FINAL BUCKEYE WIND POWER PROJECT HABITAT CONSERVATION PLAN

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ABPP	Avian and Bat Protection Plan
ac	acres

AEPS	Alternative Energy Portfolio Standard
agl	above ground level
APLIC	Avian Power Line Interaction Committee
b/n/n	bats per net per night
BBSH	big brown/silver-haired bat guild
BBSHHB	big brown bat/silver-haired bat/hoary bat guild
BCI	Bat Conservation International
BCM	Bat Conservation and Management
BFO	Bloomington Field Office (USFWS)
BGEPA	Bald and Golden Eagle Protection Act
BO	Biological Opinion
C	Celsius
CBD	Center for Biological Diversity
CECPN	Certificate of Environmental Compatibility and Public Need
CFR	Code of Federal Regulations
cm	centimeters
CRP	Conservation Reserve Program
CWA	Clean Water Act
dbh	diameter-at-breast height
DOE EIA	Department of Energy: Energy Information Administration
DOF	Division of Forestry
DOW	Division of Wildlife
DPL	Dayton Power and Light
DU	Ducks Unlimited
EA	Environmental Assessment
EDR	Environmental Design and Research
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESI	Environmental Solutions and Innovations
F	Fahrenheit
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Impact
Fed. Reg.	Federal Register
FRCC	Fire Regime Condition Class
ft	feet
GIS	Geographic Information System
ha	hectares
HB	hoary bat guild
HCP	Habitat Conservation Plan
HHEI	Headwaters Habitat Evaluation Index
I-70	Interstate 70
in	inch
IPCC	Intergovernmental Panel on Climate Change
ITP	Incidental Take Permit
km	kilometers
km/hr	kilometers per hour
kV	kilovolt
m	meters

m/s	meters per second
MCP	minimum convex polygon
MET	meteorological
mi	miles
mm	millimeters
mph	miles per hour
MTM/VF	mountaintop mining with valley fills
MW	megawatt
MWh	megawatt hour
MYSP	*Myotis* guild
NCDC	National Climatic Data Center
NE1	Northeast 1
NE2	Northeast 2
NEPA	National Environmental Policy Act
NLCD	National Land Cover Database
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NWF	National Wildlife Federation
NWI	National Wetlands Inventory
O&M	operations and maintenance
ODA	Ohio Department of Agriculture
ODNR	Ohio Department of Natural Resources
ODOD	Ohio Department of Development
ODOH	Ohio Department of Health
ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
OHPO	Ohio Historic Preservation Office
OMNR	Ontario Ministry of Natural Resources
OPSB	Ohio Power Siting Board
P1	Priority 1 hibernaculum
P1A	Priority 1A hibernaculum
P1B	Priority 1B hibernaculum
P2	Priority 2 hibernaculum
P3	Priority 3 hibernaculum
P4	Priority 4 hibernaculum
PHDI	Palmer Hydrological Drought Index
PCM	Post-construction monitoring
PUCO	Public Utilities Commission of Ohio
RBTB	eastern red bat/tri-colored bat guild
RC	Revised Code
rpm	rotations per minute
RU	Recovery Unit
s/d/n	sequences per detector per night
SMCRA	Surface Mining Control and Reclamation Act
SR	State Route
Stems/ac/PA	Stems per acre, on average, per Planting Area

SWPPP	Stormwater Pollution and Prevention Plan
TIR	thermal infrared
UNKN	unknown guild
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USC	United States Code
USDA	United States Department of Agriculture
USDA-SCS	United States Department of Agriculture: Soil Conservation Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WNS	White-Nose Syndrome or White Nose Syndrome
WQC	Water Quality Certification

LIST OF PREPARERS

This Habitat Conservation Plan (HCP) was primarily prepared by the following Stantec staff members: Cara Meinke, Kristen Watrous, Elizabeth Annand, Terry VanDeWalle, Janice Huebner, Quintana Baker, Jess Costa, James Kiser, Jeff Brown, Jon Ryan, Trevor Peterson, and Gino Giumarro. Dr. Bill Warren-Hicks of EcoStat Inc. was a co-author of the Collision Risk Model. The following third party reviewers provided comment on this HCP and/or its appendices: Dr. Allen Kurta of Eastern Michigan University provided scientific oversight and comments on the HCP and all appendices; Dr. Tim Carter of Ball State University provided an independent review of the HCP and all appendices; Dr. John Hayes of the University of Florida provided an independent review of the Appendix A – the Collision Risk Model; and an internal panel of statisticians at the U.S. Fish and Wildlife Service also provided an independent review of Appendix A. Regulatory, scientific, and technical oversight and guidance were provided by Megan Seymour, Melanie Cota, Keith Lott, Mary Knapp, Lisa Mandell, TJ Miller, and Rick Amidon (among many others) at the U.S. Fish and Wildlife Service, and Jennifer Norris at the Ohio Department of Natural Resources Division of Wildlife. The contribution of these individuals is gratefully acknowledged. While these individuals and organizations have provided extensive input to the document, the HCP is the product of Buckeye Wind LLC. The acknowledgement of the above contributors should not be interpreted as approval of the document as a whole by those individuals or the organizations they represent.

The format and style for this document generally followed the *Journal of Wildlife Management Guidelines* (Chamberlin and Johnson 2008).

1.0 INTRODUCTION

1.1 Overview and Purpose of the HCP

Buckeye Wind LLC, a wholly owned subsidiary of EverPower Wind LLC, (EverPower; hereafter referred to as Buckeye Wind) has prepared this Habitat Conservation Plan (HCP) in order to apply to the United States Fish and Wildlife Service (USFWS) for an Incidental Take Permit (ITP) under section 10(a)(1)(B) of the Endangered Species Act of 1973, as amended (ESA; 16 United States Code [USC] §§ 1531-1544, 1539). The purpose of the ITP is to allow incidental take of the federally endangered Indiana bat (*Myotis sodalis)* as a result of actions associated with the proposed Buckeye Wind Power Project (Project). This HCP analyzes potential impacts to the Indiana bat from construction, operation, maintenance, and decommissioning of the Project and describes how the Project will meet the criteria for issuance of an ITP set forth in section 10(a)(2) of the ESA and the implementing regulations, 50 Code of Federal Regulations (CFR) 17.22. Conservation actions and impact analyses for other non-federally listed bats and migratory birds are detailed in the Buckeye Wind Environmental Impact Statement (EIS) and Avian and Bat Protection Plan (ABPP; Stantec 2011a).

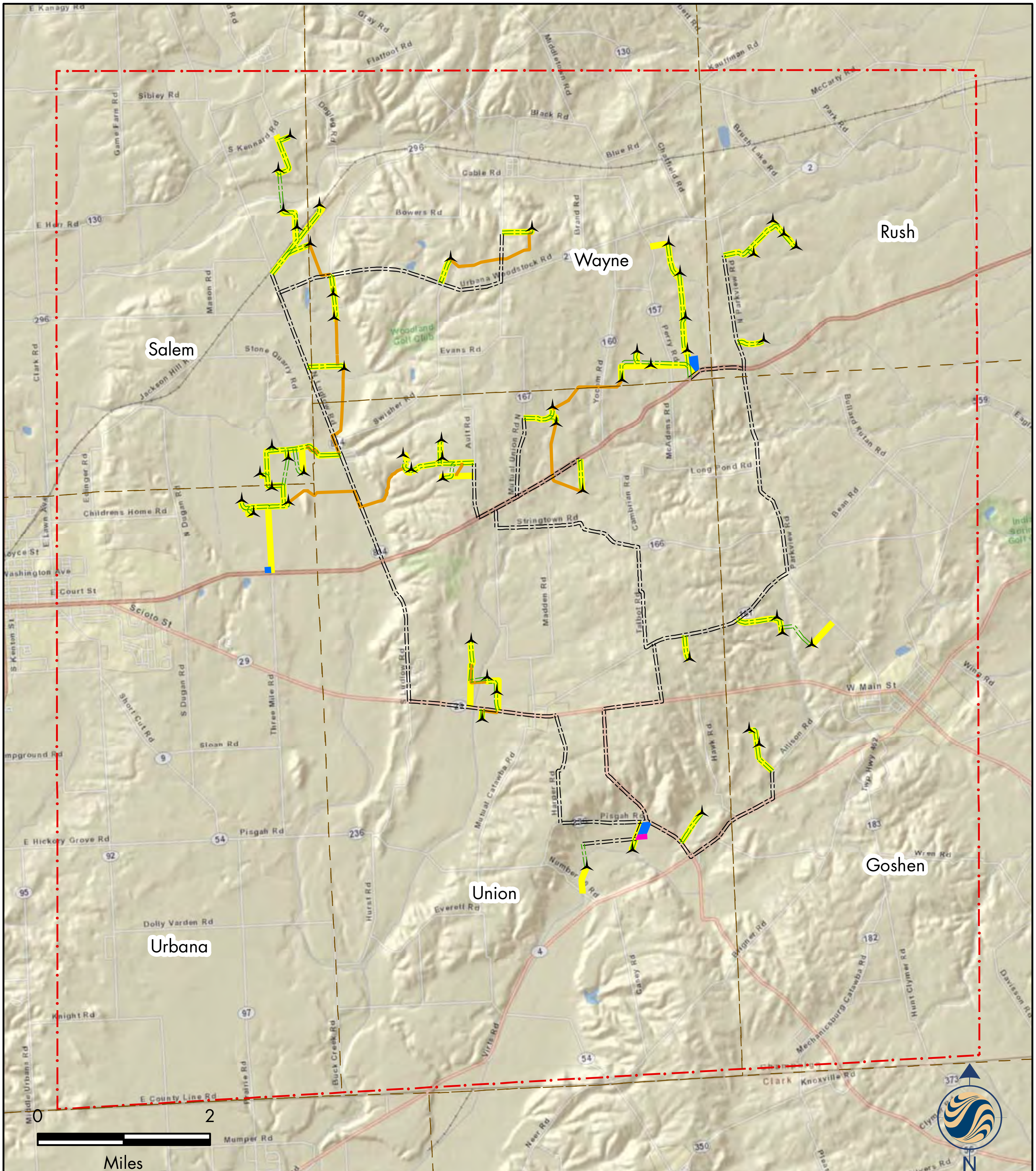
Summer resident Indiana bats are known to occur within the vicinity of the Project. Mist-netting conducted in Champaign County during summer 2009 for an unrelated project resulted in the capture of 5 Indiana bats in the current Action Area. Therefore, Buckeye Wind, together with the USFWS, has determined that actions associated with the Project have the potential to incidentally take Indiana bats, listed as federally endangered under the ESA. Indiana bats could be injured or killed by colliding with or coming in close proximity to operational turbines. Section 10 of the ESA allows for incidental take of ESA listed species through the completion of a USFWS-approved HCP and subsequent issuance of an ITP by the USFWS.

