swarming Behavior of the Indiana Bat (Myotis sodalis). Final Report. Indiana Department of Natural Resources Division of Forestry, Indianapolis, Indiana. 25pp. plus appendices.

Hayes, J.P. 1997. Temporal variation in activity of bats and the design of echolocation-monitoring studies. Journal of Mammalogy 78:514–524.

Hayes, J.P. 2000. Assumptions and practical considerations in the design and interpretation of echolocation-monitoring studies. Acta Chiropterologica 2:225–236.

Hicks, A. 2004. Indiana Bat (Myotis sodalis): protection and management in New York State. Endangered species investigations performance report. Prepared for project number W-166-E Segment 2003-2004, New York Department of Environmental Conservation. 15 pp.

Hicks, A., and C. Herzog. 2006. Migratory Behavior of Female Indiana Bats in New York and Implications for Wind Development. Proceedings NWCC Wildlife Workgroup Research Planning Meeting VI, San Antonio, Texas, USA. November 14-15, 2006.

Hobson and Holland 1995. Post-hibernation movement and foraging of a male Indiana bat, Myotis sodalis (Chiroptera: Vespertilionidae) in Western Virginia. Brimleyana, 23:95-101.

Horn, J.W., E.B. Arnett, and T.H. Kunz. 2008. Behavioral responses of bats to operating wind turbines. Journal of Wildlife Management 72:123-132.

Humphrey, S.R. and J.B. Cope. 1976. Population ecology of the little brown bat, Myotis lucifugus, in Indiana and north-central Kentucky. Special publication No. 4 The American Society of Mammalogists. 80pp.

Humphrey, S.R., A.R. Richter, and J.B. Cope. 1977. Summer habitat and ecology of the endangered Indiana bat, Myotis sodalis. Journal of Mammalogy 58:334-346.

Jain, A.A. 2005. Bird and bat behavior and mortality at a northern Iowa windfarm. M.S. thesis, Iowa State University. 108 pp.

Johnson, G. 2005. A review of bat mortality at wind-energy developments in the United States. Bat Research News 46:45-48.

Judy, D.J., J.O. Whitaker Jr., D.W. Sparks, C.M.Ritzi. 2010. Unusual migratory behavior by an Indiana bat (Myotis sodalis). Proceedings of the Indiana Academy of Science 119(1):99-100.

Kalko, E.K.V., and C.O. Handley. 2001. Neotropical bats in the canopy: diversity, community structure, and implications for conservation. Plant Ecology 153:319–333.

Kalko, E.K.V., S.E. Villegas, M. Schmidt, M. Wegmann and C.F.J. Meyer. 2008. Flying high—assessing the use of the aerosphere by bats. Integrative and Comparative Biology Advance Access published online on May 13, 2008.

Kerns, J., Erickson, and E. Arnett. 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia Bat and bird. Pages 24-95 in E. B. Arnett, technical editor. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Kiser, J.D. and C.L. Elliot. 1996. Foraging habitat, food habits, and roost tree characteristics of the Indiana bat (Myotis sodalis) during autumn in Jackson County, Kentucky. Final Report, Nongame Program, Kentucky Department of Fish and Wildlife Resources, Frankfort.

Kiser, J.D. and J.R. MacGregor. 2005. Indiana bat (Myotis sodalis) mist net surveys for coal mining activities. Pp. 169-172 in K.C. Vories and A. Harrington (eds.), The Proceedings of the Indiana bat and coal mining: a technical interactive forum Office of Surface Mining, U.S. Department of the Interior, Alton, IL.

Kuenzi, A.J., and M.L. Morrison. 1998. Detection of bats by mist-nets and ultrasonic sensors. Wildlife Society Bulletin 26:307–311.

Kunz, T. H., E. B. Arnett, W. P. Erickson, A.R. Hoar, G. D. Johnson, R. P. Larkin, M. D. Strickland, R. W. Thresher, and M. D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5: 315-324.

Kurta, A. 2000. The bat community in northwestern Lower Michigan, with emphasis on the Indiana bat and eastern pipistrelle. Report submitted to United States Forest Service, Huron-Manistee National Forests, Cadillac, MI 43 pp.

Kurta, A. 2005. Roosting ecology and behavior of Indiana bats (Myotis sodalis) in summer. In K.C. Vories and A. Harrington (Eds.), The proceedings of the Indiana bat and coal mining: A technical interactive forum (pp. 1-34). Alton, Illinois: U. S. Department of the Interior: Office of Surface Mining.

Kurta, A. and H. Rice. 2002. Ecology and management of the Indiana bat in Michigan. Michigan Academician 34:175-190.

Kurta, A., and S. W. Murray. 2002. Philopatry and migration of banded Indiana bats (Myotis sodalis) and effects of using radio transmitters. J. of Mammalogy 83:585-58

Kurta, A., J. Kath, E.L. Smith, R. Foster, M.W. Orick, and R. Ross. 1993. A maternity roost of the endangered Indiana bat (Myotis sodalis) in an unshaded, hollow, sycamore tree (Platanus occidentalis). American Midland Naturalist 130:405-407.

