United States Department of the Interior

FISH AND WILDLIFE SERVICE

Ecological Services
4625 Morse Road, Suite 104
Columbus, Ohio 43230
(614) 416-8993 / FAX (614) 416-8994

May 17, 2017

Kristin Kerwin
Department of Energy
Golden Field Office
15013 Denver West Parkway
Golden, CO 80401-3393

TAILS# 03E15000-2015-F-1224

Re: Biological Opinion for a Bat Acoustic Deterrent Study by Bat Conservation International, Blue Creek Wind Energy Facility, Ohio

Dear Ms. Kerwin,

This letter acknowledges the U.S. Fish and Wildlife Service's May 9, 2017 receipt of your comments on the Draft Biological Opinion (BO) for the subject project. The comments you provided have been addressed and the final BO and Incidental Take Statement are enclosed.

This concludes consultation on this action as required by section 7(a)(2) of the Endangered Species Act. Should, during the term of this action, additional information on listed or proposed species or their critical habitat become available, or if new information reveals effects of the action that were not previously considered, consultation with the Service should be reinitiated to assess whether the determinations are still valid.

If you have questions or concerns about this consultation or the consultation process in general, please feel free to contact Biologist Megan Seymour, Megan_Seymour@fws.gov, 614-416-8993 ext. 16.

Sincerely,

Angela L. Boyer

for Dan Everson
Field Supervisor

cc: Nathan Reardon, ODNR-DOW
Kate Parsons, ODNR-DOW
Melissa Moser, ODNR-DOW

BIOLOGICAL OPINION

on the

Ultrasonic Acoustic Bat Deterrent Study at Blue Creek Wind Energy Facility

for the

Federally Endangered Indiana Bat (*Myotis sodalis*)

Submitted to the U.S. Department of Energy

May 17, 2017

Prepared by:

U.S. Fish and Wildlife Service
Ohio Ecological Services Field Office
4625 Morse Road, Suite 104
Columbus, Ohio 43230

Angela Boyer
for
Dan Everson, Field Supervisor
Ohio Ecological Services Field Office

Table of Contents

Figures

Tables

INTRODUCTION

In accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.), this document transmits the U.S. Fish and Wildlife Service's (USFWS) Biological Opinion (BO) based on our review of the U.S. Department of Energy's (DOE) formal consultation initiation packaged for an ultrasonic acoustic bat deterrent study (proposed study) at the Blue Creek Wind Energy Facility (Blue Creek), Paulding and Van Wert Counties, Ohio. DOE has determined that the study is likely to adversely affect the federally endangered Indiana bat (*Myotis sodalis*) and federally threatened northern long-eared bat (*Myotis septentrionalis*). On March 16, 2017, USFWS received DOE's request for formal consultation. The USFWS determined that the initiation package was complete in accordance with 50 CFR §402.14. Thus, formal consultation was initiated on March 16, 2017.

The northern long-eared bat was listed as a federally threatened species on April 2, 2015. With the species' listing, the USFWS published an interim, species-specific rule pursuant to section 4(d) of the ESA (80 FR 17973). On January 14, 2016, the USFWS published a final, species-specific rule pursuant to section 4(d) of the ESA (80 FR 17973). Section 4(d) of the ESA states that:

> *Whenever any species is listed as a threatened species… the Secretary shall issue such regulations as he deems necessary and advisable to provide for the conservation of such species (*16 U.S.C. 1533(d)).

The USFWS's final 4(d) rule for the northern long-eared bat exempts some take of the species from section 9 prohibitions of the ESA. The exemptions described below apply to federal agencies for actions located partially or wholly inside the WNS zone. All of the state of Ohio is inside the WNS zone. The following take of northern long-eared bats is exempted under the final 4(d) rule:

1) Take that is incidental to activities that do not involve tree removal and do not take place within hibernacula or would not alter the hibernaculum's entrance or environment, even when the bats are not present at the hibernaculum.
2) Take that is incidental to removal of hazardous trees.
3) Take that is incidental to removal of trees, at any time, beyond 0.25 mile of a hibernaculum.
4) Take that is incidental to removal of trees, at any time, beyond 150 feet of a known occupied maternity roost tree; or take that is incidental to removal of trees within 150 feet of a known roost tree between August 1 and May 31.
5) Purposeful take in defense of human life, including for public health monitoring.
6) Purposeful take that results from removal of bats from human structures, but only if the actions comply with all applicable State regulations.

Northern long-eared bats can be killed from operation of wind turbines, and may be killed during implementation of the proposed study. This take would fall under take exempted by the 4(d) rule. Within the *Key to the Northern Long-Eared Bat 4(d) Rule for Federal Actions that May Affect Northern Long-Eared Bats,* published by the USFWS on January 13, 2016, it states that Federal agencies may rely on the Intra-Service Programmatic Biological Opinion to fulfill their project-specific section 7(a)(2) responsibilities. Thus, take of Northern long-eared bats associated with this project are addressed under the Programmatic BO and is not addressed further in this document.

The federal action requiring formal consultation and this biological opinion is the expenditure of federal funds to conduct studies to determine the effectiveness of bat acoustic deterrent devices at reducing bat mortality at a wind project. In this opinion the USFWS has determined that the federal action may result in incidental take of Indiana bats, but that this take will not jeopardize the continued existence of this species.

This Biological Opinion (BO) is based on information provided in the BA, meetings, telephone conversations, and e-mail exchanges among the USFWS, DOE, Avangrid Renewables (Avangrid) (owner of Blue Creek), and Bat Conservation International (BCI) and U.S. Geological Survey (USGS) who propose to implement the study, and other sources of information. A complete administrative record of this consultation is on file at the USFWS's Ohio Field Office.

CONSULTATION HISTORY

Table 1 presents a summary of the primary points in the consultation history.

Table 1 Summary of consultation history.

DATE	EVENT/ACTION
November 7, 2016	BCI, Avangrid, and USFWS call to discuss the proposed acoustic deterrent study at the Blue Creek Wind Energy Facility
November 11, 2016	Avangrid email summarizing goals of study, next steps, and action items
November 22, 2016	BCI email providing draft proposed study design
November 30, 2016	BCI, Avangrid, DOE, USGS, and USFWS meeting to discuss revisions to the draft proposed study design
December 30, 2016	BCI email submitting revised proposed study design
January 9, 2017	BCI, Avangrid, USFWS call to discuss modifications to the revised proposed study design. USFWS follows call with email providing recommended modifications.
February 8, 2017	BCI email submitting final study design
February 13, 2017	DOE and USFWS call to discuss components of initiation package
March 16, 2017	USFWS receives complete initiation package.

BIOLOGICAL OPINION

I. DESCRIPTION OF THE PROPOSED ACTION

Bat fatalities at wind power facilities can be very high and are the highest source of bat mortality from any anthropogenic cause (Cryan and Barclay 2009). Post-construction monitoring reports at wind energy sites across the Midwest and eastern U.S. and Canada indicate that bats are killed by colliding with spinning turbine blades at wind energy sites each year. The cumulative impact of annual mortality and the predicted expansion of wind energy facilities across the U.S. could cause population level effects to some species (Erickson et al. 2016; Frick et al. 2017). Thus, research into methods to reduce bat fatality at wind projects is paramount.

Methods for monitoring carcasses and estimating bat mortality rates at wind facilities are well established, but biases vary between sites and over time (Arnett et al. 2008). Carcass distribution patterns relative to the area searched for carcasses is a bias that can be very influential in estimating bat mortality rates. Recent evidence from Blue Creek suggests that turbines operating at higher wind speeds may result in a distribution of bat carcasses further from the turbine compared to turbines operating at lower wind speeds (Good et al. 2016). Carcass distribution patterns under various operational wind speeds need to be better understood to better ensure that bat mortality estimates are correctly addressing this bias.

DOE is proposing to provide federal funding to BCI and its research partners to conduct a study of ultrasonic acoustic deterrent devices at the Blue Creek Wind Energy Facility in Paulding and Van Wert Counties, Ohio (Figure 1). This existing wind facility is owned by Avangrid Renewables. The proposed study is designed to measure the effectiveness of bat deterrent devices at wind farms and to investigate the distribution of bat carcasses between control turbines and turbines operating with measures to reduce bat mortality. The study would occur from June 14-October 3, 2017.

Figure 1. Blue Creek Wind Energy Facility, in Paulding and Van Wert Counties, Ohio

BCI has studied methods to reduce bat fatalities at turbines for many years. Early studies focused on the use of raised cut-in speeds (the wind speeds at which wind turbine blades begin turning) and feathering of blades (orienting turbine blades so that they do not catch the wind). These studies documented a significant reduction in bat mortality from elevating cut-in speeds and feathering blades (Arnett et al. 2009; Hein et al. 2014) compared to control turbines. Subsequent studies by others also documented reductions in all-bat fatality rates from using elevated cut-in speeds and feathering (Table 2). The studies included in Table 2 generally support the concept that higher cut-in speeds result in lower all-bat fatality rates, and that feathering blades results in lower bat fatality rates than not feathering blades.

Table 2. Results from Publicly Available Cut-in Speed and Feathering Studies

Study Name	Normal Cut-in Speed (m/s)[1]	Treatment Cut-in Speed (m/s)	Mean Percent Reduction in Mortality	Mean Percent Reduction in Mortality Per Cut-in Speed	Source
Fowler Ridge, IN 2011[a]	3.5	3.5	36	36	Good et al. 2012
Summerview, Alberta[a]	4.0	4.0	58	58	Baerwald et al. 2009
Fowler Ridge, IN 2011	3.5	4.5	57	52	Good et al. 2012
Anonymous Project (AN01), USFWS Region 3	3.5	4.5	47		Arnett et al. 2013
Casselman, PA 2008	3.5	5.0	82	61	Arnett et al. 2010
Casselman, PA 2009	3.5	5.0	72		Arnett et al. 2010
Fowler Ridge, IN 2010[b]	3.5	5.0	50		Good et al. 2011
Pinnacle, WV 2012[c]	3.0	5.0	47		Hein et al. 2013
Pinnacle, WV 2013	3.0	5.0	54		Hein et al. 2014
Summerview, Alberta	3.5	5.5	60	68	Baerwald et al. 2009
Fowler Ridge, IN 2011	4.0	5.5	73		Good et al. 2012
Anonymous Project (AN01), USFWS Region 3	3.5	5.5	72		Arnett et al. 2013
Sheffield, VT[d]	4.0	6.0	60	60	Arnett et al. 2013
Casselman, PA 2008	3.5	6.5	82	77	Arnett et al. 2010
Casselman, PA 2009	3.5	6.5	72		Arnett et al. 2010
Fowler Ridge, IN 2010[b]	3.5	6.5	78		Good et al. 2011
Pinnacle, WV 2013	3.0	6.5	76		Hein et al. 2014

[a] Manufacturer's cut-in wind speed was not raised, but turbines were feathered under normal cut-in wind speed
[b] Study did not include feathering below cut-in speed
[c] This effect was only found when an outlier (i.e., a night when 7 fatalities were recovered from a 5 m/s all night treatment turbine) was removed from the dataset
[d] Raised cut-in speeds were applied only when temperatures were above 49° F (9.5° C)

Beginning in 2006, BCI began investigating the use of ultrasonic acoustic deterrents to reduce bat fatalities at wind energy facilities. This research was promising, but the technology required further refinement to prove effective. BCI has been working for several years to improve the design and functionality of the ultrasonic deterrent, and it is now ready for additional testing. DOE has awarded funding to test the deterrent during 2017 and BCI has selected the Blue Creek project as the location for the study. Blue Creek has conducted mortality studies since 2012 so substantial baseline information is available and established search plots exist.

The deterrent study will involve 16 of the 152 turbines at Blue Creek. At these 16 turbines, daily searches for bat carcasses will be conducted along 5-m wide transects within a cleared, 90-m radius of each turbine. Monitoring will occur from June 14-October 3, 2017, which incorporates the dates of highest bat fatalities across all previous years of monitoring at Blue Creek.

[1] Note that in some cases mean reductions for given operational adjustment treatments have been combined for studies with different "normal" cut-in speeds. It is recognized that there may be differences in mortality rates attributable to differences in the normal cut-in wind speed used; however, variation in operational parameters of different turbines and site-specific factors make it impossible to account for this difference in any predictable, quantitative way.

The 16 turbines will be subject to a randomized block design of four treatments: control turbines (deterrents off and turbines operating at manufacturer's cut-in speed); deterrent-equipped turbines (deterrents on and turbines operating at manufacturer's cut-in speed); operational minimization turbines (deterrents off and turbines feathered up to a 5.0 m/s cut-in speed); and combination turbines (deterrents on and turbines feathered up to a 5.0 m/s cut-in speed).

Bat fatality among the four treatments will be compared to assess differences in all-bat fatality rates and differences in fatality rates between species and echolocation frequency group if sample size allows. This will be the first test of potential synergistic effect of both cut-in speeds and acoustic deterrents. Bat carcass distribution will also be recorded for all treatment types.