The Project will be situated within an approximately 32,395 hectares (ha; 80,051 acres [ac]) area that includes portions of Union, Wayne, Urbana, Salem, Rush, and Goshen Townships in Champaign County, OH (referred to hereafter as the Action Area; Figure 1-1). Within the Action Area, the permanent footprint (the area of permanent disturbance) for the entire Project will be no more than 52.5 ha (129.8 ac), or 0.16% of the total Action Area. Development of the Project will include installation of up to 100 wind turbine generators (turbines), each with a nameplate capacity rating of 1.6 megawatt (MW) to 2.5 MW, resulting in a total generating capacity of up to 250 MW. The Project will also include development of service roads, electricity collection lines, staging areas, and an operations and maintenance (O&M) facility. While only 52 turbine locations are known at this time, the HCP will address impacts to Indiana bats from the construction and operation of the full 100-turbine Project with expected lifespan of 30 years from construction through decommissioning (ITP Term; see Section 2.5 – ITP Duration). The location of the additional 48 turbines will not significantly change the net effect on the species and the level of authorized take described in this HCP will not be greater.

The design evaluated as the primary option in this HCP includes approximately 113.5 kilometers (km; 70.5 miles [mi]) of 34.5 kilovolt (kV) interconnect lines that are to be built above ground on rebuilt poles in existing public road right-of ways. The lines would be over-hung on poles used by the local electric utilities to distribute power to local residences and businesses. Buckeye Wind has identified a possible re-design of the Project collection system that would allow a more efficient infrastructure that would result in greater ease of construction but would not significantly change the net effect on the Indiana bat and would not result in a higher level of take described in this HCP. The potential redesign would move a portion of those lines to an underground system located on private land under easement ("Redesign Option"). This Redesign Option is under consideration and would require various state and local permits and amendments to those permits. As such, it is offered here as an optional Project design that would be implemented at Buckeye Wind's discretion. While the exact design is not known at this time, the Redesign Option would include 95.4 km (59.3 mi) of 34.5 kV interconnect lines. A maximum estimate of impacts for the 100-turbine Project with the Redesign Option is presented in this document. No turbine locations would be altered except as otherwise required as part of normal project micro-siting. Throughout this document, impacts associated with the Redesign Option are presented where applicable. Unless indicated otherwise, the impacts and discussion in this HCP would apply to either collection system design that is contemplated.

It is anticipated that development of the 100-turbine project will include the following (also see Table 2-1):

- 64.4 km; (40.0 mi) of new service roads that will connect wind turbines to existing access roads;
- 113.5 km (70.5 mi) of 34.5 kV electrical interconnect lines that will connect individual turbines to the substation, of which,
    - 56.7 km (35.2 mi) will be installed underground with the majority (approximately 84%) installed parallel to Project access roads, requiring no additional clearing or soil impacts beyond those required for access road construction, and
    - 56.8 km (35.3 mi) will be installed overhead in public road right-of-ways (mostly co-located with existing electric distribution facilities);
- Under the Redesign Option, there would be 95.4 km (59.3 mi) of 34.5 kV electrical interconnect lines that will connect individual turbines to the substation, of which;
    - 86.4 km (53.7 mi) will be installed underground with about 32% installed parallel to Project access roads.
    - 9.0 km (5.6 mi) will be installed overhead;
- Temporary crane paths totaling approximately 22.7 km (14.1 mi);
- Up to 4 temporary construction staging areas, occupying a cumulative area of approximately 9.2 ha (22.9 ac);
- 1 substation that will allow connection with the existing transmission line, occupying an area of approximately 2.0 ha (5.0 ac);
- 1 O&M facility and associated storage yard (likely to be refurbishment of existing facility); and
- Up to 2 concrete batch plants occupying a cumulative area of 2.4 ha (6.0 ac).



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Legend:

- Proposed Turbines
- Township
- HCP Action Area
- Proposed Substation
- Staging Areas
- Buried Inteconnect
- Overhead Interconnect
- Crane Paths
- Access Roads

Source: Buckeye Wind, LLC

Figure: 1-1

BUCKEYE WIND PROJECT ACTION AREA AND COMPONENTS

Areas where trees will be temporarily or permanently removed are anticipated to comprise approximately 6.5 ha (16.1 ac) for the 100-turbine Project, or 0.2% of the 2,744 ha (6,779 ac) of forested habitat available in the Action Area (6.8 ha [16.8 ac] for the Redesign Option)[1].

Actions associated with the Project (i.e., Covered Activities; see Section 2.3 – Covered Activities) have the potential to incidentally take Indiana bats, listed as federally endangered under the ESA. Indiana bats could be injured or killed by colliding with or coming in close proximity to operational turbines. Additionally, suitable Indiana bat habitat will be impacted during construction activities. Direct effects of habitat loss will be completely avoided and any indirect effects are expected to be insignificant and discountable and will not constitute "take" (i.e., killing, harming, or harassing) under Section 9 of the ESA (16 USC 1538). A full assessment of the potential impacts of the Covered Activities is included in Chapter 5 of this document. Section 10 of the ESA allows for incidental take of ESA listed species through the completion of a USFWS-approved HCP and subsequent issuance of an ITP by the USFWS.

Besides the general issuance criteria listed in 50 CFR 13.21(b), an HCP must fulfill the following requirements as established under 50 CFR 17.22(b)(2)(i): "(A) The taking will be incidental; (B) The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such takings; (C) The applicant will ensure that adequate funding for the conservation plan and procedures to deal with unforeseen circumstances will be provided; (D) The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; (E) The measures if any, required under paragraph (b)(1)(iii)(D) of this section will be met; and (F) He or She [the Director] has received such other assurances as he or she may require that the plan will be implemented."

Activities covered by an ITP must also not result in adverse modification of "critical habitat", in accordance with Section 7 of the ESA. Critical habitat consists of "the specific areas within the geographical area occupied by the species, at the time it is listed … on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection" (§ 1532 (5)(A)(i)). No designated critical habitat for Indiana bats or other ESA listed species exists within the Action Area.

Though no known Indiana bat hibernacula are located within the Action Area, summer resident Indiana bats are known to occur within the Action Area and vicinity. Bat mist-netting surveys were conducted in the summer of 2008 within an area that included the current Action Area in Champaign County and an area to the north extending into Logan County ("initial study area"; see Figure 1-2). These surveys documented the presence of Indiana bats approximately 7.8 km (4.8 mi) to the north of the current Action Area. Two reproductive adult female and 1 non-reproductive adult male Indiana bats were captured as part of the 2008 survey. The initial study area was revised to be at least 8 km (5 mi) from the 2008 Indiana bat capture and roost locations and then further expanded, creating the current Action Area. The current Action Area also avoids caves supporting other species of bats (not Indiana bats) during hibernation (see Section 3.2.3 – Pre-Construction Bat Surveys Conducted).

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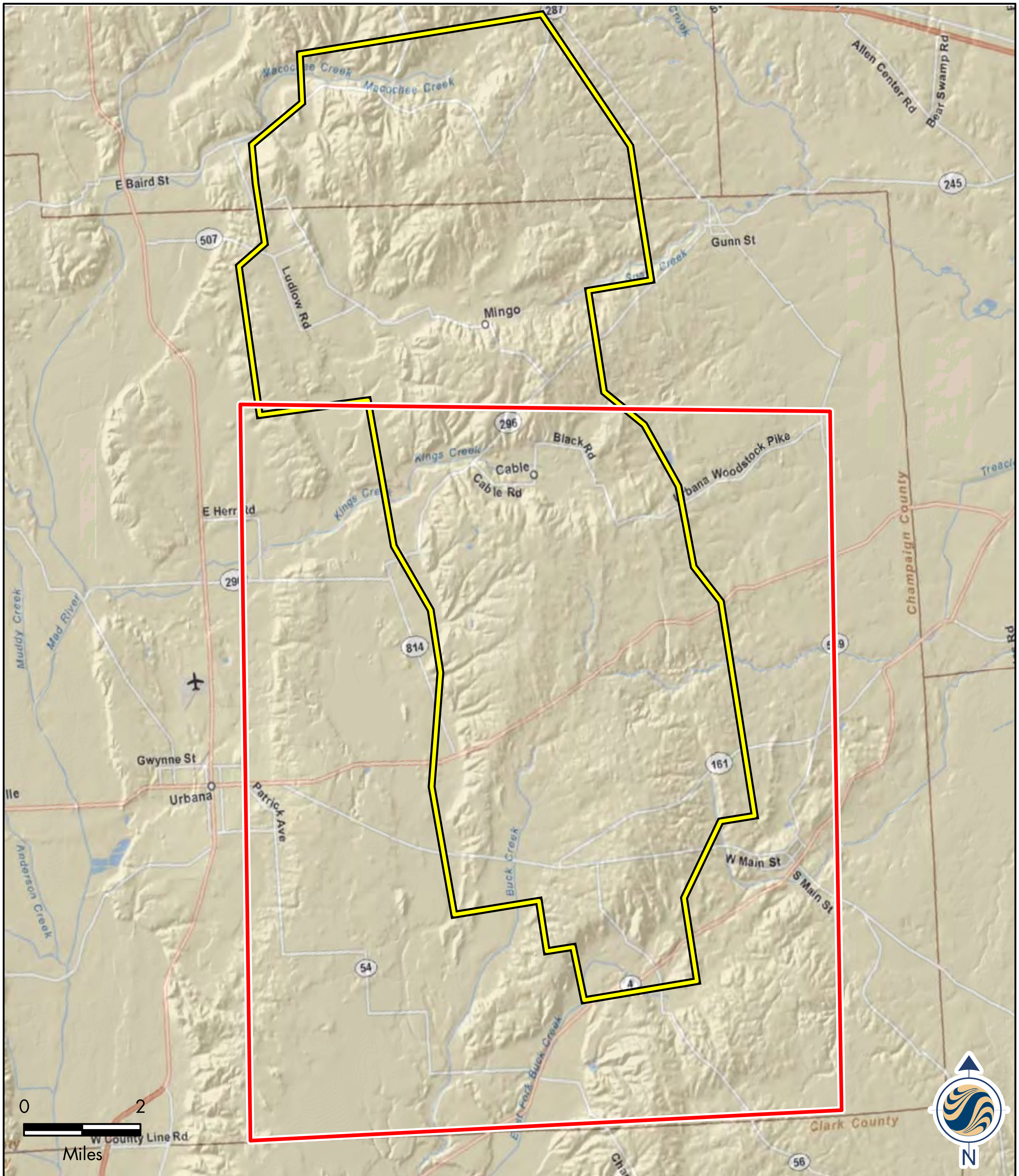
[1] Note that much of this area is located along the edges of woodlots or along thin/sparse tree lines separating parcels, resulting in a conservative estimate. Avoidance and minimization measures described in Section 6.0 will likely reduce the area of tree removal to less than the estimated 6.5 ha (16.1 ac), or 6.8 ha (16.8 ac) for the Redesign Option, based on construction needs, landowner preference, and quality of habitat.