Kurta, A., S.W. Murray, and D.H. Miller. 2002. Roost selection and movements across the summer landscape. Pp. 118-129 in A. Kurta and J. Kennedy (eds.), The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, TX.

Lacki, M. J., Cox, D. R., & Dickinson, M. B. (2009). Meta-analysis of summer roosting characteristics of two species of myotis bats. American Midland Naturalist 162:318-326.

Lacki, M.J. 1984. Temperature and humidity-induced shifts in the flight activity of little brown bats. Ohio Journal of Science, 84:264-266.

Larson, D.J., and J.P. Hayes. 2000. Variability in sensitivity of Anabat II detectors and a method of calibration. Acta Chiropterologica, 2:209–213.

LaVal, R. K., R. L. Clawson, M. L. LaVal, and W. Caire. 1977. Foraging behavior and nocturnal activity patterns of Missouri bats, with emphasis on the endangered species Myotis grisescens and Myotis sodalis. Journal of Mammalogy, 58:592-599

LaVal, R. K., R. L. Clawson, M. L. LaVal, W. Caire, L. R. Wingate, and M. L. LaVal. 1976. An evaluation of the status of myotine bats in the proposed Meramec Park Lake and Union Lake project areas, Missouri. Unpublished report to U.S. Army Corps of Engineers, St. Louis, MO.

LaVal, R.K. and M.L. LaVal. 1980. Ecological studies and management of Missouri bats with emphasis on cave-dwelling species. Missouri Department of Conservation Terrestrial Series 8: 1-53.

Lawrence, B.D., and J.A. Simmons. 1982. Measurements of atmospheric attenuation at ultrasonic frequencies and the significance for echolocation by bats. Journal of the Acoustical Society of America. 71(3):585-590.

McShea, W. J. and H. Lessig. 2005. Migration of female Indiana bats (Myotis sodalis) from winter hibernacula to summer maternity roost. Draft report to the Virginia Department of Game and Inland Fisheries, Richmond, USA.

Menzel, J.M., W.M. Ford, M.A. Menzel, T.C. Carter, J.E. Garnder, J.D. Garner, J.E. Hoffman. 2005. Summer habitat use and home-range Analysis of the endangered Indiana bat.

Meinke, C.W., K. Watrous, and W. Warren-Hicks. 2010. Indiana bat Collision Risk Model for the Buckeye Wind Power Project, Champaign County, Ohio.53 pp

Murray, K.L., E.R. Britzke, B.M. Handley, and L.W. Robbins. 1999. Surveying bat communities: a comparison between mist nets and the Anabat II bat detector system. Acta Chiropterologica 1:105–112.

Murray, S. and A. Kurta. 2004. Nocturnal activity of the endangered Indiana bat (Myotis sodalis). Journal of Zoology, 262(2):197-206.

Norberg, U.M., and J.M.V. Rayner. 1987. Ecological morphology and flight in bats (Mammalia; Chiroptera): wing adaptations, flight performance, foraging strategy and echolocation. Philosophical Transactions of the Royal Society of London 316: 335–427.

O'Farrell, M.J. and W.G. Bradley. 1970. Activity patterns of bats over a desert spring. Journal of Mammalogy, 51(1):18-26.

Patriquin, K.J., L.K Hogberg, B.J. Chruszcz, and R.M.R. Barclay. 2003. The influence of habitat structure on the ability to detect ultrasound using bat detectors. Wildlife Society Bulletin 31(2):475-481.

Pfeffer, E., P. Kudlu, A. Mann, and V. Brack, Jr. 2008. Fall Mist Net Radio-Telemetry Surveys for the Indiana Bat (*Myotis sodalis*) On Fort Drum, Jefferson and Lewis Counties, New York. Final Report. Fort Drum Natural Resources Fish and Wildlife Program, Fort Drum, New York. Volume 1 of 2.

Racey, P.A. and A.C. Entwistle. 2003. Conservation ecology of bats: reproduction. Pp. 680-743 in T.H. Kunz and M.B. Fenton (eds.), Ecology of bats. University of Chicago Press, Chicago, IL.

Risch, T. S., and S. Brandebura. 2007. Roosting Ecology of the Indiana Bat in Arkansas. Final Report. U.S. Fish and Wildlife Service, Conway, Arkansas. 22 pp.

Robbins, L.W., K.L. Murray, and P.M. McKenzie. 2008. Evaluating the effectiveness of the standard mist netting protocol for the endangered Indiana Bat (Myotis sodalis). Northeastern Naturalist.15:275-282.

Rodrigue, J.L. 2004. Biological Assessment: Fernow Experimental Forest. U.S. Department of Agriculture, Forest Service, Northeastern Research Station, Parsons, WV. Final Report. 105 pp.