The remaining 136 turbines will be feathered up to a 5.0 m/s cut-in speed. These turbines will be monitored every 3 days from June 14-October 3, 2017 on roads and pads out to120 m from the turbine. Data collected will be used to assess whether the fall distribution of carcasses can be accurately estimated using carcasses observed only from road and pad searches, and whether the fall distribution of fatalities at turbines operating at 5.0 m/s compared to normally operating turbines is different. If sample size allows, analysis of carcass distribution relative to wind direction may also occur.

The results of the study will be provided to DOE and the Bats and Wind Energy Cooperative for peer-review. Manuscripts will be submitted for publication and results will be disseminated at professional conferences.

Action Area

The action area includes all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area is defined by measurable or detectable changes in land, air, and water. The action area is not limited to the "footprint" of the action and should consider the biotic, chemical, and physical impacts to the environment resulting from the action.

All actions associated with this study will occur within the boundary of the Blue Creek Wind Energy Facility, and are associated with the operation and monitoring of the existing wind turbines. Impacts to the environment are limited to clearing search areas around turbines either by mowing or chemical application. Changes to the operational regime of all turbines at Blue Creek will occur, which may influence bat mortality at each turbine. Thus, the action area for this BO is defined as the boundary of the Blue Creek Wind Energy Facility (Figure 2).

The action area is 40,481 acres in size and is located within the Huron/Erie Lake Plain Ecoregion, which is characterized by relatively flat topography and formerly supported elm and ash swamps and beech forests. Today the action area has been cleared and drained and is dominated by corn, soybean, livestock, and vegetable farms. Only small isolated wooded parcels remain within approximately 1% of the action area.

The Blue Creek project supports 152 2.0 megawatt Gamesa G90 turbines. The manufacturer's cut-in speed of these turbines is 3.0 m/s. The turbine towers are 100 meters tall and the blades are 45 m long. Each turbine is surrounded by a gravel pad extending about 3 m from the turbine. Access roads extend from county and township roads to each turbine, and each turbine is serviced by underground electric and communication cables that allow turbines to be operated remotely. There are two electrical substations and one operations and maintenance building that cover roughly 9 acres of land.

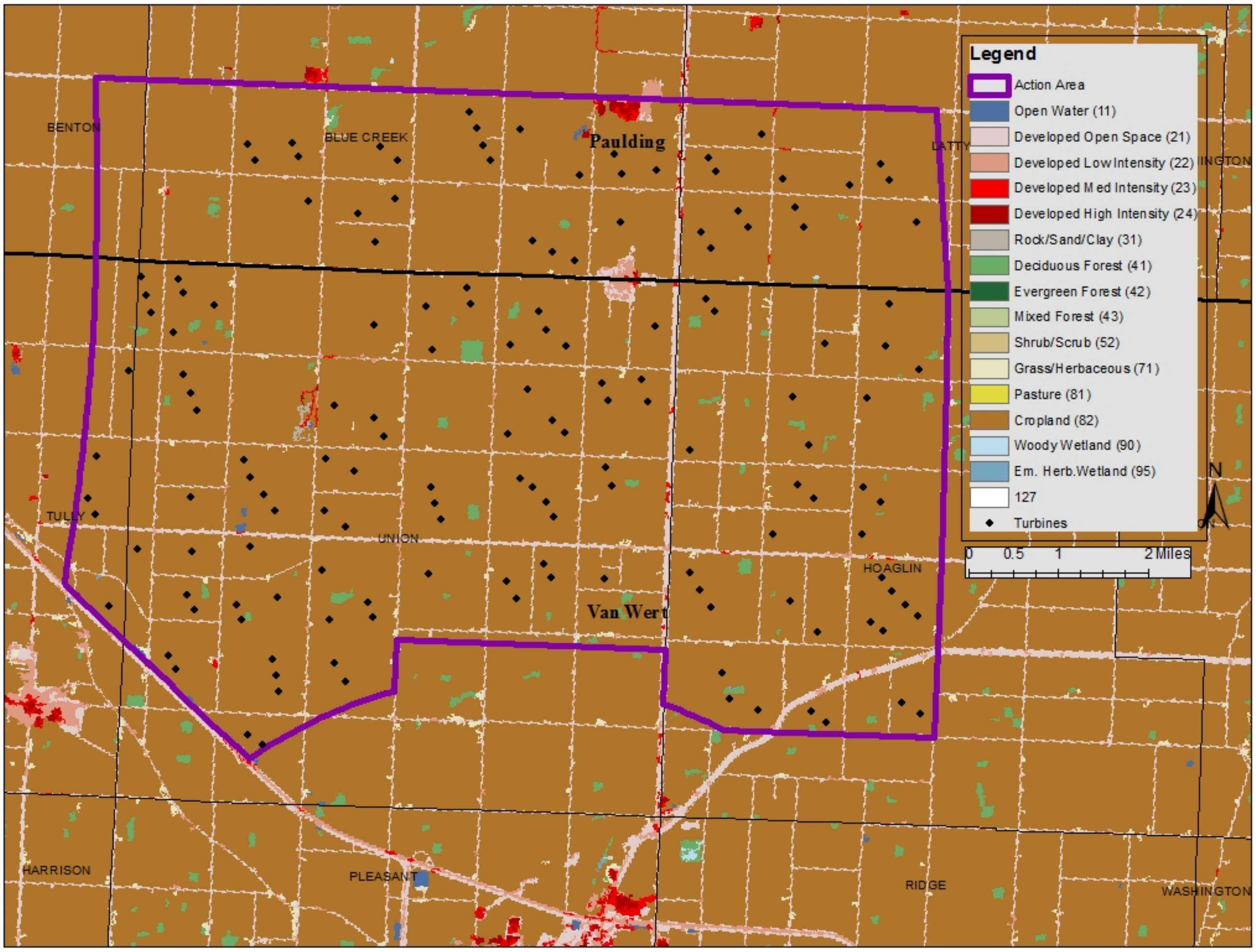


Figure 2 Map of Action Area, showing cropland as dominant land cover.

II. STATUS OF THE SPECIES

The Indiana bat was officially listed as an endangered species on March 11, 1967 (Federal Register 32[48]:4001), under the Endangered Species Preservation Act of October 15, 1966 (80 Stat. 926; 16 U.S.C. 668aa[c]). The ESA subsequently extended full legal protection from unauthorized take to the species.

Description and Distribution

The Indiana bat is a temperate, insectivorous, migratory bat that hibernates in caves and mines in the winter and summers in wooded areas. It is a medium-sized bat, having a wing span of 23 to 28 cm (9 to 11 in) and weighing only 7.1 g (0.25 oz.). It has brown to dark-brown fur and the facial area often has a pinkish appearance. The Indiana bat closely resembles the little brown bat (*Myotis lucifugus*) and the northern long-eared bat (*Myotis septentrionalis*). It is distinguished from these species primarily by its foot structure and fur color. The Indiana Bat Draft Recovery Plan (USFWS 2007) provides a comprehensive summary of the description of the species and is incorporated here by reference.

Life History and Population Dynamics

The Indiana bat is a migratory bat, hibernating in caves and mines in the winter (typically October through April) and migrating to summer habitat in the spring. Although some Indiana bat bachelor colonies have been observed (Hall 1962, Carter et al. 2001), males and non-reproductive females typically do not roost in colonies, and may stay close to their hibernacula (Whitaker and Brack 2002) or migrate long distances to their summer habitat (Kurta and Rice 2002). Some reproductive females have been documented to migrate up to 574.5 km (357 mi) (Winhold and Kurta 2006) to form maternity colonies. Some maternity colonies form within a few miles of their hibernacula. Both males and females migrate back to hibernacula in late summer or early fall to mate and store up fat reserves for hibernation. By mid-November, male and female Indiana bats have entered hibernation. They typically emerge in April, at which time they again migrate to summer habitat. The Indiana Bat Draft Recovery Plan (USFWS 2007) provides a comprehensive summary of Indiana bat life history.

Fall Swarming, Mating, and Hibernation

From late-August to mid-October, prior to entering the hibernacula, large numbers of bats fly in and out of cave or mine openings from dusk until dawn in a behavior called swarming. During swarming large numbers of bats fly in and out of cave entrances from dusk to dawn, while relatively few roost in caves during the day. Swarming usually lasts for several weeks and mating occurs toward the end of this period. Male Indiana bats tend to be active for a longer period of time than females during swarming and will enter the hibernacula later than the females (USFWS 1999). Adult females store sperm through the winter thus delaying fertilization until early May. Temperature and relative humidity are important factors in the selection of hibernation sites. Beginning in early autumn, Indiana bats roost in warm sections of caves and move down a temperature gradient as temperatures decrease. During winter, Indiana bats are restricted to suitable underground habitats known as hibernacula. The majority of hibernacula consist of limestone caves, especially in karst areas of east central United States, but abandoned underground mines, railroad tunnels, and even hydroelectric dams can provide winter habitat throughout the species' range (USFWS 2007). Indiana bats tend to roost in portions of the cave where temperatures are cool (37 to 43 degrees Fahrenheit). Relative humidity in Indiana bat hibernacula tends to be high, ranging from 66 percent to 95 percent (Barbour and Davis 1969). Ohio contains one Priority 2 and one Priority 3 hibernacula (USFWS 2007). Including these two Priority hibernacula, Ohio has seven hibernacula where Indiana bat hibernation has been observed.

Spring Emergence

Spring emergence occurs when outside temperatures have increased and insects are more abundant (Richter et al. 1993). Some bats may remain in close proximity to the cave for a few days before migrating to summer habitats. During this mid-spring period, adult females occupy trees that are similar to those used in summer in terms of species, size, and structure (Britzke et al. 2003, Butchkoski and Turner 2005, Britzke et al. 2006). This activity is known as spring staging. Others head directly to summer habitat. Migration distances range from a few miles to over 483 km (300 mi) (Winhold and Kurta 2006).

Migration

Fall migration begins when male and non-reproductive female Indiana bats start leaving their summer habitat as early as late-July and begin arriving at hibernacula in August (USFWS 2007). Females and juveniles from maternity colonies disperse as early as August or as late as early October (Humphrey et al. 1977, Kurta et al. 1993, Kurta and Rice 2002).

Spring migration generally begins in late March to early April, and is complete by mid-May, with females typically departing earlier than males (Cope and Humphrey 1977, LaVal and LaVal 1980). Weather conditions and latitude may influence spring emergence times (Hall 1962). Weather may also influence migration behavior, as Roby and Gumbert (2016) reported that both spring and fall migrating bats ceased migrating or did not begin nightly migration at all when ambient temperatures were below 50 degrees F.

Little is known about the behavior of Indiana bats during migration. Bats may try to minimize the time spent in transit, because migration is energetically expensive and dangerous (Fleming and Eby 2003). This may be especially true for reproductive females during the spring when they are pregnant and energetically constrained from spending the winter in hibernation.

Most of what is known about fall migration comes from band returns (i.e., individuals banded during the summer are discovered during hibernacula counts), which provide information about migration distances and beginning and ending destinations, but not information about migration routes (Figure 3). One recent study in Indiana found that fall migrating Indiana bats flew faster and in a straighter trajectory in fewer nights than spring migrating bats (Roby and Gumbert 2016). They also found that the two Indiana bats they tracked completed fall migration in one night, avoided brightly lit areas, and flew nearly all night (8.5 and 10.8 hours) (Roby and Gumbert 2016). A 2014 fall migration telemetry study conducted on a population of Indiana bats in the Middle Fork of the Vermillion River riparian corridor showed that most tagged individuals did not appear to follow the river corridor when the maternity colonies broke up, but rather headed northeast across the open landscpae (Boyles and McGuire, unpublished report). The discoveries of seven Indiana bat carcasses at various wind power facilities in Ohio, Indiana, Pennsylvania, and Illinois in the fall demonstrates that some individuals cross open, treeless landscapes during the fall migration.