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Legend:

- Action Area
- Initial Study Area

Figure: 1-2

BUCKEYE WIND POWER INITIAL STUDY AREA AND ACTION AREA

Mist-netting conducted in Champaign County during summer 2009 for an unrelated project resulted in the capture of 5 Indiana bats in the current Action Area. Of those 5 Indiana bats, 3 adult female Indiana bats and 1 Indiana bat of unknown sex (it escaped the net before identification was completed) were captured in the same mist-net on a single night in the northernmost portion of the Action Area. The 3 females were radio-tracked to determine their roost locations and home ranges. Based on roost tree use, all 3 females were determined to be from the same maternity colony. The area encompassing the home ranges of all 3 females comprised approximately 3% of the total Action Area size. An additional adult female was captured in summer 2009 in the central portion of the Action Area and was tracked to her roost tree located outside of the Action Area, approximately 2.3 km (1.5 mi) to the east of the eastern boundary.

In addition to the 8 Indiana bats captured in 2008 and 2009 in southern Logan and Champaign Counties, an additional 18 adult Indiana bats (17 females and 1 male) were captured during summer mist-netting surveys during 2008 and 2009 outside of the Action Area in nearby northern Logan and Hardin Counties, OH. Based on simultaneous emergence counts conducted at known Indiana bat roost trees within or near the Action Area, a minimum Indiana bat population size of 99 individuals was documented in summer 2009 (See Appendix A, Section 2.1.1). Using a combination of these site-specific, empirical data, models predicting and quantifying suitable habitat within the Action Area, and conservative assumptions based on relevant literature and professional judgment, the number of Indiana bats estimated to use the Action Area during summer ranged from 10.1 to 2,271.4 Indiana bats (details of analysis included in Appendix A).

In addition to their known presence in the Action Area during the summer maternity season (approximately 1 Jun to 31 Jul), Indiana bats are presumed to fly through the Action Area during migration in spring (approximately 1 Apr to 31 May) and fall (approximately 1 Aug to 31 Oct) as they travel to and from hibernacula. Based on data from 2009 hibernacula surveys compiled by the USFWS and assumptions based on relevant literature and professional judgment, approximately 5,800 Indiana bats are estimated to fly through the Action Area during spring and fall migration (details of analysis included in Appendix A).

Steps taken by Buckeye Wind to avoid and minimize impacts to Indiana bats include early and ongoing consultation with the USFWS and the Ohio Department of Natural Resources Division of Wildlife (ODNR DOW), pre-construction planning, and multiple years of pre-construction field studies. Based on 2008 pre-construction mist-netting, Buckeye Wind adjusted the Project boundary to avoid an area of known Indiana bat use. Buckeye Wind incorporated the recommendations of resource agencies and the findings of on-site field studies into the design, construction, and decommissioning plan to minimize and avoid impacts to Indiana bats, as well as other birds and non-federally listed bats and their habitats. For example, included in this HCP are provisions for restricting tree clearing to the non-active period (1 Nov to 31 Mar) for Indiana bats, avoiding impacts to wetland areas, avoiding and minimizing impacts to streams where possible, and siting turbines largely in agricultural areas that require minimal tree clearing. During construction, a Natural Resource Specialist[2] knowledgeable on Indiana bats and their habitat requirements will be present at the time of tree clearing and any potential roost trees observed within the clearing zone will be flagged. Prior to finalization of the detailed design of Project components, Buckeye Wind will make all reasonable efforts to offset the clearing radii around turbines or adjust roads/interconnects to preserve potential roost trees that have been flagged. Additionally, Buckeye Wind has worked with the USFWS to

[2] The Natural Resource Specialist will serve various roles during project construction, including monitoring for Indiana bat, breeding bird, and massasagua rattlesnake habitat and resources. Throughout the HCP, the functions and roles of the the Natural Resource Specialists is described. The functions of the Natural Resource Specialist will be filled by one or more biologists qualified in the specific tasks decribed and approved by the USFWS and the ODNR DOW.

conduct a field habitat assessment characterizing the quality of these areas for Indiana bat foraging and roosting activities and identifying potential roost trees.

As a result of effective avoidance and minimization efforts by Buckeye Wind during siting, construction, maintenance and decommissioning, operation of the Project is the only activity covered by this HCP that is expected to result in take of Indiana bats. As such, the primary method to minimize impacts to Indiana bats will be turbine feathering, whereby the wind speed at which turbines begin rotating and producing power (i.e., the cut-in speed) is increased from the manufacturer's specified cut-in speed (e.g., 3.0 meters per second [m/s]; 6.7 miles per hour [mph]). For the purposes of this HCP, the term "feathering" or "feathered" will be used to indicate conditions whereby turbine cut-in speed is increased above the manufacturing cut-in speed, and turbines are not rotating below the increased cut-in speed. In contrast, "curtailing" or "curtailment" will refer to turbines whose cut-in speed is increased above the manufacturing cut-in speed, but turbine blades may still rotate to some degree below the increased cut-in speed.

Operational adjustments will vary according to seasonal patterns of Indiana bat activity and based on patterns of mortality documented in bat mortality studies at wind facilities across the United States. Because there have been very few documented Indiana bat fatalities due to collision with wind turbines, it is hypothesized that Indiana bat mortality patterns will follow general seasonal patterns seen across all bat species. As such, there will be 3 periods that will have unique feathering strategies (collectively, the "active period"):

- Spring emergence and migration, or "spring" (1 Apr to 31 May);
- Summer habitat use, or "summer" (1 Jun to 31 Jul), and
- Late summer and fall migration, or "fall" (1 Aug to 31 Oct).

Initially, feathering will be applied to turbines using variable cut-in speeds, with the most restrictive cut-in speeds applied to turbines and to seasonal periods that are expected to present the greatest risk to Indiana bats (see Section 6.2.3 – Feathering Plan Phases).

Seasonal Indiana bat mortality from collision with turbines or barotrauma (i.e., tissue damage to lungs caused by rapid or excessive pressure changes formed in the wake of rotating turbine blades) was estimated using a collision risk model (Appendix A). The model used empirical data, relevant literature, expert opinion, and professional judgment to inform assumptions about Indiana bat flight height, activity under certain temperatures and wind speeds, potential movement through the turbine array, and survival probability. For the full 100-turbine Project, annual mortality of Indiana bats from collision with turbines and/or barotrauma, without feathering, was estimated to range from 6.9 Indiana bats to 25.4 Indiana bats per year, with 51% to 65% of mortality expected to occur during the fall migration period.

Reductions in bat mortality observed over 2 years in the operational adjustment study conducted at the Casselman wind facility in PA indicated that feathering at 5.0 and 6.5 m/s would reduce bat mortality to between 44% and 93% of that at turbines operating at the manufacturer's specified cut-in speeds (Arnett et al. 2010). Data from a study conducted at the Fowler Ridge wind facility in IN indicated that curtailing up to 5.0 m/s would reduce bat mortality to between 38% and 68% of that at turbines operating at the manufacturer's specified cut-in speeds, and curtailing up to 6.5 m/s would reduce bat mortality to between 71% and 85% (Good et al. 2011). Since Buckeye Wind proposes to use similar cut-in speeds as those used in the Casselman and Fowler Ridge studies, employing operational feathering at the Buckeye Wind Project is expected to reduce Indiana bat mortality to between 0.5 Indiana bat and 14.2 Indiana bats per year, with an average take of 5.2 Indiana bats per year (see Section 5.1.2.5.3 – Estimated Take With Feathering).

To account for this uncertainty in estimated take, as well as fluctuations in annual mortality resulting from natural stochasticity, this HCP proposes that multi-year levels of take be authorized over the ITP Term. Accordingly, the average annual mortality estimated by the collision risk model was used to develop 5-year and 25-year take limits. A maximum level of mortality of 26.0 Indiana bats is proposed for the mortality authorized under the ITP over any 5-year period, and 130 individuals taken over the ITP Term (see Section 5.1.2.5.3 – Estimated Take with Feathering). While annual take levels provide a benchmark for the monitoring of take and will enable implementation of adaptive management actions to appropriately reduce annual take, the 5-year limit is expected to more closely reflect the average annual mortality that will result from the Project (i.e., 5.2 Indiana bats on average per year). If estimated take exceeds 5.2 Indiana bats in any given year, Buckeye Wind will implement adaptive management as outlined in Section 6.5 – Monitoring and Adaptive Management.