Rommé, R.C., A.B. Henry, R.A. King, T. Glueck, and K. Tyrell. 2002. Home range near hibernacula in spring and autumn. In, Kurta, A. and J. Kennedy, eds. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, Texas. pp. 153-158.

Rydell, J. 1991. Seasonal use of illuminated areas by foraging northern bats, Eptesicus nilssoni. Holartic Ecology, 14(3):230-207.

Rydell, J., L. Bach. M. Dobourg-Savage, M. Green, L. Rodrigues, and A. Hedenström. 2010. Bat mortality at wind turbines in northwestern Europe. Acta Chiropterologica 12(2):261-274.

Sampaio, E.M., E.K.V. Kalko, E. Bernard, B. Rodriguez-Herrera, and C.O. Handley. 2003. A biodiversity assessment of bats (Chiroptera) in a tropical lowland rainforest of Central Amazonia, including methodological and conservation considerations. Studies on Neotropical Fauna and Environment 38:17–31.

Sanders, C., J. Chenger, and B. Denlinger. 2001. Williams Lake telemetry study: New York Indiana bat spring migration tracking study. Report for Bat Conservation and Management. 21 pp.

Scherer, A. 2000. A survey for the federally listed endangered Indiana bat (Myotis sodalis), Picatinny Arsenal, Morris County, New Jersey. Report prepared for U.S. Army Tank, Automotive and Armaments Command, Armament Research Development and Engineering Center, Picatinny Arsenal, Morris County, NJ. 27+ pp.

Schnitzler, H.U., and E.K.V. Kalko. 2001. Echolocation by insect-eating bats. Bioscience 51:557–69.

Schnitzler, H.U., C.F. Moss, and A. Denzinger. 2003. From spatial orientation to food acquisition in echolocating bats. Trends Ecol Evol 18:386–94.

Shiel, C.B., and J.S. Fairley. 1998. Acitvity of Leisler's bat Nyctalus leisleri (Kuhl) in the field in south-east county Wexford, as revealed by a bat detector. Biology and Environment: Proceedings of the Royal Irish Academy. 98B(2):105-112.

Sparks D.W., M.T. Simmons, C.L. Gummer, and J.E. Duchamp. 2003. Disturbance of roosting bats by woodpeckers and raccoons. Northeastern Naturalist 10:105-8.

Sparks, D.W., J.O. Whitaker, and C.M. Ritzi. 2005. Foraging ecology of the endangered Indiana bat. Journal of Mammalogy 86:713-718.

Stantec 2010. Unpublished data from ongoing research along the Bellefontaine ridge in west-central Ohio submitted to U.S. Fish and Wildlife Service.

Timpone, J.C., J.G. Boyles, K.L. Murray, D.P. Aubrey and L.W. Robbins. 2010. Overlap in roosting habits of Indiana bats (Myotis sodalis) and northern bats (Myotis septentrionalis). American Midland Naturalist 163:115-123.

Turner, G. G. 2006. Bat Migratory Behaviors and Routes in Pennsylvania and Maryland. Proceedings NWCC Wildlife Workgroup Research Planning Meeting VI, San Antonio, Texas, USA. November 14-15, 2006.

Tuttle, M.D. 1976. Population ecology of the gray bat (Myotis grisescens): philogpatry, timing and patterns of movement, weight loss during migration, and seasonal adaptive strategies. Occasional papers of the Museum of Natural History Number 54:1-38. University of Kansas, Lawrence, Kansas.

Tuttle, M.D. and D. Stevenson. 1982. Growth and survival of bats. Pages 105-150 in Ecology of Bats, Kunz (ed.).Plenum Press, New York, NY.

U.S. Fish and Wildlife Service (USFWS). 2007. Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision. U.S. Fish and Wildlife Service, Fort Snelling, MN. 258 pp.

Vaughan, N., G. Jones, and S. Harris. 1997. Habitat use by bats (Chiroptera) assessed by means of a broad-band acoustic method. Journal of Applied Ecology, 34(3):716-730.

WEST, Inc. 2011. Bat Monitoring Studies at the Fowler Ridge wind Energy Facility, Benton County, Indiana. April 13-October 15, 201 Stantec 2010. Unpublished data from ongoing research along the Bellefontaine ridge in west-central Ohio submitted to U.S. Fish and Wildlife Service 0. 76 pp. + Appen

Whitaker Jr., J. O., D.W. Sparks and V. Brack, Jr. 2004. Bats of the Indianapolis International Airport area, 1991-2001. Proceedings of the Indiana Academy of Science 113:151-161.

Whitaker, J.O., Jr. and V. Brack, Jr. 2002. Distribution and summer ecology in Indiana. Pp. 48-54 in A. Kurta and J. Kennedy (eds.), The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, TX

Winhold, L. and A. Kurta. 2006. Aspects of Migration by the Endangered Indiana Bat, Myotis sodalis. Bat Research News 47:1-11.