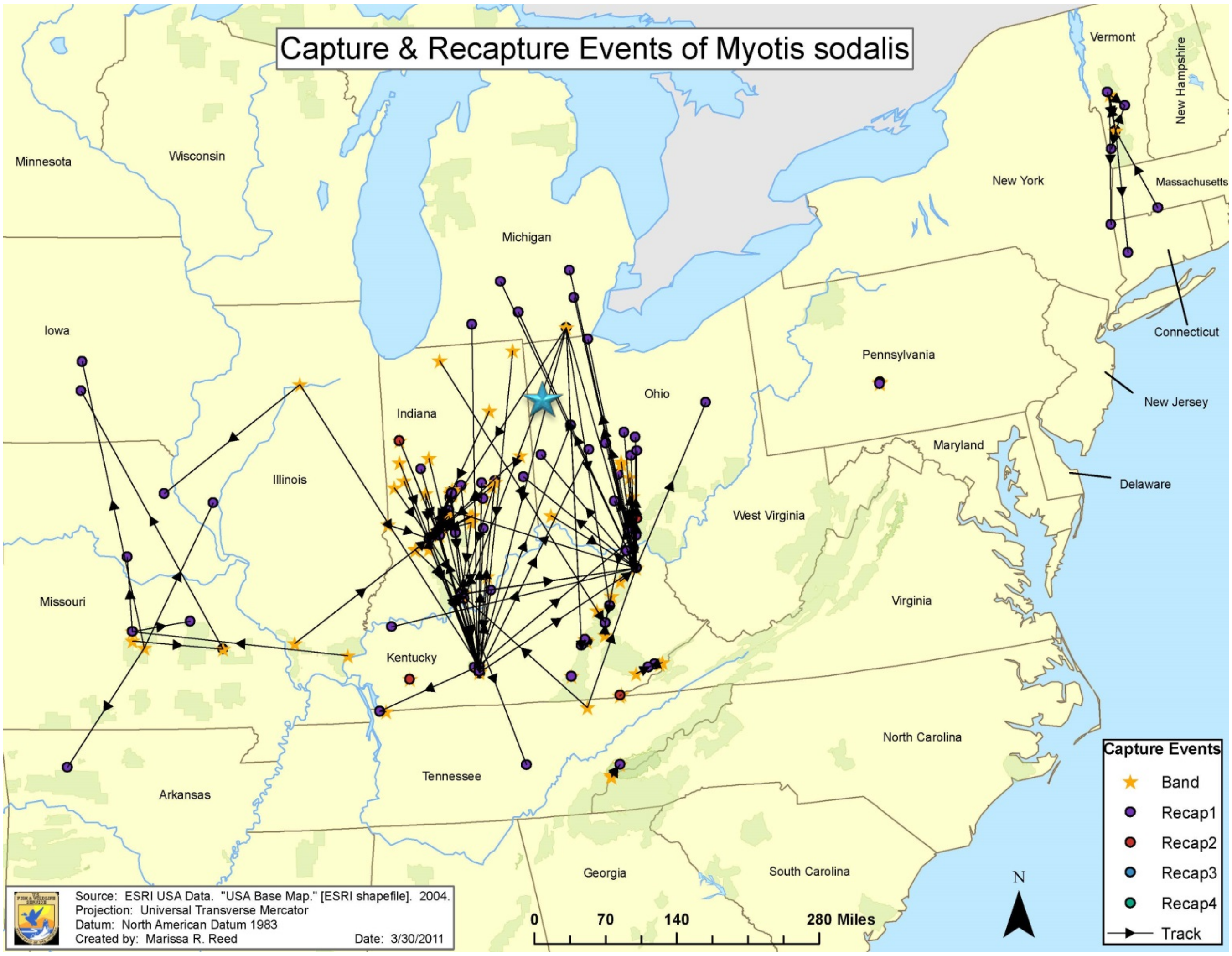


Figure 3 Locations of marked and recaptured Indiana bats with inferred straight-line trajectories between summer and winter habitats. The Blue Creek Wind Energy Facility is indicated with a blue star.

Indiana bats in the Midwest Recovery Unit appear to primarily migrate from hibernacula in Kentucky and Indiana to summer ranges to the north based on band recovery information (Figure 3) (Gardner and Cook 2002, Whitaker and Brack 2002, Winhold and Kurta 2006). Twelve female Indiana bats 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), which is the maximum migration distance recorded for the species. Gardner and Cook (2002) also reported long-distance migrations for Indiana bats traveling between summer ranges and hibernacula in the Midwest. Some non-reproductive female and male Indiana bats do not migrate as far as reproductive females, and instead remain in the vicinity of their hibernacula throughout the summer (Gardner and Cook 2002, Whitaker and Brack 2002).

Evidence from radio-tracking studies in New York and Pennsylvania indicate that Indiana bats are capable of migrating at least 48-64 km (30-40 mi) in one night (Sanders and Chenger 2001, Hicks et al. 2005, Butchkoski and Turner 2006) and a fall migration study in Indiana found Indiana bats migrating approximately 200 km in one night (Roby and Gumbert 2016).

Spring radio telemetry studies have documented migrating Indiana bats traveling in relatively direct flight patterns towards their summer habitat. Eighty-two female Indiana bats radio tracked to 65 maternity colonies in New York from 2000 to 2005 followed more or less direct routes from the hibernacula to their summer ranges (Hicks et al. 2005). Indiana bats tracked from a hibernaculum in Pennsylvania flew almost straight lines to their roost trees 135 km to 148 km (83 mi to 92 mi) away in Maryland (Butchkoski and Turner 2005). Roby and Gumbert (2016) tracked two bats both of which flew in relatively straight paths from hibernacula to summer habitat. They found that spring migration took longer than fall migration and that Indiana bats stop to forage during spring migration. A 2011 spring migration study at the Blackball Mine hibernaculum in Illinois documented that the majority of tracked Indiana bats emerging from Blackball travelled south and west down the forested Illinois River corridor (Hicks et al. 2012). An Indiana bat mortality was noted during spring migration at a nearby wind facility in Ohio located in an agricultural setting. Similar to fall migration, this mortality indicates that Indiana bats will migrate across open areas during spring and may be at risk from wind projects during spring migration.

Female Maternity Colony and Summer Roosting Habitat

Indiana bats first arrive at their summer locations as early as April or early May (Humphrey et al. 1977, Kurta and Rice 2002). During summer, female and juvenile Indiana bats almost always roost in trees, as do adult males. While Indiana bats primarily roost in trees, some colonies have been found in artificial roost sites (e.g., buildings, bat boxes, utility poles), however this is uncommon (USFWS 2007).

Females form maternity colonies once they arrive at their summer roosting habitat. Females usually start grouping into larger maternity colonies by mid-May and give birth to a single young between late June and early July (Humphrey et al. 1977). These colonies are typically located under the sloughing bark of live, dead and partially dead trees in upland and lowland forest (Humphrey et al. 1977; Gardner et al. 1991). Colony trees are usually large-diameter, standing dead trees with direct exposure to sunlight. Direct solar exposure on the tree surface provides increased temperatures within the roost fostering development of fetal and juvenile young (Racey 1982). The average maternity colony size is 50 to 80 adult females (Whitaker and Brack 2002). With pups, a maternity colony could contain 100 or more Indiana bats.

Densities of tree-roosting bats are generally greater in old growth forests in temperate regions where structural diversity provides more roosting options (Crampton and Barclay 1996, Brigham et al. 1997, Racey and Entwistle 2003). Within the range of the Indiana bat, particularly within the core maternity range in the Midwest (including Ohio) old growth forest has been virtually eliminated. While the forest cover in Ohio has increased since the Indiana bat became federally listed in 1967, the composition of these forests is primarily second growth forest. Forest quantity is not necessarily a reliable indicator of increased suitable Indiana bat habitat. Habitat suitability models for the Indiana bat have been developed (Rommé et al. 1995, Farmer et al. 2002) that suggest density of suitable roost trees may be the only reliable predictor of habitat suitability

Roost trees often provide suitable habitat as a maternity roost for only a short period of time. Roost trees are ephemeral in nature; suitable trees fall to the ground or lose important structural characteristic such as bark exfoliation (Gardner et al. 1991; Britzke et al. 2003). Dead trees retain their bark for only a certain period of time (about 2-8 years). Once all bark has fallen off a tree, it is unsuitable to the Indiana bat for roosting. Gardner et al. (1991) found that 31% of Indiana bat occupied roost sites were unavailable the summer following their discovery; 33% of the remaining occupied roost sites were unavailable by the second summer. For this reason, an area must provide a continual supply of suitable roost trees in order to support a colony over the long-term.

Lacki et al. (2009) analyzed published and gray literature on 915 summer roost trees used by both sexes of Indiana bats, and USFWS (2007a) also summarized roost tree data available through 2004. Table 3 summarizes the findings on Indiana bat roost tree use.

Table 3. A summary of Indiana bat summer roosting habitat tree characteristics compiled in USFWS (2007a) and Lacki et al. (2009).

Data Source	Age/Sex	Average Diameter (cm)	Average Height of Tree (m)	Average Height of Exit (m)	Average Total Bark Remaining (%)	Average Canopy Cover (%)	Snag Density (#/ha.)	Roost Location
USFWS 2007	Adult ♀ &, Juvenile ♂ & ♀	45 ± 2	20 ± 1	9 ± 1	59 ± 5	50 ± 10	na	na
USFWS 2007	Adult ♂	33 ± 2	18 ± 1	10 ± 1	57 ± 1	63 ± 10	na	na
Lacki et al 2009	Mixed adult and juvenile ♀and ♂	41.4 ± 2.4	na	8.6 ± 0.5	na	na	66.6 ± 16.6	30.0% used crevices

Female Indiana bats have shown strong site fidelity to both their summer maternity grounds and specific roost trees, and will use suitable roost trees in consecutive years, if they remain standing and have sloughing bark (Gardner et al. 1991; Callahan et al. 1997; Kurta and Murray 2002). Traditional summer areas are essential to the reproductive success of local populations. The distance and time that female Indiana bats will search to find new roosting habitat if their traditional roost habitat is lost or degraded is unknown. If they are required to search for new roosting habitat this effort is assumed to place additional stress on pregnant females at a time when fat reserves are low or depleted and they are already stressed from the energy demands of migration. Belwood (2002) anecdotally described the effects of a lost roost tree and the apparent reestablishment of the colony 20 m (65.6 ft.) from the lost tree.

The number of roosts that are critical to the survival of a colony is unknown, but the temporary nature of the use of the roost trees dictates that several must be available in an area if the colony is to return to the same area and raise their young successfully. Indiana bats require many roost trees to fulfill their needs during the summer. Callahan et al. (1997) report 10-20 trees may be used each summer. In Michigan, Indiana bats used two to four different roost trees during the course of one season (Kurta and Williams 1992). In Missouri, each colony used between 10-20 roost trees, and these were not widely dispersed (all within a circle ranging in size from 0.81 to 1.48 km (0.5 to 0.9 mi)) (Miller et al. 2002).

The important factors associated with roost trees are their ability to protect individuals from the elements, and to provide thermal regulation of their environment. Maternity colonies have at least one primary roost, which is generally located in an opening or at the edge of a forest stand. Maternity colonies also use multiple alternate roosts which are located in the open or in the interior of forest stands. Exposure to sunlight is important during development of fetal and juvenile young. In Missouri, use of dead trees in the forest interior increased in response to unusually warm weather (i.e., shading provided a cooler thermal environment), and use of live trees and snags in interior forest increased during periods of precipitation (Miller et al. 2002). Maternity colonies in North Carolina and Tennessee used roosts located above the surrounding canopy (Britzke et al. 2003).

Studies have shown that 97% of trees used as maternity roosts are deciduous species; however, a few coniferous trees have also been used (Harvey 2002, Britzke et al. 2003, Palm 2003). The predominance of deciduous trees used as roosts reflects greater availability of these species in the range of the Indiana bat, as other species of bats roost in conifers and Indiana bats use coniferous trees during autumn swarming (Gumbert et al. 2002). Male and juvenile bats have also shown variability in their selection roost trees. Both males and females have been known to use coniferous tree species for roosts (USFWS 2007).

Non-reproductive females and males may roost individually or in small groups, and occasionally are found roosting with reproductive females. Adult males have been found to use mature forests near their hibernacula for roosting and foraging from spring through fall. Others have been found migrating far from their hibernacula area (Hobson and Holland 1995; Timpone 2004). Male Indiana bats also exhibit summer habitat philopatry.

Roosting habitat for male Indiana bats appears similar to female bats, and males and females have been caught using the same general area (e.g., Fishhook Creek, Illinois, Gardner et al. 1991). However, there are often notable gender differences in roost tree size and the juxtaposition of roosting and foraging areas. Male Indiana bats have been found roosting in trees as small as 6.4 cm (2.5 in) dbh (Gumbert 2001), although the average diameters reported in literature are much larger: 38.1 cm (14.9 in) in Indiana (n=14, Brack et al. 2004) and 28.6 cm (11.2 in) in Kentucky (n=41, Gumbert 2001). As male bats roost solitarily or in small groups, the size of the roost tree in terms of its available roosting space, is not likely a limiting factor. Male bats must thermoregulate, thus roost tree size and other characteristics affecting the microclimate of the roost site are still germane. The connectivity between roosting and foraging sites may not be as critical for males as it is for maternity colonies because the latter must have prey close to their roost trees for nursing females and newly volant bats.

Foraging

Indiana bats feed exclusively on flying aquatic and terrestrial insects. Although no consistent trends exist, diet appears to vary across their range, as well as seasonally and with age, sex and reproductive-status (Murray and Kurta 2002; Belwood 1979). Murray and Kurta (2002) found that diet is somewhat flexible across the range and that prey consumed is potentially affected by regional and local differences in bat assemblages and/or availability of foraging habitats and prey. For example, Lee and McCracken (2004) and Murray and Kurta (2002) found that adult aquatic insects (Trichoptera and Diptera) made up 25-81% of Indiana bat diets in northern Indiana and Michigan. However, in the southern part of the species range terrestrial insects (Lepidoptera) were the most abundant prey items (as high as 85%) (Brack and LaVal 1985; LaVal and LaVal 1980; Belwood 1979). Kiser and Elliot (1996) found that Lepidopterans (moths), Coleopterans (beetles), Dipterans (true flies) and Homopterans (leafhoppers) accounted for the majority of prey items (87.9% and 93.5% combined for 1994 and 1995, respectively) consumed by male Indiana bats in their study in Kentucky. Diptera, Trichoptera, Lepidoptera, and Coleopterans also comprised the main prey of Indiana bats in Michigan (Murray and Kurta 2002), however, Hymenopterans (specifically, alate ants) were also taken when abundant.