To mitigate for take of Indiana bats that cannot be avoided, Buckeye Wind will dedicate funds to compensate for the impacts of the take to be used for habitat restoration and preservation to enhance the reproductive potential and survival probability of Indiana bats or purchase credits from a USFWS approved Indiana bat mitigation bank. Based on best available information, it is estimated that preservation and enhancement of 87.8 ha (217.04 ac) of habitat within 11.2 km (7 mi) of a Priority 2 Indiana bat hibernaculum in OH will effectively mitigate for take of 130.0 Indiana bats over the ITP Term (see Section 6.3 – Mitigation Measures for more details).

Because there is a lack of information regarding risk to Indiana bats from collision and/or barotrauma, there is a need for research on Indiana bat-wind interaction to be conducted at wind facilities. Filling these data gaps will help ensure that future avoidance, minimization, monitoring and mitigation measures are as effective as possible. To help fill these data gaps, Buckeye Wind will provide funding for the implementation of conservation measures that will increase scientific knowledge regarding Indiana bat behavior as it relates to wind power. This will serve to reduce uncertainty and increase the effectiveness of minimization techniques applied to the Project and potentially other wind power projects (See Section 6.4 – Conservation Measures).

This HCP includes monitoring and adaptive management plans that will provide a mechanism to ensure all biological goals and objectives are met by: 1) ensuring that the authorized level of Indiana bat take is not exceeded, 2) evaluating the effectiveness of feathering and minimization techniques, and 3) ensuring success of mitigation. Adaptive management will allow effective management decisions to be made in the face of uncertainty by refining minimization measures over time, as understanding about impacts to Indiana bats from the Project increases.

1.2 Biological Goals and Objectives of the HCP

The biological goals of an HCP are the broad, guiding principles for the operating conservation program and the rationale behind minimization and mitigation strategies. The biological objectives of an HCP are the different components or measurable targets needed to achieve the biological goals.

While this HCP is not required to result in the recovery of an ESA-listed species or contribute to the recovery objectives outlined in the *Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision* (hereafter 2007 Draft Recovery Plan; USFWS 2007), both the biological goals and objectives of this HCP will be consistent with actions to promote the recovery of the Indiana bat as identified in the 2007 Draft Recovery Plan and the HCP will not preclude recovery of the species.

In order for the USFWS to approve this HCP, the USFWS must determine that the HCP meets issuance criteria listed in Section 10(a)(2) of the ESA (see Section 1.4.1 – Federal Endangered Species Act). Two of the statutory criteria are that the take resulting from the proposed activity, as described in the HCP, will not appreciably reduce the likelihood of survival and recovery of the species in the wild, and that the Applicant will minimize and mitigate to the maximum extent practicable the impacts of the taking. The biological goals and objectives will be used to help translate the statutory and regulatory criteria or standards into meaningful biological measures, specific to this particular HCP situation and in a manner that will facilitate monitoring (Notice of Availability of a final Addendum to Handbook for HCP, 65 Federal Register [Fed. Reg.] 35242, June 1, 2000).

The biological goals of this HCP are to minimize take of Indiana bats to the maximum extent practicable and to promote the health and viability of Indiana bat populations both locally and in the Midwest Recovery Unit (RU)[3]. The biological objectives that will be implemented to achieve these goals are:

Objective 1: Implement an operational feathering strategy that will limit mortality of Indiana bats due to collision with turbines or barotrauma resulting from near collisions with moving blades to no more 26 Indiana bats over any 5-year period beginning in any year in which more than the Expected Average Mortality of 5.2 Indiana bats is estimated[4], and not more than 130.0 Indiana bats over the 30-year ITP Term;

Objective 2: Mitigate for the impacts of the incidental taking of 130.0 Indiana bats over the 30-year ITP Term through the purchase or easement acquisition and subsequent restoration and/or enhancement (if necessary), with permanent preservation, of 87.8 ha (217.0 ac) of suitable Indiana bat habitat within 11.2 km (7 mi) of a Priority 2 Indiana bat hibernaculum in OH, or purchase credits from a USFWS approved Indiana bat mitigation bank (see Section 6.3 – Mitigation Measures for more details);

Objective 3: Enhance understanding of the factors that contribute to increased risk of Indiana bat collisions and barotrauma resulting from near collisions with moving blades and tailor the conservation program to meet the biological goals. Specific factors that will be considered include:

- Seasonal variation in mortality;
- Variation in mortality with respect to turbine location and habitat; and
- Variation in mortality with respect to weather characteristics (wind speed, temperature, barometric pressure, and humidity).

Objective 4: Maximize operational output of the project, such that the environmental benefits of wind energy are maximized, thereby reducing potentially harmful effects of other energy

[3] Based on information from band returns and genetic studies, the range of the Indiana bat has been divided into RUs, each representing a distinct Indiana bat population (USFWS 2007, see Section 4.4.3.2 – Migration Direction and Behavior). Since the Project is located in the Midwest RU, Project-related impacts are expected to occur in the Midwest RU. Therefore, discussion of the Indiana bat and Project impacts will focus on the Midwest RU in this HCP.

[4] The five year take limit can only be calculated beginning in the first year of above expected average take. In this way, the 130.0 lifetime take limit is assured and it avoids a situation where above expected average take in the 5th year of a 5-year period that has otherwise seen expected average take would result in violation of the 5-year take limit, with no opportunity for Adaptive Management.

products. In particular, increased generation from wind energy facilities will offset carbon emissions from other electric generation technologies. Carbon emissions contribute to global climate change, which has been identified as a potential risk to Indiana bats (USFWS 2007). Other environmental benefits are also associated with wind energy (see Section 1.3.1 – Fossil Fuel Offsets and Reductions, and Section 5.4 – Potential Beneficial Effects of Wind Energy on Indiana bats).

An in-depth discussion of the measures that will be used to meet these objectives, and the criteria that will be used to evaluate their success, will be provided in Section 6.0 – Conservation Program.

1.3 Purpose and Need for the Project

The purposes and needs of the Buckeye Wind Project are to:

- Develop a renewable source of energy to reduce the reliance on energy sources that emit carbon dioxide and that contribute to global climate change;
- This need has been legislated through Ohio's Alternative Energy Portfolio Standard (AEPS) and stipulated through Executive Order 13212 (dated 18 May 2001) and "Barack Obama and Joe Biden: New Energy for America" plan (Obama for America 2008);
- Provide a domestic source of energy that will help to increase energy security in OH and the United States;
- Cost-effectively generate ample, clean, renewable wind energy that will help meet the OH AEPS;
- Locate wind facilities in areas where adequate wind resources are available to make commercial wind development possible;
- Construct wind facilities with turbines of adequate size and number to be operated in a manner that allows them to be economically viable.

1.3.1 Fossil Fuel Offsets and Reductions

The atmospheric buildup of carbon dioxide and other greenhouse gases is largely the result of human activities, such as the burning of fossil fuels (Environmental Protection Agency [EPA] 2009a). In the United States, more than 90% of greenhouse gas emissions come from the combustion of fossil fuels, which has increased by approximately 40% in the last 150 years (i.e., since large-scale industrialization began). According to the EPA (2009a), scientists know with "virtual certainty" that increasing greenhouse gas concentrations are warming the planet and that rising temperatures may, in turn, produce changes in precipitation patterns, storm severity, and sea level, commonly referred to as "climate change."

According to the Intergovernmental Panel on Climate Change (IPCC) (2007), the earth's climate has warmed between 1.1° Fahrenheit (F) and 1.6°F over the past century, and most of the observed increase in globally averaged temperatures since the mid-20th century is "very likely due to the observed increase in anthropogenic greenhouse gas concentrations." Combustion of fossil fuels also produces air pollutants such as nitrogen oxides, sulphur dioxide, volatile organic compounds, and heavy metals. Of all fossil fuels used to provide electricity in the United States, coal has the highest carbon dioxide content per unit of electricity produced (United States Department of Energy, Energy Information Administration [DOE EIA] 2007). Approximately 71% of the United States' electricity is generated from fossil fuels, with 49% produced from coal. The state of OH depends heavily upon coal for its electrical generation. As shown in Table 1-1, OH relies more heavily on fossil fuels than the national average, with 86% of electricity generated from coal (Public Utilities Commission of Ohio [PUCO] 2008). Ohio was the fourth largest contributor of carbon dioxide emissions from fossil fuel combustion in the United States in 2007 (267.67 million metric tons), behind PA, CA, and TX (in increasing order; EPA 2009a).

Table 1-1. Percent of electric generation by energy source in OH (PUCO 2008).

Energy generation source	Percent of OH fuel mix
Coal	86
Nuclear	10
Natural & other gases	2
Petroleum	1
Hydroelectric & other renewable	1
Total	**100**

In addition to well documented negative environmental and health effects, fossil fuels generating facilities have higher operating costs due to the costly and changeable price of fuels (Jacobson and High 2008). Historically, oil prices have fluctuated based on ever-changing supply and demand, as well as political conditions in fuel-producing countries. Such instability increases the economic vulnerability of the United States and jeopardizes the ability of Americans to successfully carry out activities that are essential to their security and livelihood. Reducing the proportion of United States' energy portfolio that comes from fossil fuels would potentially reduce unpredictable energy cost fluctuations.

Electricity generated by the Project has the potential to displace electricity generated at fossil-fueled plants and thereby reduce energy production from inefficient and environmentally harmful sources of power. The emissions values shown in Table 1-2 are representative of potential fossil fuel emissions that could be displaced by a 250 MW wind power facility (assuming a 30% capacity factor and based on emissions rates for electricity used in OH).

Table 1-2. Estimated annual displacement (tons) of fossil fuels by the 100-turbine Buckeye Wind Project, Champaign County, OH (Abraxas Energy 2009, Leonardo Academy 2008).