The function of foraging habitat is to provide a source of food, but it also provides night roosts for resting and digesting meals between forays and shelter from predators. The few studies conducted to date indicate that (1) Indiana bats appear to be solitary foragers (2) individuals establish several foraging areas; likely in response to varying insect densities, and (3) individuals are faithful to their foraging areas (Kiser and Elliot 1996, Murray and Kurta 2004). Foraging areas may or may not overlap with day or night roosting areas, but individual foraging ranges commonly overlap (Menzel et al. 2001). Indiana bats generally prefer foraging in wooded areas (LaVal et al. 1976, Brack 1983, Gardner et al. 1991, Butchkoski and Hassinger 2002, and Murray and Kurta 2002), and are frequently associated with streams, floodplain forests, forested wetlands, and impounded water bodies (Garner and Gardner 1992, Murray and Kurta 2002). Woody vegetation with a width of at least 30.5 m (100 ft.) on both sides of a stream has been characterized as excellent foraging habitat (Cope et al. 1974). Indiana bats forage and fly within air space from 2 to 30 m (6 to 100 ft.) above ground level (Humphrey et al. 1977), typically in and around tree canopy and in openings (Humphrey et al. 1977, LaVal et al. 1976, Brack 1983, Garner and Gardner 1992, Gardner et al. 1996, Murray 1999).

Indiana bats will forage in small openings, but generally appear to avoid foraging over large open expanses and prefer forested areas (Humphrey et al. 1977, Brack 1983, Brack and LaVal 1985, Gardner and Gardner 1992, Murray and Kurta 2004). In Michigan, Murray and Kurta (2004) found that Indiana bats used wooded corridors for traveling and foraging, even when this required them to significantly increase their nightly commuting distance.

Another important aspect of Indiana bat habitat is mid-story clutter. It is important to discuss forest clutter for two reasons. First, when foraging in clutter, bats must detect targets amid the echoes from non-target objects (Fenton 1990). The greater the density of non-target items the more noise bats must decipher. Second, the greater the physical and acoustical clutter, the more difficult it is for Indiana bats to maneuver to avoid collisions. Indiana bats navigate and forage during flight. Foraging in less spatially complex habitats is likely to be less energetically expensive. Hence, it is acknowledged that a relatively open mid-story (<40% of trees are 2-4.7 in (5-12 cm) dbh) (Rommé et al. 1995) is an important feature of high quality Indiana bat foraging habitat.

Connectivity of the foraging area to the roosting area is also an important feature. Murray and Kurta (2002) suggested that within a home area, bats appear to be faithful to their travel corridors as they observed Indiana bats using the same corridors for more than 5 years. There have been reports of bats traveling through relatively open areas (e.g., bats documented crossing over or under bridges on I-70 in Indiana) to reach foraging habitat (USFWS 2002; Butchkoski and Hassinger 2002, Kniowski and Gehrt 2011). Whether bats in these instances are specifically choosing to use the open areas or whether they have no other option is unknown. In the case of the bats tracked in Ohio, one bat was observed travelling over an open area from one wood lot to another. For lactating females and newly volant pups, the distance between foraging and roosting sites would presumably be minimized to the extent possible. Murray and Kurta (2004) found that lactating females returned two to four times per night to their day roosts, presumably to nurse their young; while non-lactating females did not return to their day roosts. Barclay (1991) and MacGregor (1999) have found that female bats chose roost sites based on high insect abundance in the area (along with other roost suitability criteria), so that foraging doesn't come at too high an energetic cost.

The maximum distance that Indiana bats will travel to forage is unknown and studies have revealed a considerable range of movement capabilities. Foraging distances reported range between 1 and 7.8 km

(0.62-4.85 mi) for females and 1 and 3 km (0.62-1.86 mi) for males (Gardner et al. 1991, Garner and Gardner 1992; Kiser and Elliot 1996, Kniowski and Gehrt 2011). This great variability likely reflects differences in habitat quality and/or prey availability. Although the ideal configuration of a colony's or individual bat's home-range is unknown, presumably the closer the essential habitat elements are located, the better. Contiguous habitat elements reduce the travel time between foraging and day roosting areas, which will decrease exposure time to predation and reduce energetic costs of foraging.

Foraging habitat for females has been found to include forest habitats with open understories and canopy closures of 50 to 70 percent. However, other foraging habitat includes upland, bottomland, and riparian woodlands, as well as forest and cropland edges, fallow fields, and areas of impounded water (Kiser and Elliott 1996). Females tend to use larger foraging areas than males during the summer. A post-lactating female has been recorded as having a foraging range of approximately 214.5 ha (530 ac). Males have an area of approximately 56.7 ha (140 ac) (Kiser and Elliott 1996). Kniowski and Gehrt (2011) calculated home ranges for 32 Indiana bats in Ohio. Depending on the method to calculate the size, Indiana bat home ranges were estimated to be 210.5±130.6 hectares (0.84±0.52 mi^2) to 374.2±359.6 hectares (1.49±1.44 mi^2).

<u>Range-wide Status</u>

The current range of the Indiana bat includes much of the eastern half of the United States, from Oklahoma, Iowa, and Wisconsin east to Vermont, and south to northwestern Florida. The species has disappeared from, or greatly declined, in most of its former range in the northeastern United States due to the impacts of WNS. The current revised recovery plan (USFWS 2007) delineates four recovery units for the Indiana bat: Ozark-Central, Midwest, Appalachian Mountains, and Northeast. Ohio lies within the Midwest recovery unit.

Hibernacula are divided into priority groups that have been redefined in the USFWS's Draft Recovery Plan (USFWS 2007):

- Priority 1 (P1) hibernacula typically have a current and/or historically observed winter population of greater than or equal to 10,000 Indiana bats;
- P2 have a current or observed historic population of 1,000 or greater, but fewer than 10,000;
- P3 have current or observed historic populations of 50 to 1,000 bats; and
- P4 have current or observed historic populations of fewer than 50 bats.

Based on winter surveys, as of August 2015, there are a total of 27 P1 hibernacula in seven states: Illinois; Indiana; Kentucky; Missouri; New York; Tennessee; and West Virginia. A total of 56 P2, 166 P3, and 270 P4 hibernacula are also known from the aforementioned states, as well as 10 additional states.

The majority of known maternity sites have been located in forested tracts in agriculturally dominated landscapes such as Missouri, Iowa, Indiana, Illinois, southern Michigan, western Ohio, and western Kentucky, as well as the Northeast, with multiple spring emergence telemetry studies.

From 1965 to 2001, there was an overall decline in the range-wide population of the Indiana bat (USFWS 2007). Despite the discovery of many new, large hibernacula during this time, the range-wide population estimate dropped approximately 57 percent from 1965 to 2001, which has been attributed to various causes (e.g., habitat loss/degradation, forest fragmentation, winter disturbance, and environmental contaminants). Between 2001 and 2007, the estimated range-wide population increased, from 451,554 to 590,875 Indiana bats (USFWS 2013). According to the 2015 Range-wide Population Estimate for the Indiana Bat (USFWS 2015a), the total known Indiana bat population was estimated to be approximately 523,636, a 17.6 percent decrease from the 2007 range-wide estimate (Figure 4, USFWS 2015a).

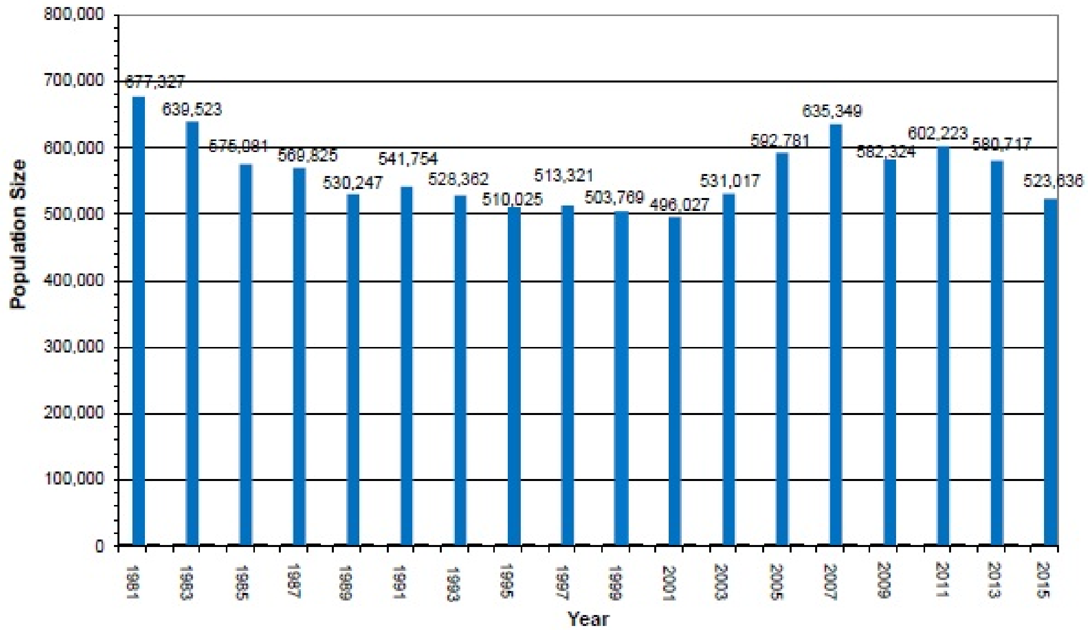


Figure 4 Indiana Bat Rangewide Population Estimates 1981-2015. (Source: USFWS 2015a)

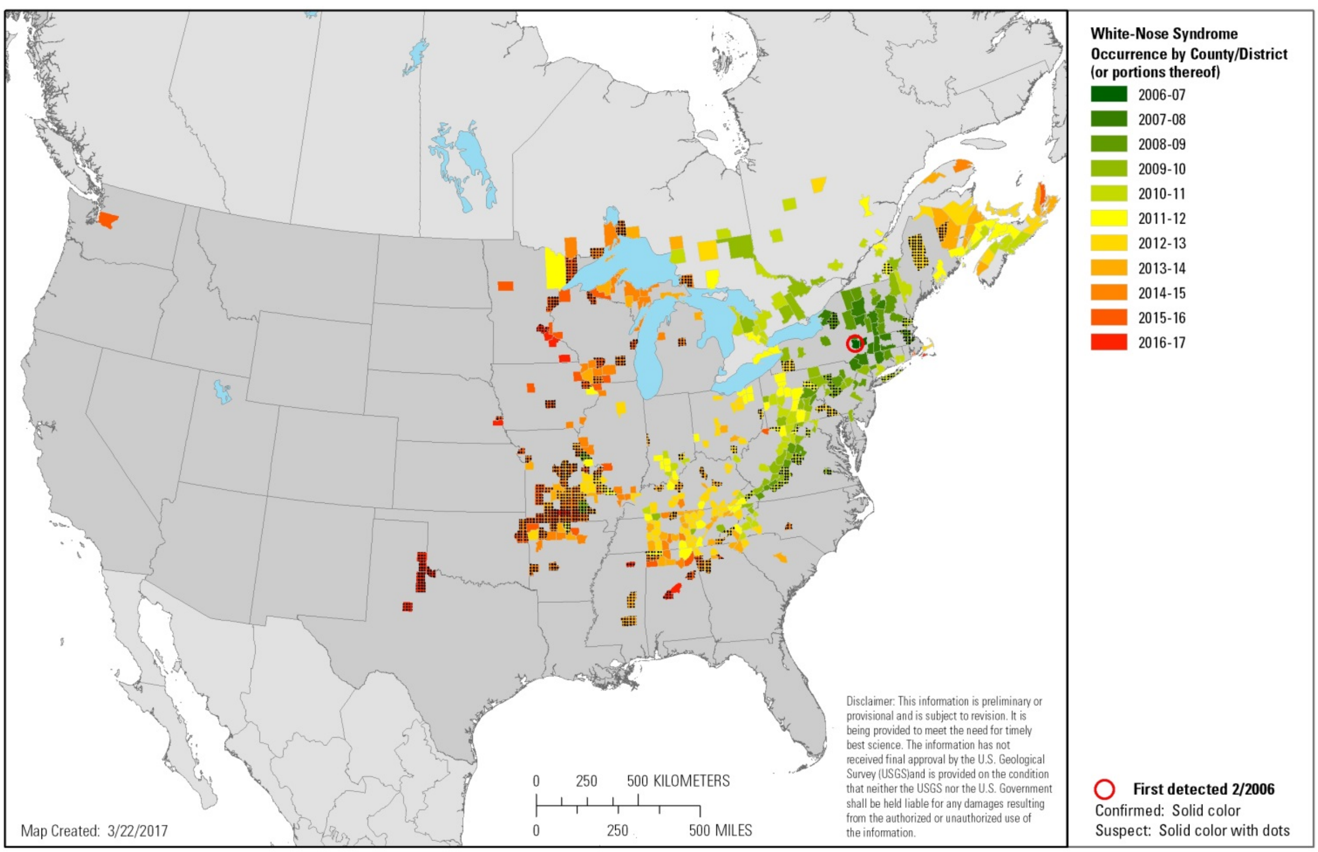
<u>Threats to the Species</u>

The Indiana bat was one of 78 species first listed as being in danger of extinction under the Endangered Species Preservation Act of 1966 because of large decreases in population size and an apparent lack of winter habitat (USFWS 1983, USFWS 1999). The 1967 federal document that listed the Indiana bat as "threatened with extinction" (32 FR 4001, March 11, 1967) did not address the five factor threats analysis later required by section 4 of the 1973 ESA. The subsequent recovery plans do address threats to the species in greater detail. Threats to the species discussed in the 2007 Recovery Plan (USFWS 2007) include the following: destruction/degradation of hibernation habitat (caves and mines); loss and degradation of summer habitat, migration habitat, and swarming habitat (especially forested habitats); disturbance of hibernating bats; predation; competition; inadequacy of existing regulations, particularly regulations that protect summer roosting habitat; natural catastrophes in hibernacula, such as flooding; and, environmental contaminants.

Since 2006, white-nose syndrome (WNS) has emerged as a new threat that may have serious implications for Indiana bat recovery. WNS primarily affects hibernating bats. Affected bats usually exhibit a white fungus on their muzzles, ears, and wings (Blehert et al. 2009). The fungus associated with WNS has been identified as *Pseudogymnoascus destructans* (formerly *Geomyces destructans*), a previously undescribed species (Minnis and Lindner 2013). The fungus thrives in the cold and humid conditions of bat hibernacula (USFWS 2011). The skin infection caused by *P. destructans* is thought to act as a chronic disturbance during hibernation (USGS 2010). The fungus invades living tissue, causing cup-like epidermal erosions and ulcers (Meteyer et al. 2009, Puechmaille et al. 2010). These erosions and ulcers may in turn disrupt the many important physiological functions that wing membranes provide, such as water balance (Cryan et al. 2010). Infected bats exhibit premature arousals, aberrant behavior, and premature loss of critical fat reserves which is thought to lead to starvation prior to spring emergence (Frick et al. 2010). It has been determined that *P. destructans* is the primary cause of death (Lorch et al. 2011).

It is believed that WNS is primarily transmitted through bat-to-bat contact. In addition, people may unknowingly contribute to the spread of WNS by visiting affected caves and subsequently transporting fungal spores to unaffected caves via clothing and gear (USFWS 2011). Within the U.S., WNS has been diagnosed on the Indiana bat, northern long-eared bat, gray bat (*Myotis grisescens*), little brown bat (*Myotis lucifugus*), eastern small-footed bat (*Myotis leibii*), tri-colored bat (*Perimyotis subflavus*), and big brown bat (*Eptesicus fuscus*).

First documented in a New York cave in 2006, WNS has since spread to 31 states and five Canadian provinces, including over 50 known Indiana bat hibernacula (Figure 5). Affected hibernacula typically exhibit significant mortality (USFWS 2013). WNS has resulted in significant population declines in the Northeast and Appalachian Recovery Units (RU). Between 2007 and 2011, the Northeast RU lost 70% of its Indiana bat population (USFWS 2013). WNS is spreading rapidly throughout the rest of the Indiana bat's range. WNS continues to be found at an increasing number of sites throughout the Midwest RU. In March 2011, the first case of WNS was confirmed in Ohio, in an abandoned mine in Lawrence County. Currently, 16 counties in Ohio have been confirmed as WNS positive (ODNR 2014).



Map depicts the first time WNS is reported suspect or confirmed in a county or district (or portions thereof); each time period in the legend spans a winter bat hibernation period.

Citation: White-nose syndrome occurrence map - by year (2017). Data Last Updated: 3/22/2017. Available at: https://www.whitenosesyndrome.org/resources/map.

Figure 5 Bat White-Nose Syndrome Occurrence Map (as of 03/23/2017).

Wind turbine operation has been documented to cause mortality of Indiana bats. To date, ten Indiana bat fatalities have been documented at wind energy facilities (USFWS 2017, A. Schorg, USFWS, pers. comm. 2017). Of these, eight have occurred within the USFWS Midwest region, including three in Ohio. Seven mortalities have occurred during fall (Aug. 1-Oct. 31), two have occurred in summer (May 15-July 31), and one has occurred in spring (April 1-May 14). A recent model suggests that the wind turbine mortality is additive and that coupled with significant population declines from WNS could result in meta-population effects, particularly to smaller winter colonies (Erickson et al. 2016).

In an effort to avoid unauthorized take of Indiana bats, the USFWS developed a take avoidance strategy centered on the operation of wind turbines. Based on an anticipated reduction in bat mortality as cut-in speeds increase (Table 2) and the small size of Indiana bats compared to long-distance migrating tree bats, USFWS has determined that feathering turbines below a cut-in speed of 6.0 m/s at night during spring and fall migration periods is likely to avoid take of Indiana bats from operating wind turbines (USFWS 2015b). Blue Creek has been operating with this strategy to avoid take since 2015.

III. ENVIRONMENTAL BASELINE

The environmental baseline is defined as the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process (50 CFR 402.02).

As described above, the action area is 40,481 acres in size, located in portions of Paulding and Van Wert Counties, and was historically forested. Since the time of European settlement land within the action area has been cleared of trees, drained, and converted primarily to agriculture, and remains primarily in agricultural use today (Figure 2). There are several hundred residential homes within the action area, and associated lawns, driveways, and outbuildings. The Villages of Haviland, Hoaglin, and Scott are entirely or partially within the action area. U.S. Route 127 runs north/south through the action area, US Route 30 is the southwest border of the action area, and U.S. Route 224 cuts through in the southeast corner. The action area is bounded on the north by State Route 114 and a network of local roads cross the action area in a north-south and east-west 1-square mile grid pattern.

In addition to agricultural and residential uses, there is an active rock quarry within the action area, approximately 135 acres in size.

As described above, the existing Blue Creek Wind Energy Facility occurs entirely within the action area. This includes 152 turbines and associated access roads, underground cables, two substations and one maintenance building. The Facility connects to an electrical transmission line that occurs in the action area.

Status of the Species within the Action Area

During the winter, Indiana bats hibernate in caves and abandoned mines. No documented hibernacula for the species exist in Paulding or Van Wert County. Thus, this species is not likely to occur in the action area during winter, roughly defined as November 1-March 31.

Ohio is considered to be in the core maternity range of the Indiana bat (USFWS 2007) and thus, all counties within Ohio could support the species during summer and during spring and fall migration, approximately April 1-October 31.

To document whether or not a maternity colony of Indiana bats occurs within the action area, Avangrid commissioned a summer mist net survey for bats. The survey was conducted July 18-25, 2016, at five sites supporting suitable forested habitat within the action area. The survey exceeded the USFWS survey protocol level of effort and weather conditions during the survey were suitable for detecting bats. No Indiana bats were captured during 2016 mist-net surveys. A total of eleven bats were captured comprising three species at three sites, including eight big brown bats (*Eptesicus fuscus*), two eastern red bats (*Lasiurus borealis*), and one hoary bat (*Lasiurus cinereus*) (Iskali et al. 2017). Thus, the USFWS assumes that no summer maternity colonies of Indiana bat occur within the action area.

Bat acoustic call data has been collected within the action area over several years. Between March 5 and November 15, 2009, a total of 541 bat calls, including 11 *Myotis* calls, were identified using two ultrasound detectors placed on one meteorological (met) tower in the action area. Of the 11 *Myotis* calls, six (6) occurred during August through October, but none of these were Indiana bat calls (Rhett Good, WEST Inc., pers. comm. 2017). Bat activity was acoustically monitored from April 1 to November 15 in 2012, 2013, and 2015 using four detectors at two permanent met towers in the action area. The number of bat passes was 7,724, 3,146, and 3,960 in 2012, 2013, and 2015, respectively, but none of these were identified as Indiana bat calls (R. Good, pers. comm. 2017).

While the acoustic data provides some information on *Myotis* bat activity at one or two points within the action area during spring and fall migration, it does not fully inform our risk analysis. During spring and fall migration, Indiana bats bats may pass through the action area over the course of just a few minutes in a single night. We have no data indicating whether or not they are actively calling, or at what height they are flying. Acoustic detectors can detect the calls of high-frequency bats (including *Myotis* bats) for a short distance, after which the calls attenuate such that they cannot be detected or identified. Thus it is impossible to effectively sample the entire action area to determine if and when Indiana bats are passing through during migration, and in what densities.

Post-construction mortality monitoring at Blue Creek occurred in 2012, 2013, 2015, and 2016. During post-construction monitoring one Indiana bat fatality was documented on October 3, 2012. No northern long-eared bat fatalities have been documented. The proportion of bat carcasses that are documented relative to the proportion of bat fatalities that occur at Blue Creek varies from year to year, depending on the monitoring strategy that is employed. The more effectively the site is searched, the higher the probability any carcasses of Indiana bats that are present will be found. Following is a description of the search effort and operational protocols at Blue Creek since 2012, relative to the number of bat carcasses detected and estimated to occur.

During 2012, the Blue Creek operated at the manufacturer's cut-in speed without feathering for the majority of the year. During this time, one Indiana bat mortality was detected (Ritzert et al. 2013). Upon detection of the Indiana bat, all turbines began operating at 6.9 m/s cut-in speeds and were "paused" until the cut-in speed was reached from October 5-November 15, 2012. Rigorous post-construction mortality monitoring occurred following Ohio Department of Natural Resources "Option B" protocol, which involves a subset of turbines searched daily to 90-m on cleared plots, a subset of turbines searched every three days to 60-m on cleared plots, and the remainder of turbines searched weekly on roads and pads. Searches occurred from April 1-November 15. The post-construction monitoring report indicates that 850 bat carcasses were detected during the monitoring, and based on correction factors the estimated all-bat fatality rate was 11.62 bats/MW/year (Ritzert et al. 2013). Only 20 bats were detected as mortalities while implementing the 6.9 m/ s cut-in speed.

If the fatality rate at the facility was 11.62 bats/MW/year, and there are 304 MW, a total of 3,532 total bats were killed in 2012. Of the 3,532 total bats killed, 850 (24%) were detected during searches, thus, 76% were missed during searches. One Indiana bat was detected, and therefore we assume that this represents 24% of the total Indiana bats that were killed. Therefore we assume that as many as four Indiana bats were killed in 2012 during mostly normal operations.

During 2013 Blue Creek operated at the manufacturer's cut-in speed without feathering for the majority of the year. From August 1-October 15 a cut-in speed of 4.5 m/s was applied to 68 of the 152 turbines. The same monitoring protocol was applied to the project as in 2012. The post-construction monitoring report indicates that 728 bat carcasses were detected during the monitoring, and based on correction factors the estimated all-bat fatality rate was 7.95 bats/MW/year when including the subset of turbines with 4.5 m/s cut-in speeds and feathering. If only considering the normally operating turbines, the mortality rate was estimated to be 12.16 bats/MW/year, similar to 2012 rates (Good et al. 2014).

If the fatality rate at the facility was 7.95 bats/MW/year, and there are 304 MW, a total of 2,416 total bats were killed in 2013. Of the 2,416 total bats killed, 728 (30%) were detected during searches, thus, 70% were missed during searches. No Indiana bats were detected, but because only approximately 30% of carcasses were detected, we assume that Indiana bats could have been killed but gone undetected.

During 2015-2016 Blue Creek has operated to avoid potential take of Indiana bats. This involves operating at a 6.9 m/s cut-in speed and feathering from March 15-May 15 and from August 1-October 31, which encompasses spring and fall migration, when Indiana bats are most likely to be at risk of mortality from operation of the turbines at Blue Creek. Use of this cut-in speed and feathering regime is also anticipated to avoid take of northern long-eared bats. Using the same monitoring methods as in 2012 and 2013, 375 bat carcasses were detected and the all-bat fatality rate for 2015 was 6.34 bats/MW/year (Good et al. 2016).

If the fatality rate at the facility was 6.34 bats/MW/year, and there are 304 MW, a total of 1,927 total bats were killed in 2015. Of the 1,927 total bats killed, 375 (19%) were detected during searches, thus, 81% were missed during searches. Because the turbines were operating at a 6.9 m/s cut-in speed during spring and fall, we assume that no Indiana bats or northern long-eared bats were killed during 2015.