	Estimated annual displacement in tons[a]
Pollutant	**250 MW project 100 turbines (657,000 megawatt hours [MWh])**
CO_2 (carbon dioxide)	593,600
NO_x (nitrogen oxides)	2,267
SO_2 (sulfur dioxide)	5,223
Mercury compounds	5,283
Lead compounds	9,323

[a] This table is meant to approximate the potential emissions reductions from the project based on a typical capacity factor (30%) for the wind regime at the site. Depending on the final turbine selected, impacts of operational feathering, final capacity of turbines installed and other site-specific factors, the actual reductions could be more or less than those presented here. With the Feathering Plan proposed in this HCP, capacity factor is expected to be above 30% and therefore the numbers here can be considered a minimum estimate.

1.3.2 State and Federal Policies

Another important need for the Project is reflected in the OH AEPS, signed into law by Governor Strickland on 1 May 2008 (49 ORC 4928.64). The law mandates that by 2025, at least 25% of all electricity sold in OH comes from alternative energy resources. At least half of that standard, or 12.5% of electricity sold, must be generated by renewable resources[5], and at least half of this renewable energy must be generated in-state. Buckeye Wind anticipates selling the power to OH entities, helping to satisfy the AEPS. Regardless of where and to whom the power is sold, the Project's power will provide renewable energy benefits to the environment and offset fossil fuel emissions. In addition, the project will provide an economic boost to the region, creating jobs and investment in the surrounding communities (see discussion in the EIS).

Federal policy also has promoted increased renewable energy generation in the United States. The Project is consistent with Executive Order 13212 (dated 18 May 2001), which states:

> "The increased production and transmission of energy in a safe and environmentally sound manner is essential to the well being of the American people. In general, it is the policy of this Administration that executive departments and agencies shall take appropriate actions, to the extent consistent with applicable law, to expedite projects that will increase the production, transmission, or conservation of energy."

The Obama-Biden administration affirms this goal within its comprehensive "Barack Obama and Joe Biden: New Energy for America" plan, which includes in its objectives the creation of 5 million new jobs over 10 years and ensuring that 10% of our electricity comes from renewable sources by 2012, and 25% by 2025 (Obama for America 2008). Consistent with these state and federal policies, the Project would help fulfill the need for the production and transmission of renewable energy, which would serve the public interest. The Project will maximize its energy production from wind resources in order to deliver clean, renewable, low cost electricity. The electricity generated by the Project will be transferred to the transmission grid operated by PJM Interconnection for sale in the wholesale market.

1.3.3 Project Viability

Quality of wind resource, proximity to the bulk power transmission system, and availability of land are the primary factors driving the initial site selection of any wind power project. In addition to these factors, wind energy facilities also require an adequate number of appropriately-sized turbines to produce sufficient power to provide an economic return. The manner in which these turbines are operated also affects a wind facility's economic viability; increases to the manufacturer's specified cut-in speeds can impact annual power production and revenue.

1.4 Regulatory and Legal Framework

1.4.1 Federal Endangered Species Act

Section 9 of the ESA in 50 CFR Section 17.31(a) prohibits take of any fish or wildlife species listed as endangered or threatened under the ESA unless an exemption is granted under Section 7 or Section 10 of the ESA or a special rule is promulgated for a threatened species under Section 4(a) of the ESA and 50 CFR § 17.40 to 17.48. Take is defined under the ESA as "to harass, harm, pursue, hunt, shoot, wound, kill,

[5] The additional 12.5% of the overall 25% standard can also be met through alternative energy resources such as third-generation nuclear power plants, fuel cells, energy efficiency programs, and clean coal technology that can reduce or prevent carbon dioxide emissions.

trap, capture, or collect" listed species (16 U.S.C. § 1532(19)). Harm, in this case, means an act that actually kills or injures wildlife and may include significant habitat modification or degradation that "actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering" (50 CFR 17.3). To harass means to perform an "intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 CFR 17.3).

Section 7(a)(2) of the ESA states that each federal agency shall ensure that any action it authorizes, funds, or carries out is not likely to jeopardize the continued existence of ESA listed species or result in destruction or adverse modification of designated critical habitat (16 U.S.C. §1536 (a)(2)). A federal action is defined as "…all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies in the United States or upon the high seas" (50 CFR § 402.02). Actions of federal agencies that are not likely to jeopardize the continued existence of ESA listed species or result in destruction or adverse modification of their designated critical habitat, but that could adversely affect the species, or result in a take, must be addressed under Section 7 (16 U.S.C. §1536 (a)(2)).

Section 10 of the ESA allows, under certain terms and conditions, for the incidental take of ESA listed species by non-federal entities that would otherwise be prohibited by Section 9 of the ESA. Incidental take is defined by the ESA as take that is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (16 U.S.C. §1539(a)(1)(B)). Under Section 10, incidental take may be approved through the successful completion of a USFWS-approved HCP that demonstrates that the impacts of incidental take have been minimized and mitigated to the maximum extent practicable. Incidental take may be permitted through the issuance of an ITP if the following 6 criteria of 50 CFR 17.22(b)(2) and 50 CFR 17.32 (b)(2) are met.

- All takings must be incidental;
- Impacts of such taking must be minimized and mitigated "to the maximum extent practicable;"
- There must be both adequate funding for the plan and provisions to address "unforeseen circumstances;"
- The taking must "not appreciably reduce the likelihood of the survival and recovery of the species in the wild;"
- The Applicant must ensure that additional measures required by the Secretary will be implemented; and
- Federal regulators must be assured that the HCP can and will be implemented.

An ITP can only be issued if the HCP addresses all of these requirements. Per 50 CFR 17.22 (b) (1), in order to demonstrate that all 6 requirements have been adequately addressed, the HCP must document and describe:

- Impacts likely to result from the proposed taking of the species for which ITP coverage is requested;
- Measures the Applicant will undertake to monitor, minimize, and mitigate such impacts;
- Funding that will be made available to undertake such measures;
- Procedures to deal with unforeseen circumstances;
- Alternatives the Applicant considered that would not result in incidental take, and the reasons why such alternatives are not being utilized; and
- Other necessary and appropriate measures the USFWS may require as necessary or appropriate for purposes of the plan.

The issuance of an ITP is a federal agency action under Section 7(a)(2) of the ESA; therefore, USFWS must comply with the requirements of Section 7. In order to issue an ITP, the USFWS is required under Section 7 of the ESA to prepare a Biological Opinion (BO) that evaluates the impacts of the proposed action (i.e., issuance of an ITP) and establishes an overall effect determination. Section 7 of the ESA requires that analysis of the direct and indirect effects of a proposed action, the cumulative effects of other future non-Federal activities within the Action Area, and effects of the action on critical habitat demonstrate that the authorized action "is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification" of designated critical habitat (16 U.S.C. §1536(a)(2)).

In addition to these necessary HCP elements, the Five-Point Policy (65 Fed. Reg. 35242-35257, June 1, 2000), an addendum to the *Habitat Conservation Planning and Incidental Take Permit Processing Handbook* (USFWS and National Oceanic and Atmospheric Administration [NOAA] 1996) describes 5 clarifying components that should be included in an HCP. Each of these HCP elements is discussed briefly in the sections below.

Biological Goals and Objectives

According to the Five-Point Policy, HCPs should include a clear description of the biological goals of the plan, including the broad guiding principles and the rationale behind strategies for minimization and mitigation. The desired outcome for species covered under the HCP and their habitat will be described in terms of the objectives to be achieved through implementation of the HCP. For each biological goal, the specific biological objectives must be described in terms of measurable targets for achieving the goals in the HCP (USFWS and NOAA 1996).

Adaptive Management

Adaptive management is a process of iterative decision making, with the aim to reduce uncertainty over time through monitoring. Thus, adaptive management is a method for examining alternative strategies that can be used to meet measurable biological goals and objectives, and if necessary, altering future management actions based on what has been learned (USFWS and NOAA 1996).

The Five-Point Policy encourages the development of an adaptive management plan for the HCP that identifies the uncertainty inherent in the HCP's existing assumptions, develops experimental strategies to answer questions relating to that uncertainty, and integrates information from a monitoring program into future management actions. This creates an information feedback loop that links implementation and monitoring to a decision making process about appropriate changes in management. This adaptive management strategy should ultimately achieve the biological goals of the HCP (USFWS and NOAA 1996).

Monitoring

Monitoring is a mandatory component of all HCPs under the Five-Point Policy. The monitoring plan must describe how compliance with the HCP will be evaluated, identify how biological goals and objectives of the HCP will be met, and provide information that will inform the adaptive management strategy (USFWS and NOAA 1996).

ITP Duration

The Five-Point Policy specifies that HCPs should clearly define the desired duration the ITP will be in effect and include a discussion about the factors considered in determining the length of the ITP. In making its decision as to the appropriate ITP duration, the USFWS will consider the expected positive and negative effects on species covered under the HCP, the length of time necessary to implement and achieve the benefits of the operating HCP, the availability and quality of scientific and commercial data used to develop the HCP, and the extent to which the HCP incorporates adaptive management strategies (USFWS and NOAA 1996).

Public Participation

The Five-Point Policy expanded the public comment period for most HCPs. The addendum indicates that most HCPs will be provided to the public for a 60-day comment period, but that large, complex HCPs require a 90-day public comment period (USFWS and NOAA 1996).

1.4.2 National Environmental Policy Act

The issuance of an ITP by the USFWS constitutes a federal action subject to National Environmental Policy Act (NEPA) compliance and review (42 USC §§ 4321-4347, as amended). The purpose of NEPA is to ensure that the potential environmental impacts of any proposed federal action are fully considered and made available for public review. The scope of the NEPA analysis considers the effects of proposed and alternative actions on the human environment, which includes biological resources as well as non-biological resources, such as water quality, air quality, and cultural resources.

To evaluate the environmental effects of a proposed action, the USFWS typically prepares and provides for public review an Environmental Assessment (EA). If the USFWS finds that significant impacts to the human environment are not expected as a result of the proposed action, then a Finding of No Significant Impact (FONSI) is issued. If significant impacts are anticipated, then a comprehensive EIS is prepared and distributed for public review. After the USFWS completes their review of an EA/FONSI or EIS, they issue a Record of Decision of their findings. The USFWS can issue an ITP only after the NEPA review process has been completed.