Using a less robust monitoring method in 2016 where approximately 11% of the bat carcasses were detected and monitoring only occurred in spring and fall, 99 all-bat carcasses were found (Good et al. 2017). This method yielded an all-bat take estimate of 1.62 bats/MW/spring and fall (Good et al. 2017). Because the turbines were operating at a 6.9 m/s cut-in speed during spring and fall, we assume that no Indiana bats or northern long-eared bats were killed during 2016.

Based on the above information, we assume that individual Indiana bats fly through the action area during spring and fall migration, but that they are not residents in the summer or winter. Based on the lack of acoustic detections, and the documented mortality of only one Indiana bat over four years of post-construction monitoring, we assume that the species does not occur in high densities within the action area, but is likely to pass through in small numbers during migration at night in spring and fall. Individuals of the species may stop over for one or more days during the migration period, roosting in forested habitat within the action area. If the weather is suitable for migration Indiana bats would typically stay only one day, but if weather is unsuitable for migration they may stay several days.

Factors Affecting Species Environment within the Action Area

The overall threats to the Indiana bat are described on pages 16-17. Of those threats to the species, the following are specific to the action area for this BO.

Land Management
The elm, ash, and beech swamp and upland forests that used to occur within the action area would have provided suitable migration stop-over and summer habitat for Indiana bat and northern long-eared bat. The tree clearing and draining associated with the conversion of the area to agriculture and residences and other associated development has removed most of that habitat. Approximately 300 acres of the action area still remains forested. This area may provide suitable migration stop-over habitat for Indiana bats, but based on the results of summer mist net surveys, these species do not use these areas for summer maternity habitat.

WNS
As described above, WNS is a devastating disease affecting many eastern U.S. bats, including the Indiana bat and northern long-eared bat. The disease was first documented in Ohio in 2011 and has since spread to multiple hibernacula throughout the Midwest. The two largest hibernacula known in Ohio (Lewisburg Mine in Preble County and an abandoned mine in Lawrence County) are infected. WNS has now been confirmed in 18 Ohio counties. Many of the hibernacula within the Indiana bat's Midwest Recovery Unit (including OH, MI, IN, KY, AL, GA, MS, and most of TN) have been documented to contain WNS (Figure 5). We assume that all Indiana bats that hibernate in caves in the Midwest Recovery Unit have been exposed to WNS, including those that may migrate through the action area. It is anticipated that the spread of the disease across the landscape will result in continued population declines, although the extent is unknown.

Wind power fatalities
As noted above, the Blue Creek Wind Energy Facility has documented the mortality of one Indiana bat in four years of monitoring at various probabilities of detection. It is likely that additional Indiana bats have been killed but not detected over the five years that the project has been in operation.

IV. EFFECTS OF THE ACTION

In evaluating the *effects of the action*, section 7 of the ESA and the implementing regulations (50 CFR §402) require the USFWS to consider both the direct and indirect effects of the action on the species, together with the effects of other activities that are interrelated or interdependent with the action that will be added to the environmental baseline. *Direct effects* are those effects that have immediate impacts on the species or its habitat while *indirect effects* are those that are caused by or will result from the proposed action and are later in time, but are still reasonably certain to occur. *Interrelated actions* are those that are part of a larger action and depend on the larger action for project justification. *Interdependent action*s are those actions that have no independent utility apart from the action under consideration.

The *effects* evaluation is necessary to make the required determination under 7(a)(2), of insuring the Federal action does not jeopardize the continued existence of the species, or result in the destruction or adverse modification of designated critical habitat. *Jeopardize the continued existence* of a species means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species. No critical habitat for the Indiana bat is present in Ohio or within the action area; therefore, no adverse modifications to critical habitat will result from the proposed action.

The following analysis evaluates the effects of the proposed action in relation to the reproduction, numbers, and distribution of Indiana bats within the action area, and then further evaluates these effects in the context of the overall range-wide species status and cumulative effects to the species.

Direct Effects

Wind Turbine Operation

Wind turbine operation is known to cause mortality of both Indiana bats and northern long-eared bats. Testing of acoustic deterrents and elevated cut-in speeds with feathering is anticipated to reduce mortality of both species, but may not completely avoid mortality. Feathering and use of a 5.0 m/s cut-in speed has resulted in a range of reduction in all-bat mortality from 47% (Hein et al. 2013) to 87% (Arnett et al. 2010).

During 2012, the Blue Creek Wind Energy Facility operated at the manufacturer's cut-in speed without feathering for the majority of the year. Thus we will use this data to calculate the baseline take that is likely to occur without implementation of cut-in speeds or deterrents. During 2012, rigorous post-construction mortality monitoring occurred following Ohio Department of Natural Resources "Option B" protocol. Searches occurred from April 1-November 15. The post-construction monitoring report indicates that 850 bat carcasses were detected during the monitoring, and based on correction factors the estimated all-bat fatality rate was 11.62 bats/MW/year (Ritzert et al. 2013). If the fatality rate at the facility was 11.62 bats/MW/year, and there are 304 MW, a total of 3,532 total bats were killed in 2012. Of the 3,532 total bats killed, 850 (24%) were detected during searches, thus, 76% were missed during searches. One Indiana bat was detected, and therefore we assume that this represents 24% of the total Indiana bats that were killed. Therefore we assume that as many as four Indiana bats were killed in 2012 during mostly normal operations.

The proposed action, funding the testing of deterrents and cut-in speeds and monitoring their effectiveness at reducing all-bat mortality, is likely to result in lower all-bat fatality rates at Blue Creek than in 2012. Implementation of a 5.0 m/s cut-in speed is likely to result in 47-87% reductions in all-bat fatality rates based on past studies at other sites (Arnett et al. 2010, Hein et al. 2013). Implementation of the acoustic deterrents is anticipated to also reduce all-bat fatality rates, though the percent reduction is unknown. However, it is uncertain how effective either of these measures will be at reducing *Myotis* bat mortality specifically. None of the cut-in speed studies have had sufficient *Myotis* bat sample size to analyze genera-specific effectiveness. Thus, for the purposes of our analysis we conservatively assume that there will be no reduction in Indiana mortality from the 5.0 m/s cut-in speed and acoustic deterrents, and that four Indiana bats may be killed during the study.

To date, the sex of six of the ten Indiana bats killed at wind projects has been determined—five were female and one was male. Thus, we assume that 83%, or three of the Indiana bats killed at Blue Creek would be female, and 17% or one Indiana bat would be male.

For the sake of this analysis, we assume that all Indiana bats that may be taken during migration belong to the same summer maternity colony. This is a conservative assumption as data indicate that bats from the same maternity colony migrate to various different hibernacula (Winhold and Kurta 2006).

Thogmartin et al. (2013) describe a stochastic, stage-based population model developed to forecast the population dynamics of the Indiana bat, subject to WNS. The model explicitly incorporates environmental variability in survival and reproduction rates and demographic stochasticity. The model considers only the female portion of the population because of the polygynous nature of the species. It assumes individual wintering populations are closed (no immigration or emigration).

We used the Thogmartin et al. (2013) model to assess the impact of the anticipated take of Indiana bats at 2 levels: 1) maternity colony level; and, 2) winter colony level by comparing the trajectories of the colonies without project take (baseline scenario) and with project take. We also considered the impact of the take of Indiana bats at the Recovery Unit level. But, based on the results of the analysis at the maternity colony and winter colony levels, we were able to conclude our analysis at the Recovery Unit level without use of the Thogmartin et al. (2013) model.

Whitaker and Brack (2002) indicated that average maternity colony size in Indiana was approximately 80 adult female bats, but to be conservative in our assessment, we used 60 adult females as the starting population. Persistence of the maternity colony over time was modeled with take of 3 female bats in year 1.

We also analyzed the potential impact of the take of three adult female Indiana bats on the hibernaculum population to which they belong. For the sake of this analysis, we assume that all Indiana bats that may be taken during migration belong to the same hibernaculum. This is a conservative assumption as data indicate that bats from the same maternity colony migrate to various different hibernacula (Winhold and Kurta 2006). One well-studied maternity colony in Norvell Township, Jackson County, Michigan banded bats that were recovered in seven different hibernacula in Indiana and Kentucky (Winhold and Kurta 2006). Straight line flight trajectories between the township that supports the maternity colony and the various hibernacula where the bands were recovered indicate that the Blue Creek project is within the migration pathway of Indiana bats migrating from Norvell Township in Michigan to Colossal Cave in Kentucky (Winhold and Kurta 2006). Thus, we assume that all Indiana bats that could be killed during the study are hibernating at Colossal Cave.

For all modeled scenarios, the following parameters apply: we use Indiana bat post-WNS population mortality rates, with WNS starting to impact the population in 2011 when WNS was first detected in Ohio; we apply the project take in year 1 and model the population out to 50 years; we model only the female portion of the population; and, all take from the project is additive on top of other mortality (e.g., mortality from WNS).

For each modeled scenario we ran 10,000 model simulations and we summarized the median model simulation results for the following metrics: probability of extinction, median time to extinction, and median ending population growth rate (lambda) after 50 years. We compare the results of the baseline scenarios of each population unit with the projected take results scenarios of each population unit. If there is an appreciable difference (e.g. loosely defined as greater than 5%) in the results between the baseline and any of the take scenarios for any of the population units, we completed an analysis of the how these population-level impacts will impact the likelihood of survival and recovery of the Indiana bat at the Recovery Unit level.

For the maternity colony take scenario, the Thogmartin model (Thogmartin et al. 2013) predicts a 66.7% probability that the colony from which migratory females are taken would be extinct with a median timeframe of extinction of 22 years (Table 4). These results are only 2% different than the baseline scenario, therefore the take associated with the project would not cause an appreciable decline in the fitness of the maternity colony to which the taken individuals belong.

Table 4. Results of Thogmartin et al. (2013) model of project take impact on maternity colony

	Female Bats taken	Probability of Extinction in 50 Years	Median Time to Extinction (years)	Median Ending Lambda after 50 Years
Baseline	0	64.6%	22	0
With project	3	66.7%	22	0

For the hibernacula take scenario the Thogmartin model (Thogmartin et al. 2013) results do not show appreciable reductions relative to the baseline scenario in any of the metrics (Table 5). Therefore, the take associated with the project would not cause an appreciable reduction in the fitness of the winter population to which the taken individuals belong.

Table 5. Results of Thogmartin et al. (2013) model of project take impact on hibernaculum

	Probability of Extinction in 50 Years	Median Time to Extinction (years)	Median Ending Lambda after 50 Years
Baseline	44.5%	26	0.926555945
With Project (3 bats over 1-year permit)	45.6%	25	0.925497341

Because there was no appreciable reduction in the fitness of the maternity colony or winter population to which the taken individuals belong, there would also be no appreciable impact on the Midwest Recovery Unit, or on the listed entity.

Indirect Effects

No effects to habitat for the Indiana bat are anticipated. No additional indirect effects from implementation of the proposed action are anticipated.

Global Climate Change

Humphries et al. (2002) used climate change models to predict a northern expansion of the hibernation range of the little brown bat; such modeling would likely result in predictions of range shifts for Indiana bats as well. Potential impacts of climate change on hibernacula can be compounded by mismatched phenology in food chains (e.g., changes in insect availability relative to peak energy demands of bats). Changes in maternity roost temperatures may also result from climate change, and such changes may have negative or positive effects on development of Indiana bats, depending on the location of the maternity colony (USFWS 2007). The role of climate change and its effect on temperatures in hibernacula, which can then affect bat population trends, needs investigation. Although current data are not sufficient to definitively determine the cause of regional disparities, both protection of hibernacula and suitable temperature regimes, in concert, appear to be key to understanding trends in the overall population and recovery of these species.

The geographic positions of states where Indiana bat populations historically were declining and states where they were stable or increasing must be considered in light of the possibility that regional and/or global climate change was driving some changes in Indiana bat populations. Clawson's summary reveals a clear division in population trends between states in the northern part of the Indiana bat's range versus states in the southern part of the range (2002). Overall, the southern population has apparently declined by 74% in the 45-year period from 1960 through the 2007 estimate. In contrast, there apparently has been an overall increase in population of 50% in the northern states over the same time. While of interest, this difference may be of much less significance in the face of the range-wide population declines anticipated from WNS.

Beneficial Effects

The proposed study will provide results that inform the effectiveness of cut-in speeds and acoustic deterrents at reducing all-bat mortality at wind projects, and may provide *Myotis*-specific mortality minimization information. Further, the study will inform bias correction factors related to bat carcass distribution around turbines, which is an important factor in assessing all-bat and *Myotis* bat fatality estimates on a per-project and per-MW basis. This information will aid in minimizing take of Indiana bats at wind facilities in the future, and in generating more accurate take estimates at wind projects range-wide.

V. CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this BO. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the Act.

The Service is not aware of any non-Federal activities that would affect Indiana bats or their habitat that are planned within the Action Area. Though we have not identified any proposed developments that would affect Indiana bat habitat, we anticipate that occasional tree/snag removal or timber harvesting by non-Federal entities on private land may take place occasionally within the Action Area.

Most land in the Action Area is privately owned and used for agricultural purposes. Additional single family residences, out buildings, and other small scale development may also occur within the Action Area within the next year. No quantification of the number or location of these activities is available. It is possible that tree harvest associated with these activities could harm or harass individual Indiana bats if that occurred during periods of time during spring or fall migration when Indiana bats are stopping over in the action area. However, the scale of these types of projects is unlikely to result in habitat loss on a scale that would significantly impact the quantity or distribution of suitable habitat within the Action Area and would not rise to the level of population-level impacts. Standard farming practices would not result in effects to Indiana bat or suitable habitat for these species. Therefore we do not anticipate significant cumulative effects from the proposed action, combined with other reasonably foreseeable non-Federal actions.

VI. CONCLUSION

After reviewing the current status of the Indiana bat, the environmental baseline for the action area, the effects of the implementation of the proposed study, and the cumulative effects, it is the USFWS's biological opinion that the proposed action is not likely to jeopardize the continued existence of the Indiana bat. No critical habitat for this species has been designated in Ohio; therefore, no destruction or adverse modification of critical habitat will occur.

As described in our effects analysis, we anticipate that up to four Indiana bats (3 female, one male) may be lethally take during operation of turbines associated with the study of acoustic deterrents and cut-in speeds. No impact to habitat for the species is anticipated.

Our analysis indicates that take of 3 female Indiana bats will not appreciably reduce the fitness of the maternity colony or wintering populations of Indiana bats to which the taken individuals belong. Because the fitness of these populations will not be appreciably impacted by the proposed taking, the proposed taking will not appreciably reduce the likelihood of the survival and recovery of the Midwest RU, or the entirety of the population of the species in the wild.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the USFWS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the USFWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

The measures described below are non-discretionary, and must be undertaken by DOE so that they become binding conditions of any grant or permit issued to BCI, USGS, or Avangrid, as appropriate, for the exemption in section 7(o)(2) to apply. DOE has a continuing duty to regulate the activity covered by this incidental take statement. If DOE (1) fails to assume and implement the terms and conditions, or (2) fails to require the applicant(s) to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse.

In order to monitor the impact of incidental take, DOE must report the progress of the action and its impact on the species to the USFWS as specified in the Incidental Take Statement [50 CFR §402.14(i)(3)].

Amount or Extent of Take Anticipated

In this incidental take statement, we are evaluating the incidental take of Indiana bats and northern long-eared bats that may result from the implementation of DOE’s funding of a study of bat acoustic deterrents and cut-in speeds at the Blue Creek Wind Energy Facility from June 14-October 3, 2017. Based on the history of operation of the Blue Creek project, we anticipate take in the form of mortality of up to four Indiana bats (three female, one male). The level of take anticipated may be lower than this based on the implementation of the study, which is designed to test several mechanisms to reduce all-bat mortality rates from operation of the facility.

Mortality monitoring is proposed to occur, and is a central focus of the analysis, but still, incidental take of Indiana bats will be difficult to detect because the species is small, cryptically colored, and could occur within unsearched areas of the facility. However, we believe the level of take of the species can be monitored by conducting the mortality monitoring as proposed in the study, and extrapolating those results using Evidence of Absence software.

EFFECT OF THE TAKE

In the accompanying BO, the USFWS determined that, based on the proposed project, anticipated take is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

To minimize incidental take to the maximum extent feasible, we believe the following reasonable and prudent measures are necessary and appropriate:

1. Check turbines, turbine operation system, and acoustic deterrents frequently to ensure that cut-in speeds are being applied as intended and that deterrent is functioning.
2. Any observed mortality of Indiana bat or northern long-eared bat should be reported to USFWS within 24 hours.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the ESA, DOE or their grantees must comply with the following terms and conditions, which implement the reasonable and prudent measures. These terms and conditions are non-discretionary.

1. Frequent inspections of the turbines, turbine operational system, and acoustic deterrents should occur to ensure that the technology is functioning as intended. Inspections should ensure that the turbines are turning on and off at appropriate cut-in speeds (5.0 m/s on all turbines except for four control turbines set at manufacturer's cut-in speed), that the turbines' operational system is programmed appropriately, and that the acoustic deterrents are in good working order. Any errors should be immediately remedied, prior to the next night's operation.
2. At least one extra acoustic deterrent device should be available at the project area for use in case one installed deterrent should fail.
3. Any Indiana bat or northern long-eared bat carcasses or bat carcasses that cannot be conclusively ruled out as being Indiana bats or northern long-eared bats, should be bagged and frozen. USFWS should be notified by phone [(614) 416-8993], within 24 hours of the finding. The bat carcass(es) should be turned over to USFWS within 48 hours.
4. Any other bat carcasses should be disposed of per the direction of ODNR Division of Wildlife. If ODNR allows, these carcasses may be used in bias trials onsite.
5. Live, uninjured bats found onsite below turbines may be released at or near the point of capture. Injured bats should be handled per the direction of the ODNR Division of Wildlife. If the injured bat is an Indiana bat or northern long-eared bat, USFWS should be contacted immediately and the bat should be taken to a licensed wildlife rehabilitator.
6. The final report associated with this project should be made publicly available such that if these methods are found to reduce bat mortality at turbines, other facilities can implement these measures.

In conclusion, the USFWS believes that no more than four Indiana bats will be taken as a result of the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. DOE must immediately provide an explanation of the causes of the taking and review with the USFWS the need for possible modification of the reasonable and prudent measures.

REINITIATION NOTICE

This concludes formal consultation on the action outlined in DOE's request. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if; (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect Indiana bats or their critical habitat in a manner or to an extent not considered in this opinion; or (3) the agency action is subsequently modified in a manner that causes an effect to Indiana bats or northern long-eared bats or their critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1) In collaboration with the USFWS, fund or implement research focused on better understanding exposure of bats to wind turbines, measures to minimize collision risk, and monitoring methods.
2) Encourage collection and reporting of migratory bird mortality to USFWS at DOE-funded wind project studies.
3) Encourage wind facilities to make bird and bat mortality data publicly available such that agencies can more effectively assess take of listed and un-listed bats, and how take may affect populations.

LITERATURE CITED

Arnett, E. B., M. Schirmacher, M. M. P. Huso, and J. P. Hayes. (2009). Effectiveness of changing wind turbine cut-in speed to reduce bat fatalities at wind facilities. An annual report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Arnett, E. B., M. R. Schirmacher, M. M. P. Huso, and J. P. Hayes. (2010). Patterns of Bat Fatality at the Casselman Wind Project in South-Central Pennsylvania. 2009 Annual Report. Annual Report Prepared for the Bats and Wind Energy Cooperative (BWEC) and the Pennsylvania Game Commission. Bat Conservation International (BCI), Austin, Texas. January.

Arnett, E. B., G. D. Johnson, W. P. Erickson, and C. D. Hein. (2013). A Synthesis of Operational Mitigation Studies to Reduce Bat Fatalities at Wind Energy Facilities in North America. A report submitted to the National Renewable Energy Laboratory (NREL), Golden Colorado. Bat Conservation International (BCI), Austin, Texas. March 2013.

Baerwald, E. F., J. Edworthy, M. Holder, and R. M. R. Barclay. (2009). A Large-Scale Mitigation Experiment to Reduce Bat Fatalities at Wind Energy Facilities. Journal of Wildlife Management 73(7): 1077-1081.

Barbour, R. W. & Davis, W. H. (1969). *Bats of America*. Lexington, KY: University of Kentucky Press.

Barclay, R. M. R. (1991). Population structure of temperate zone insectivorous bats in relation to foraging behaviour and energy demand. *Journal of Animal Ecology, 60*(1):165-178.

Belwood, J. J. (1979). *Feeding ecology of an Indiana bat community with emphasis on the endangered Indiana bat, Myotis sodalis* (Master's thesis). Gainesville, FL: University of Florida.

Belwood, J. J. (2002). Endangered bats in suburbia: observations and concerns for the future. In A. Kurta & J. Kennedy (Eds.), *The Indiana bat: biology and management of an endangered species* (pp. 193-198). Austin, TX: Bat Conservation International.

Blehert, D. S., Hicks, A. C., Behr, M., Meteyer, C., Berlowski-Zier, B. M., Buckles, E. L., Coleman, J. T., Darling, S. R., Garas, A., Niver, R., Okoniewski, J. C., Rudd, R. J., Stone, W. B., (2009) Bat White-Nose Syndrome: An Emerging Fungal Pathogen. *Science*, 323(5911), 227.

Brack, V. M., Jr. (1983). *The nonhibernating ecology of bats in Indiana, with emphasis on the endangered Indiana bat, Myotis sodalis* (Doctoral dissertation). LaFayette, IN: Purdue University.

Brack, V. & LaVal, R. K. (1985). Food habits of the Indiana bat in Missouri. *Journal of Mammalogy, 66*, 308-315.

Brack, V., Jr., Whitaker, J. O., Jr., & Pruitt, S. E. (2004). Bats of Hoosier National Forest. *Proceedings of the Indiana Academy of Science, 113*(1), 76-86.

Brigham, R. M., Vonhof, M. J., Barclay, R. M. R., & Gwilliam, J. C. (1997). Roosting behavior and roost-site preferences of forest-dwelling Californian bats (*Myotis californicus*). *Journal of Mammalogy, 78*, 1231-1239.

Britzke, E. R., Harvey, M. J., & Loeb, S. C. (2003). Indiana bat, *Myotis sodalis*, maternity roosts in the southern United States. *Southeastern Naturalist*, *2*(2), 235-242.

Britzke, E. R., Hicks, A.C., Darling, S.L., & Von Oettingen, S.R. (2006). Description of spring roost trees used by female Indiana bats (*Myotis sodalis*) in the Lake Champlain Valley of Vermont and New York. *Am. Midl. Nat*., *155*, 181–187.

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

Butchkoski, C. M., & Turner. G. (2005). *Indiana bat (Myotis sodalis) summer roost investigations. Annual job report.* Harrisburg, PA: Pennsylvania Game Commission.

Butchkoski, C. M., and G. Turner. (2006). Indiana bat (*Myotis sodalis*) summer roost investigations. Annual job report. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Callahan, E. V., Drobney, R. D., & Clawson, R.L. (1997). Selection of summer roosting sites by Indiana bats (*Myotis sodalis*) in Missouri. *Journal of Mammalogy, 78*, 818-825.

Carter, T. C., Feldhamer, G. A., & Kath, J. (2001). Notes on summer roosting of Indiana bats. *Bat Research News*, *42*, 197-198.

Clawson, R. L. (2002). Trends in population size and current status. Pages 2-8 in A. Kurta and J. Kennedy, editors. *The Indiana bat: biology and management of an endangered species*. Bat Conservation International, Austin, Texas, USA.

Cope, J. B., Richter, A. R., & Mills, R. S. (1974). A summer concentration of the Indiana bat, *Myotis sodalis*, in Wayne County, Indiana. *Indiana Academy of Science, 83*, 482-484.

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.

Crampton, L. H. & Barclay, R. (1996). Habitat selection by bats in fragmented and unfragmented aspen mixed wood stands of different ages. In R. Barclay & R. Brigham (eds.), *Bats and Forests Symposium* (pp. 238-259). Victoria, BC: British Columbia Ministry of Forests Research Branch.

Cryan, P. M., Meteyer, C. U., Boyles, J. G., & Blehert, D. S. (2010). Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. *BMC Biology, 8*, 135.

Cryan, P. M. and R. M. R. Barclay. (2009). Causes of bat fatalities at wind turbines: hypotheses and predictions. Journal of Mammalogy 90:1330-1340.

Erickson, R. A., W. E. Thogmartin, J. E. Diffendorfer, R. E. Russell, & J. A. Szymanski. (2016). Effects of wind energy generation and white-nose syndrome on the viability of the Indiana bat. PeerJ 4:e2830;DOI 10.7717/peerj.2830

Farmer, A. H., Cade, B. S., & Staufer, D. F. (2002). Evaluation of a habitat suitability index model. In A. Kurta and J. Kennedy (Eds.), *The Indiana bat: biology and management of an endangered species* (pp. 172-179). Austin, TX: Bat Conservation International.

Fenton, M. B. (1990). The foraging behavior and ecology of animal-eating bats. *Canadian Journal of Zoology, 68*, 411-422.

Fleming, T. H., and P. Eby. (2003). Ecology of bat migration. Pages 156-208 in T. Kunz and M.B. Fenton, editors. Bat ecology. The University of Chicago Press, Chicago, USA.

Frick, W. F., E.F. Baerwald, J.F. Pollock , R.M.R. Barclay, J.A. Szymanski, T.J. Weller, A.L. Russell, S.C. Loeb, R.A. Medellin, & L.P. McGuire. (2017). Fatalities at wind turbines may threaten population viability of a migratory bat. Biological Conservation 209: 172-177.

Frick, W. F., Pollock, J. F., Hicks, A. C., Langwig, K. E., Reynolds, S., Turner, G. G., Butchkoski, C.M., Kunz, T. H. (2010) An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species. *Science,* 329 (5992) 679-682.