1.4.3 State Endangered Species Legislation

Ohio Revised Code (RC) 1531.25 grants the chief of the ODNR DOW, with the approval of the wildlife council, the authority to adopt rules, modify and repeal rules restricting the taking or possession of native wildlife that is threatened with state-wide extinction. These rules may only provide for the taking of species for zoological, educational and scientific purpose, and for propagation in captivity to preserve the species. In OH, animals and plants listed as threatened or endangered receive regulatory protection under RC § 1518.01–99; 1531.25, 1531.99. At this time, the ODNR DOW does not have the explicit authority to authorize take for any listed-species, including Indiana bats, for commercial or business purposes such as the construction and operation of the Project.

1.4.4 Major Utility Facility Review

The OPSB has regulatory authority over all proposed wind power projects in OH capable of generating 5 or more MW of electricity. Prior to issuance of a Certificate of Environmental Compatibility and Public Need (CECPN) by the OPSB, wind developers must demonstrate that their wind facility complies with a variety of requirements to ensure that potential impacts to the human environment, including natural resources, have been adequately addressed. The Project has already received conditional CECPN for the first 52 turbines.

A separate OPSB application for a Certificate for Environmental Compatibility and Public Need (CECPN; see Section 1.4.4 – Major Utility Facility Review) has been submitted for the Buckeye II Wind Project (see Section 2.1 – Applicant Background and Project History). This application has been submitted by Champaign Wind LLC, a seperate EverPower subsidiary. Construction of any of the additional turbines will not commence until the CECPN for Buckeye II Wind Project is issued. Due to the timelines for developing the OPSB application and HCP and uncertainty of the outcome of the CECPN process, the level of detail provided in the OPSB application and HCP are not identical. However, ample information has been included in this HCP to adequately assess the potential impacts to the Indiana bat (see Chapter 5.0 – Impact Assessment) from the full 100-turbine Project. The assessment in the HCP includes a reasonable worse case estimate of possible impacts for the 100 turbine Project and all 100 turbines will be constructed within the Action Area described in the HCP. The additional turbines, as described in the Buckeye II Wind Project OPSB application, will not result in a greater impact to the Indiana bat than what is described and analyzed in this HCP.

Buckeye Wind will fully comply with all commitments, terms, and conditions associated with the CECPN issued for the first 52 turbines and any future CECPN that may be issued for the Buckeye II Wind Project.

1.4.5 Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) of 1918 decreed that all migratory birds and their parts (including eggs, nests, and feathers) were fully protected (16 U.S.C. 703). A migratory bird is any individual species or family of birds that crosses international borders at some point during their annual life cycle to live or reproduce. The MBTA implements 4 treaties that prohibit take, possession, transportation, and importation of all migratory, native birds (plus their eggs and active nests) occurring in the wild in the United States except for House Sparrow, European Starling, Rock Pigeon, any recently listed unprotected species in the Federal Register and non-migratory upland game birds, except when specifically authorized by the USFWS. In total, more than 1,000 bird species are protected by the Act, 58 of which can be legally hunted with a permit as game birds. The MBTA addresses take of individual birds, not population level impacts. Failure to comply with the MBTA can result in criminal penalties.

Although the MBTA does not include a provision authorizing incidental take of migratory birds, the USFWS recognizes that some level of mortality of migratory birds at wind projects can occur even if all reasonable measures to avoid mortality are implemented (USFWS 2010a). The USFWS has and continues to provide wind power project developers guidance in making a good-faith effort to comply with the MBTA. The USFWS has indicated that the Department of Justice has exercised discretion in enforcing provisions of the MBTA regarding companies who have made good faith efforts to avoid the take of migratory birds. Buckeye Wind has developed an ABPP to address the MBTA.

1.4.6 Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act (BGEPA) affords specific legal protection to bald eagles and golden eagles. Under this Act, it is a violation to "…take, possess, sell, purchase, barter, offer to sell, transport, export or import, at any time or in any manner, any bald eagle commonly known as the American eagle, or golden eagle, alive or dead, or any part, nest, or egg, thereof…." This Act defines take as pursuing, shooting, shooting at, poisoning, wounding, killing, capturing, trapping, collecting, molesting, and disturbing. "Disturb" is defined in regulation 50 CFR 22.3 as "to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior."

In fall 2009, USFWS implemented 2 rules (50 CFR 22.26 and 22.27) authorizing limited legal take of bald and golden eagles "when the take is associated with, but not the purpose of an otherwise lawful activity, and cannot practicably be avoided" (USFWS 2010). Failure to comply with the BGEPA can result in criminal penalties.

Although take permits may be issued under these new rule, Buckeye Wind is not seeking a "non-purposeful eagle take" permit under the BGEPA at this time since the Project is not expected to result in activities that would incidentally take (harm or harass) eagles (refer to Section 5.7 of the EIS and Section 4.1.5.1 of the ABPP for further details on eagle use in the Action Area).

2.0 PROJECT DESCRIPTION

2.1 Applicant Background and Project History

Buckeye Wind was created for the purpose of developing, constructing, owning, and operating a new wind generation facility in Champaign County, OH, and is a wholly owned subsidiary of EverPower. EverPower has become a leader in the renewable energy industry by partnering with local landowners and communities to maximize the environmental and economic benefits of generating renewable, clean, wind power. With offices in New York City, NY, Pittsburgh, PA, and Bellefontaine, OH (and field representatives in other locations) and over 1,500 MW of wind power projects under development across the country, EverPower's development team has experience in all aspects of financing, constructing, managing, and operating large wind power projects. The Project was the first application submitted to the OPSB for a large-scale commercial wind powered electric generation facility in OH.

The Project has been in the planning and development phase since 2006. Acquisition of land rights for the Project began in 2006 and continued through early 2009. Over 60 private landowners are voluntarily participating in the Project. A public information meeting was held on 28 June 2008 at Triad High School in North Lewisburg, OH, to facilitate public interaction with Buckeye Wind and expert consultants. Information on visual, aesthetic, and ecological studies and wind turbine technology were presented at the meeting. Pre-Application meetings with OPSB staff were conducted on 20 November 2008 and 23 February 2009. The OPSB Application for a CECPN for a 70-turbine facility was submitted by Buckeye Wind in April 2009 and a Certificate for 54 turbines was approved on 22 March 2010, conditional upon Buckeye Wind successfully obtaining an ITP for potential incidental take of Indiana bats, among other conditions.

Buckeye Wind proposes to construct and operate 100 turbines, although the locations of only 52 turbines and their associated infrastructure are currently known. During the OBSP evaluation process, 16 turbines were prohibited due to unresolved Federal Aviation Administration (FAA) obstruction violations and 2 additional turbines became unviable due to costs associated with collection line construction and operation. As a result, 18 turbines were omitted from the original OPSB Application layout and 52 turbines are currently certificated by the OPSB.

Champaign Wind LLC, a separate EverPower subsidiary, has initiated the OPSB application procedure for the Buckeye II Wind Project, consisting of approximately 56 turbines (no more than 100 total turbines will be constructed for the Buckeye Wind and Buckeye II Wind projects combined). The Buckeye II Wind Project will be transferred to Buckeye Wind prior to construction. A public information meeting for Champaign Wind LLC was held on 24 January 2012. Champaign Wind LLC's record of public interaction is available through the PUCO Docketing Information System[6].

Impacts to Indiana bats for a 100-turbine layout have been estimated by extrapolating from the known 52-turbine layout or from analyses conducted for a 70-turbine layout presented in the OPSB Application for a

[6] http://dis.puc.state.oh.us/CaseRecord.aspx?CaseNo=12-0160-EL-BGN.

CECPN (see Section 1.4.4 – Major Utility Facility Review). As such, effects on Indiana bats presented in this HCP are evaluated using the data specific to the current 52-turbine layout plus a reasonable estimate for the remaining 48 turbines, resulting in evaluation of worst-case scenario effects for the full 100-turbine project presented in this HCP.

2.2 Project Components

Development of the Project will include installation of up to 100 turbines, each with a generating capacity of 1.6 MW to 2.5 MW. Based on an analysis of the wind resource data measured at the site, the Project is expected to operate at an average annual capacity factor of about 30%, resulting in approximately 657,000 MWh of electricity generation per year. In addition to turbines, the Project will include construction of access roads, underground and overhead electricity collection lines, a substation, up to 4 temporary construction staging areas, and an O&M facility (Figure 1-1 depicts the project layout for the known 52 turbines and associated facilities). The energy generated by the Project will collect to a substation and be delivered to an existing transmission line in Union Township in Champaign County. Each of these Project components is described in the following sections.

A separate OPSB application for a Certificate for Environmental Compatibility and Public Need (CECPN; see Section 1.4.4 – Major Utility Facility Review) has been submitted for the Buckeye II Wind Project (see Section 2.1 – Applicant Background and Project History). This application has been submitted by Champaign Wind LLC, a seperate EverPower subsidiary. Construction of any of the additional turbines will not commence until the CECPN for Buckeye II Wind Project is issued. Due to the timelines for developing the OPSB application and HCP and uncertainty of the outcome of the CECPN process, the level of detail provided in the OPSB application and HCP are not identical. However, ample information has been included in this HCP to adequately assess the potential impacts to the Indiana bat (see Chapter 5.0 – Impact Assessment) from the full 100-turbine Project. The assessment in the HCP includes a reasonable worse case estimate of possible impacts for the 100 turbine Project and all 100 turbines will be constructed within the Action Area described in the HCP. The additional turbines, as described in the Buckeye II Wind Project OPSB application, will not result in a greater impact to the Indiana bat than what is described and analyzed in this HCP.

Table 2-1. Impact assumptions and calculations based on a 100-turbine layout and associated components of the Buckeye Wind Project[A], Champaign County, Ohio (EDR 2009).