Gardner, J. E., Garner, J. D., & Hofman, J. E. (1991). Summer roost selection and roosting behavior of *Myotis sodalis*, Indiana bat, in Illinois. *Final Report to the Illinois Natural History Survey.* Champaign, IL.

Gardner, J. E., Hofman, J. E., & Garner, J. D. (1996). Summer distribution of the federally endangered Indiana bat (*Myotis sodalis*) in Illinois. *Illinois State Academy of Science, 89*, 187-196.

Garner, J. D. & Gardner, J. E. (1992). *Determination of summer distribution and habitat utilization of the Indiana bat (Myotis sodalis) in Illinois.* Unpublished report prepared for Illinois Department of Conservation, Division of Natural Heritage, and Illinois Natural History Survey, Center for Biogeographic Information. Retrieved from https://www.ideals.illinois.edu/bitstream/handle/2142/10287/inhscbiv01992i00002_opt.pdf?sequence=2

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

Good, R. E., W. P. Erickson, A. Merrill, S. Simon, K. Murray, K. Bay, and C. Fritchman. (2011). Bat Monitoring Studies at the Fowler Ridge Wind Energy Facility, Benton County, Indiana: April 13-October 15, 2010. Prepared for Fowler Ridge Wind Farm. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. January 28.

Good. R.E., A. Merrill, S. Simon, K. L, Murray, and K. Bay. (2012). Bat Monitoring Studies at the Fowler Ridge Wind Farm, Benton County, Indiana. Final Report: April 11-October 31, 2011. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Bloomington, Indiana.

Good, R.E., S. Simon, M.L. Ritzert, C. LeBeau, and K. Bay. (2014). Post-Construction Fatality Surveys Blue Creek Wind Farm, Van Wert County, Ohio: April - November 2013. Prepared for Iberdrola Renewables, LLC (IR), Portland, Oregon. Prepared by WEST, Bloomington, Indiana.

Good, R.E., G. Iskali, and K. Nasman. (2016). Post-Construction Fatality Surveys, Blue Creek Wind Farm, Van Wert County, Ohio, April –November 2015, Prepared for Iberdrola Renewables, LLC Portland, Oregon. Unpublished report. 120 pp.

Good, R.E., R. Schmitt, G. Iskali, and K. Nasman. (2017). Post-Construction Fatality Surveys, Blue Creek Wind Farm, Paulding and Van Wert Counties, Ohio: March – October 2016. Prepared for Blue Creek Wind Farm, LLC, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana.

Gumbert, M. W. (2001). Seasonal roost tree use by Indiana bats in the Somerset Ranger District of the Daniel Boone National Forest, Kentucky (Master's thesis). Richmond, KY: Eastern Kentucky University.

Gumbert, M. W., O'Keefe, J. M., & MacGregor, J. R. (2002). Roost fidelity in Kentucky. In A. Kurta & J. Kennedy (Eds.), The Indiana bat: biology and management of an endangered species (pp. 143-152). Austin, TX: Bat Conservation International.

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

Harvey, M. J. (2002). Status and ecology in the southern United States. In A. Kurta & J. Kennedy (Eds.), The Indiana bat: biology and management of an endangered species (pp. 29-34). Austin, TX: Bat Conservation International.

Hein, C. D., A. Prichard, T. Mabee, and M. R. Schirmacher. (2013). Avian and Bat Post- Construction Monitoring at the Pinnacle Wind Farm, Mineral County, West Virginia, 2012. Final Report. Bat Conservation International, Austin, Texas, and ABR, Inc., Forest Grove, Oregon. April 2013.

Hein, C. D., A. Prichard, T. Mabee, and M. R. Schirmacher. (2014). Efficacy of an operational minimization experiment to reduce bat fatalities at the Pinnacle Wind Farm, Mineral County, West Virginia, 2013. An annual report submitted to Edison Mission Energy and the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Hicks, A. C., M. Clark, M. Cooper, R. Niver, and C. Herzog. (2005). Spring emergence tracking of Indiana bats in NY State during 2005. Proceedings from the Northeast Bat Working Group 2006 Annual Meeting. <http://www.batmanagement.com/Projects/NEBWG/2006/2006.html>.

Hicks, A. C., M. Cooper, W. Skinner, R. VonLinden, A. Bailey, J.A. Kath, and M. Sailor. (2012). Spring Migratory Behavior of Female Indiana Bats (Myotis sodalis) from the Blackball Mine Complex, LaSalle County, Illinois. Unpublished Report.

Hobson, C. S. & Holland, J. N. (1995). Post-hibernation movement and foraging habitat of a male Indiana bat, *Myotis sodalis* (Chiroptera: Vespertilionidae), in western Virginia. *Brimleyana, 23*, 95-101.

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

Humphries, M. M., Thomas, D. W. & Speakman, J. R. (2002). Climate-mediated energetic constraints on the distribution of hibernating mammals. *Nature,* 418, 313-316.

Iskali, G., R.E. Good, and R. Schmitt. (2017). Bat Mist-net Surveys, Blue Creek Wind Project. Final Report: July 18 – 25, 2016. Prepared for Blue Creek Wind Farm LLC. Prepared by Western EcoSystems Technology, Inc. (WEST), Bloomington, Indiana.

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

Kniowski, A. B. & Gehrt, S. (2011). *Summer Ecology of the Indiana bat (Myotis sodalis) in an Agricultural Landscape* (Master's thesis). Columbus, OH: The Ohio State University.

Kurta, A. & Murray, S. W. (2002). Philopatry and migration of banded Indiana bats (*Myotis sodalis*) and effects of radio transmitters. *Journal of Mammalogy, 83*(2), 585-589.

Kurta, A., & Williams, K. (1992). Roosting habitat, microclimate, and behavior of the endangered Indiana bat (*Myotis sodalis*) in southern Michigan. *Final report to the Michigan Department of Natural Resources*.

Kurta, A., D. King, J. A. Teramino, J. M. Stribley, and K. J. Williams. (1993). Summer roosts of the endangered Indiana bat (Myotis sodalis) on the northern edge of its range. American Midland Naturalist 129:132-138.

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

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.

LaVal, R. K., Clawson, R. L., LaVal, M. L., & Caire, W. (1976). Foraging behavior and nocturnal activity patterns of Missouri bats, with emphasis on the endangered species *Myotis grisescens* and *Myotis sodalis. Journal of Mammalogy, 58*(4), 592-599.

LaVal, R. K. & LaVal, M. L. (1980). *Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Terrestrial Series No. 8.* Jefferson City, MO: Missouri Dept. of Conservation.

Lee, Y. F. & McCracken, G. F. (2004). Flight activity and food habits of three species of Myotis bats (Chiroptera: Vespertilionidae) in sympatry. *Zoological Studies, 43*(3), 589-597.

Lorch, J. M., Meteyer, C. U., Behr, M. J., Boyles, J. G., Cryan, P. M., Hicks, A. C., . . . Blehert, D. S. (2011). Experimental infection of bats with *Geomyces destructans* causes white-nose syndrome. *Nature, 480*(7377), 376-378.

MacGregor, J. (1999). *Indiana bat roosts tree use monitoring – 1996-1997.* Summary Report to the Daniel Boone National Forest Management Team. South Golden Cave and vicinity, Pulaski and McCreary Counties: Somerset Ranger District.

Menzel, M. A., Menzel, J. M., Carter, T. C., Ford, W. M., & Edwards, J. W. (2001). Review of the forest habitat relationships of the Indiana bat (*Myotis sodalis*). Newtown Square, PA: USDA Forest Service.

Meteyer, C. U., Buckles, E. L., Blehert, D. S., Hicks, A. C., Green, D. E., Shearn-Bochsler, V., . . . Behr, M. J. (2009). Histopathologic criteria to confirm white-nose syndrome in bats. *J. Vet. Diagn. Invest.*, *21*, 411-414.

Miller, N. E., Drobney, R. D., Clawson, R. L., & Callahan, E. V. (2002). Summer habitat in northern Missouri. In A. Kurta & J. Kennedy (Eds.), *The Indiana bat: biology and management of an endangered species* (pp. 165-171). Austin, TX: Bat Conservation International.

Minnis, A. M., & Linder, D. L. (2013). Phylogenetic evaluation of *Geomyces* and allies reveals no close relatives of *Pseudogymnoascus destructans*, comb. nov., in bat hibernacula of Eastern North America. *Fungal Biology*, *117*(9), 638-649.

Murray, S. W. (1999). *Diet and nocturnal activity patterns of the endangered Indiana bat, Myotis sodalis* (Master's thesis). Ypsilanti, MI: Eastern Michigan University.

Murray, S. W. & Kurta, A. (2002). Spatial and temporal variation in diet. In A. Kurta & J. Kennedy (Eds.), *The Indiana bat: biology and management of an endangered species* (pp. 182-192). Austin, TX: Bat Conservation International.

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

Palm, J. (2003). *Indiana bat (Myotis sodalis) summer roost tree selection and habitat use in the Champlain Valley of Vermont* (Master's thesis). Keene, NH: Antioch University.

Puechmaille, S.J., P. Verdeyroux, H. Fuller, M.A. Gouilh, M. Bekaert, and E.C. Teeling. (2010). White-nose syndrome fungus (*Geomyces destructans*) in bat, France. Emerging infectious diseases, 16(2), 290.

Racey, P. A. (1982). Ecology of bat reproduction. In T. H. Kunz (Ed.), *Ecology of Bats* (pp. 57-104). New York, NY: Plenum Press.

Racey, P. A. & Entwhistle, A. C. (2003). Conservation ecology of bats: reproduction. In T. H. Kunz & M. B. Fenton (Eds.), *Ecology of bats* (pp. 680-743). Chicago, IL: University of Chicago Press.

Richter, A. R., Humphrey, S. R., Cope, J. B., & Brack, V., Jr. (1993). Modified cave entrances: thermal effect on body mass and resulting decline of endangered Indiana bats (*Myotis sodalis*). *Conservation Biology*, *7*(2), 407-415.

Ritzert, M.L., R.E. Good, M. Sonnenberg, and K. Bay. (2013). Post-Construction Fatality Surveys Blue Creek Wind Farm, Van Wert County, Ohio: April - November 2012. Prepared for Iberdrola Renewables, LLC (IR), Portland, Oregon. Prepared by WEST, Bloomington, Indiana.

Roby, P. and M. Gumbert. (2016). Bats and Wind Energy: A Comparison Between Spring and Autumn Migration Behavior. Final Report to USFWS. Unpublished Report.

Sanders, C., and J. Chenger. (2001). Williams Lake Telemetry Study. Bat Conservation and Management, Carlisle, Pennsylvania, USA.

Thogmartin, W.E., C.A. Sanders-Reed, J.A. Szymanski, P.C. McKann, L. Pruitt, R.A. King, M.C. Runge, and R. E. Russell. (2013). White-nose syndrome is likely to extirpate the endangered Indiana bat over large parts of its range. Biological Conservation 160: 162-172.

Timpone, J. C. (2004). *Roost site selection of bats in northwest Missouri with emphasis on the endangered Indiana bat (Myotis sodalis)* (Master's thesis). Springfield, MO: Southwest Missouri State University.

U.S. Fish and Wildlife Service. (1983). *Recovery plan for the Indiana bat*. Washington, D.C.: Author.

U.S. Fish and Wildlife Service. (1999). *Agency draft Indiana Bat (Myotis sodalis) revised recovery plan*. Fort Snelling, MN: U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. (2002). *Biological opinion on the application for an incidental take permit for the federally endangered Indiana bat (Myotis sodalis) for the Six Points Road interchange and associated development*. Bloomington, IN: Bloomington Field Office.

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

U.S. Fish and Wildlife Service. (2011). *Final Revised Biological Opinion: The Service's Continued Participation In and Approval of Conservation Memoranda of Agreement for the Indiana Bat (Myotis sodalis).* Frankfort, KY: USFWS Kentucky Field Office.

U.S. Fish and Wildlife Service. (2013). *Unpublished NLEB data from Indiana Bat Presence/Absence Surveys conducted from 2005-2013*. Frankfort, KY.

U.S. Fish and Wildlife Service. (2015a). *Indiana bat 2015 rangewide population*. Retrieved from http://www.fws.gov/midwest/endangered/mammals/inba/pdf/2015IBatPopEstimate25Aug2015v2.pdf

U.S. Fish and Wildlife Service. (2015b). Blue Creek Wind Farm Technical Assistance Letter, Ohio. Unpublished letter. Columbus, OH.

U.S. Fish and Wildlife Service. (2017). Indiana bat fatalities at wind energy facilities, by L. Pruitt and J. Okajima, U.S. Fish and Wildlife Service Bloomington, Indiana Field Office, updated February 2017. Available at: http://www.fws.gov/midwest/wind/wildlifeimpacts/inbafatalities.html

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

Winhold, L. & Kurta, A. (2006). Aspects of Migration by the Endangered Indiana Bat, *Myotis sodalis*. *Bat Research News, 47*, 1-11.