Components	Typical area of vegetation clearing	Area of soil disturbance (temporary and permanent)	Area of permanent disturbance (fill/structures)
Wind turbines and workspaces (100)	61 m (200 ft) radius per turbine	61 m (200 ft) radius per turbine	0.08 ha (0.2 ac) pedestal plus crane pad
Access roads (64.4 km [40.0 mi])	16.8 m (55 ft) wide	12.2 m (40 ft) wide	6.1 m (20 ft) wide
Buried electrical interconnects (except where located parallel to access roads) (56.7 km [35.2 mi], 86.5 km [53.7 mi] with Redesign Option)	7.3 m (25 ft) wide	7.3 m (25 ft) wide	None
Overhead electrical interconnects (maximum of 1,000 poles, 200 poles with Redesign Option)	clearing restricted to existing right-of-ways	< 0.01 ha (.03 ac) per pole	0.00008 ha (0.0002 ac), .00002 ha (.00005 ac) for Redesign Option
Crane paths (22.7 km [14.1 mi])	16.8 m (55 ft) wide	12.2 m (40 ft) wide	None
O&M building and associated storage yard (1)	1.2 ha (3 ac)	1.2 ha (3 ac)	1.2 ha (3 ac)
Staging areas (up to 4)	9.2 ha (22.9 ac) total	9.2 ha (22.9 ac) total	None
Substation (1)	2.0 ha (5 ac)	2.0 ha (5 ac)	2.0 ha (5 ac)
Permanent MET Towers (4)	0.4 ha (1 ac)	< 0.01 ha (.03 ac) per tower	0.0008 ha (0.002 ac)
Concrete batch plant (2)	1.2 ha (3.0 ac) per plant	1.2 ha (3.0 ac)	None
Total Impacts for 100-turbine Project		**220.9 ha (545.8 ac), or 219.9 ha (543.6 ac) for Redesign Option**	**52.2 ha (128.9 ac), or 52.5 ha (129.8 ac) for Redesign Option**

[A] The impact assumptions here are given as approximate or average values. The actual impact for a particular component or portion of the Project will depend on site specific factors. The maximum total Project impact is given in this table and in more detail in Tables 5-14 and 5-15.

Construction of the Project will begin as soon as practicable upon issuance of the ITP. Construction of access roads, underground and overhead collection system lines, and concrete turbine foundations will begin first, followed by turbine erection. Timing of construction for the first 52 turbine locations and the subsequent 48 turbines will depend on a number of factors, including the OPSB certificate process, landowner negotiations and final Project planning. Table 2-1 presents construction impact assumptions for each Project component based on values observed from recently constructed wind projects and engineering needs (Environmental Design and Research [EDR] 2009). Concrete batch plants used for Project construction may use existing, developed facilities located off-site, which would require no new vegetative clearing or soil disturbance. If new batch plants are required within the Action Area, they will be located in previously disturbed or agricultural areas that will not impact trees, streams, wetlands or Conservation Reserve Program (CRP) land. Operation and permitting of the plant will be handled by the sub-contractor selected to supply the Project construction.

2.2.1 Turbines

The specific turbine model to be used for the Project has not yet been selected. Final selection depends on a number of factors including cost, performance, availability, wherewithal of the manufacturing, and other site specific factors. Recent trends in the supply market have made it more practicable and efficient to delay capital commitments (i.e., turbine purchase agreements) until later in the Project development process. Commercially available turbine models being considered for the Project are essentially uniform in terms of dimensions, appearance, and electrical output design. Any variation among turbine models selected for the Project will be small to insignificant (i.e., ranging from approximately 2 meters [m] to 5 m [7 feet (ft) to 16 ft] difference in total height).

Although the final turbine model has not yet been selected, the Project description uses a generic turbine to illustrate the turbine design characteristics. The generic turbine model represents a reasonable estimate of the worst-case scenario in terms of potential mortality to Indiana bats based on post-construction monitoring data that suggest bat fatalities increase with increased turbine heights and/or greater rotor swept area (Johnson et al. 2003a, Johnson et al. 2004, Barclay et al. 2007, Fiedler et al. 2007). The generic turbine model includes the tallest turbine with the largest rotor swept area of those being considered for the Project and was used in the collision risk model (Appendix A) to estimate potential mortality to Indiana bats. While other turbines may have slightly different dimensions in terms of rotor diameter, hub height, and tip height, mortalities due to collision with all turbines in this range are expected to be substantially similar, and none would have a total turbine height (tower plus ½ the rotor diameter) greater than 150 m (492 ft)[7].

Figure 2-1 provides an illustration of the turbine dimensions contemplated for this Project. Turbine characteristics are summarized in Table 2-2. Each turbine will consist of 3 major components: tower, nacelle, and rotor, each described below. The Project may not utilize the same turbine model for all 100 turbines. In any case, any turbine model used will be of similar dimensions.

Table 2-2. Characteristics of a representative wind turbine generator.

Power Generation	2.5 MW per turbine
Hub Height	100 m (328 ft)
Rotor Diameter	100 m (328 ft)
Total Tower Height (Hub + ½ Rotor)	150 m (492 ft)
Height of Lowest Rotor Blade Reach	50 m (164 ft)
Rotor Swept Area	7,823 m^2 (84,206 ft^2)
Rotor Speed (*range possible*)	9.6-14.9 rotations per minute (rpm)
Rotor Tilt Angle Blade Cone Angle	5° 3.5°
Wind Speed of Generator Initiation (Cut-in)	3 meters/second (m/s; 7 mile/hour [mph])
Wind Speed of Generator Cessation (Cut-out)	20 m/s (45 mph)
Maximum Tip Speed	77 m/s (172 mph)
Rated Wind Speed (Unit Reaches Maximum Output)	12.5 m/s (28 mph)

[7] The CRM (see Appendix A) used a 100 m rotor diameter for modeling predicted take of the 100 turbine Project. If larger rotor diameter would result in a higher take estimate, adaptive management will maintain actual take numbers at the level requested in this HCP. No amendment to the take limit will be sought if a rotor diameter larger than 100 m is used for any portion of the Project.

Tower

The tubular towers used for MW-scale turbines are conical steel or concrete structures manufactured in multiple sections. Each tower will have an access door and internal lighting, along with an internal ladder and mechanical lift to access the nacelle. The nacelle is expected to be approximately 100 m (328 ft) above ground level (agl; i.e., hub height). The towers will be painted off-white in accordance with FAA regulations designed to make the structures more visible to aircraft when viewing from above, as light colors contrast sharply against the dark-colored ground. This also has the benefit of reducing visibility from ground vantage points, which are generally viewed against the background of the sky.

Nacelle

The main mechanical components of the wind turbine, including the drive train, gearbox, and generator, are housed in the nacelle. The nacelle is housed in a steel reinforced fiberglass shell that protects internal machinery from the environment and dampens noise emissions. The housing is designed to allow for adequate ventilation to cool internal machinery. The nacelle is equipped with an external anemometer and a wind vane that signals wind speed and direction information to an electronic controller. Attached to the top of some of the nacelles will be an aviation warning light. These lights are anticipated to be flashing red strobes (L-864) that operate only at night and in accordance with FAA guidelines (Advisory Circular 70/7460-1K). The nacelle is mounted on a bearing that allows it to rotate ("yaw") into the wind to maximize wind capture and energy production.

Rotor

A rotor assembly is mounted to the nacelle to operate upwind of the tower. Each rotor consists of 3 composite blades that will be up to 50 m (164 ft) in length, with a total rotor length of up to 100 m (328 ft). The rotor attaches to the drive train at the front of the nacelle. Hydraulic motors within the rotor hub feather each blade according to wind conditions, which enables the turbine to operate efficiently at varying wind speeds. The rotor can spin at varying speeds to operate more efficiently. Depending on the turbine model selected, the wind turbines will begin generating energy at wind speeds as low as 3 m/s to 3.5 m/s (6.7 mph to 7.8 mph), and cut out when wind speeds reach 20 m/s to 25 m/s (44.7 mph to 55.9 mph). The maximum rotor speed is approximately 15 rpm.

2.2.2 Access Roads

The Project will require the construction of new or improved roads to provide access to the proposed turbine and substation sites. The proposed location of access roads for the known 52-turbine Project is shown on Figure 1-1. The total length of access road required to service the100-turbine Project is approximately 64.4 km (40.0 mi), some of which will be upgrades to existing farm lanes. The road will be gravel-surfaced and typically 5 m (16 ft) in finished width; however, to assure a worst-case analysis and to account for side slope grading, a maximum finished width of 6 m (20 ft) was assumed for purposes of impact calculation.

2.2.3 Collection Lines and Substation

The Project will have an electrical system that consists of 2 parts: (1) a system of 34.5 kV shielded and insulated cables that will collect power from each wind turbine, and (2) a substation that will transfer the power from the 34.5 kV collector cables to existing transmission lines and the regional power grid. The wind turbine transformer will raise the voltage of electricity produced by the turbine generator up to the 34.5 kV voltage level of the collection system. From the transformer, cables will join the collector circuit and turbine communication cables to form the electrical interconnect system. Locations of underground and overhead collection lines for the currently known 52-turbine Project are depicted in Figure 1-1. For the 100-turbine Project, the total estimated length of 34.5 kV collection lines carrying electricity to the substation will be approximately 113.5 km (70.5 mi), or 95.4 km (59.3 mi) in the Redesign Option. It is anticipated that approximately 56.8.0 km (35.3 mi), or 9.0 km (5.6 mi) in the Redesign Option, of the 34.5 kV interconnects will be above ground (on rebuilt distribution poles in existing public road right-of-ways) and approximately 56.6 km (35.2 mi), or 86.4 km (53.7 mi) for Redesign Option, will be buried underground.

The substation will be located near the intersection of Pisgah Road and Route 56 in the Town of Union, adjacent to the Givens to Mechanicsburg section of the Urbana Mechanicsburg Darby 138 kV transmission line. The substation will step up voltage from 34.5 kV to 138 kV to allow connection with the existing transmission. The substation will include dead-end structures, circuit breakers, air break switches, metering units, relaying, communication equipment, and a control house. Construction of the substation will permanently impact an approximately 2.0 ha (5 ac) area. The substation will be enclosed by a chain link fence and accessed from Pisgah Road by a new gravel-surfaced road approximately 0.2 km (0.1 mi) in length.

2.2.4 Meteorological Tower

In order to record weather data to ensure turbine output is maximized, the Project layout will include 4 permanent meteorological test towers (MET towers). The permanent MET towers will support equipment used to measure wind speed (anemometers), wind direction (wind vanes), temperature and other pertinent weather data. The final locations of the permanent MET towers will be determined by turbine engineers. Permanent MET towers will be placed in open fields, so that turbulence from trees and other structures do not interfere with equipment readings. The permanent MET towers will be non-guyed, free standing structures.

2.2.5 Staging Areas

It is currently anticipated that Project construction will require the development of up to 4 construction staging areas (Figure 1-1 depicts the staging areas to support construction of the known 52 turbine locations). Staging areas will only be located on previously disturbed or agricultural lands. These sites will accommodate material storage, parking for construction workers, and construction trailers enclosed by fencing (at 1 site only). Development of the staging areas is anticipated to temporarily disturb an area of approximately 9.2 ha (22.9 ac), including a site for trailers. No lighting of staging areas is currently proposed, but could be added if vandalism or similar problems are experienced.

2.2.6 Operations and Maintenance Building

An O&M building and associated storage yard will be required to house operations personnel, equipment, and materials, and to provide operations staff parking. It is anticipated that an existing structure in the vicinity of the Project will be purchased or leased and refurbished for O&M activities. If a new building is needed, it is expected to permanently disturb an area of no greater than 1.2 ha (3.0 ac), and will be designed to resemble an agricultural building similar in style to those found throughout the area. If a new building is required, it will be located on previously disturbed or agricultural land.

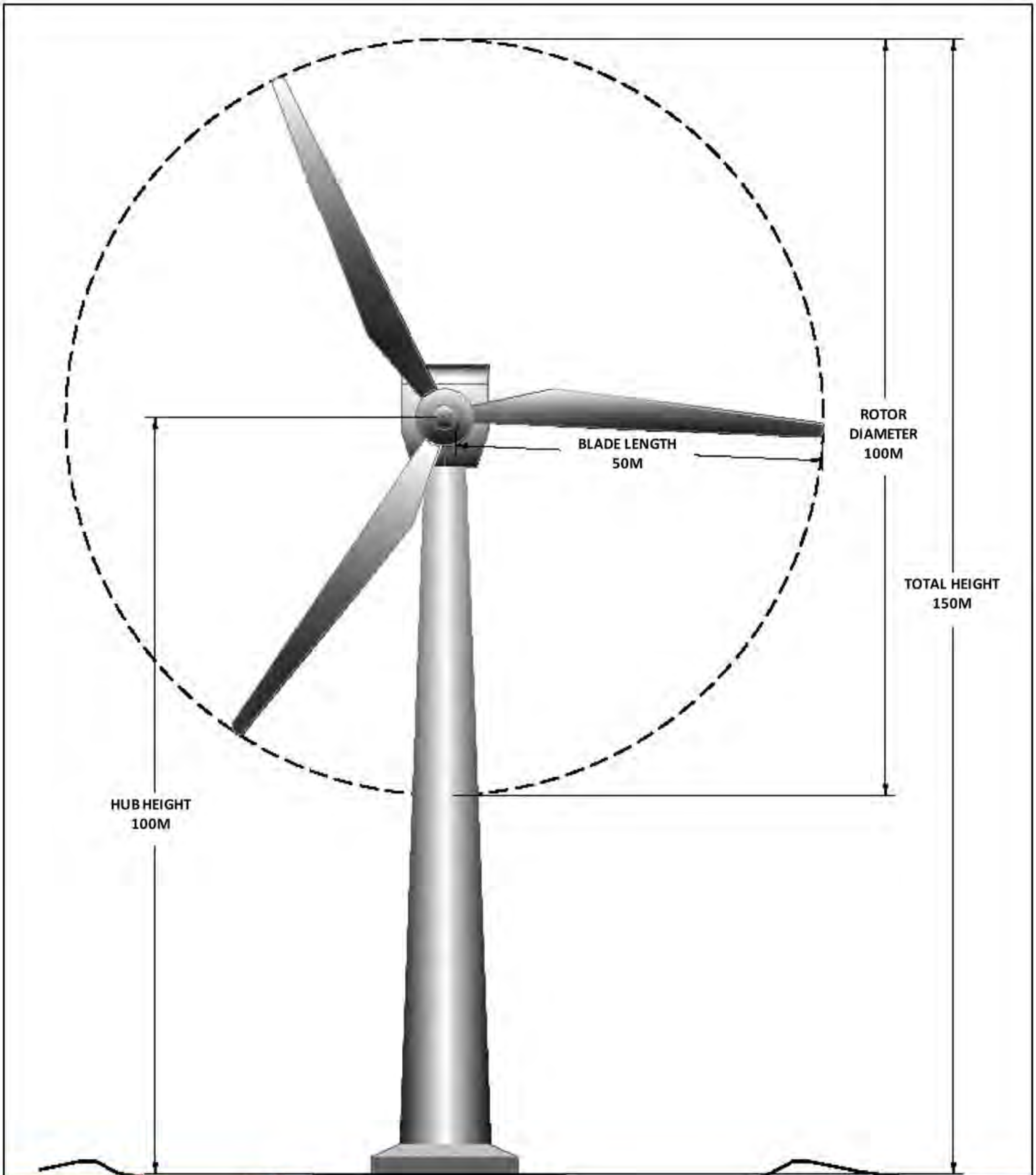
2.2.7 Concrete Batch Plant

Up to 2 concrete batch plants will be required to construct the 100-turbine Project. Concrete batch plants are expected to be located at existing, developed facilities located off-site from the Action Area that would require no vegetation clearing or soil disturbance. If a new batch plant(s) is required within the Action Area, it will be located in previously disturbed areas that will not impact trees, streams, or wetlands. Vegetation clearing and soil disturbance no greater than 1.2 ha (3.0 ac) would be required for each new batch plant, for a total temporary impact for 2 batch plants of 2.4 ha (6.0 ac), with no permanent impacts.

Operation and permitting of the plant(s) will be handled by the sub-contractor selected to supply the Project construction.

2.2.8 Crane Paths

A large erection crane will set the tower segments on the foundation, place the nacelle on top of the tower, and place the rotor onto the nacelle. The erection crane(s) will move from one turbine site to another along access roads or temporary crane paths. To complete construction of the 100-turbine Project, approximately 22.7 km (14.1 mi) of temporary crane paths will be utilized. Temporary crane paths will require vegetation clearing 16.8 m (55 ft) wide and will result in no permanent soil disturbance.



Prepared For:

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Legend:

— — Rotor Swept Area

Source: Figure derived from various turbine diagrams produced by Nordex, RePower, and GE and should be considered approximate

Figure: 2-1

DIAGRAM OF PROPOSED WIND POWER TURBINE FOR THE BUCKEYE WIND POWER PROJECT

2.3 Covered Activities

2.3.1 Project Construction

Buckeye Wind proposes to begin construction as soon as practicable contingent upon approval of the HCP, issuance of an ITP, and securing acceptable financing terms from qualified lenders. Construction activities will regularly move from place to place within the Action Area. The Project, including all 100 turbines, will be constructed within 1 to 2 construction phases, each phase expected to continue for 12 to 18 months. The exact timing of the 2 construction periods is not known and may overlap. Timing is dependent upon several factors such as turbine availability, OPSB certification, and economic considerations. The Project will be constructed using standard construction practices, including erosion and sediment control best management practices to minimize impacts on the existing environmental conditions and habitat. Per OPSB CEPCN conditions, an environmental specialist must be present during vegetation clearing in or near sensitive areas or in the vicinity of threatened and/or endangered species and their habitat. That role will be filled by the Natural Resource Specialist who will also be knowledgeable of Indiana bats and their habitats. Construction of access roads, underground and overhead collection system lines, and concrete turbine foundations will begin first, followed by turbine erection. As turbines arrive at the site, they will be set individually in concrete foundations. General construction equipment will include pick-up trucks, cranes, tractor-trailers, bulldozers, compaction equipment, and graders.

Because of the nature of the construction activities and the avoidance and minimization measures described in this HCP (see Chapter 6.0), Buckeye Wind anticipates that no Indiana bats will be taken prior to a turbine becoming operational (in this document, "operational" means any time that the turbine is spinning and producing electricity). It is not anticipated that noise, vibration, or disturbance associated with construction will result in harm of Indiana bats and therefore the direct effects from these construction activities are insignificant or discountable and take is not likely to occur (see Section 5.1.1.1 – Noise, Vibration, and Disturbance). No direct effects to Indiana bats are expected during Project construction because no known roost tree will be cut, and any potential roost trees that cannot be avoided will only be cut during the non-active period for Indiana bats. Vehicular collisions associated with construction are not anticipated to result in harm or mortality of Indiana bats and therefore the direct effects from this activity are insignificant or discountable and take is not likely to occur (see Section 5.1.1.2 – Collision with Vehicles). It is not anticipated that any habitat loss or displacement will result in take of Indiana bats and therefore indirect effects are insignificant or discountable (see Section 5.2.1 – Indirect Effects – Construction and Decommissioning). However, the ITP should cover Project construction in the extremely unlikely event that Indiana bat(s) is/are taken during construction activities.

As a component of this HCP, Buckeye Wind will employ the avoidance and minimization measures more fully described in Section 6.1 – Avoidance Measures and Section 6.2 – Minimization Measures and generally including:

- Planning and Project design that specifically avoids and minimizes impacts to wooded areas, streams, wetlands and other sensitive habitat features;
- All tree clearing will be conducted between 1 Nov and 31 Mar to avoid potential direct impacts to Indiana bats;
- Natural Resources Specialist on-site who is knowledgeable on Indiana bats; and,
- Clear demarcation of clearing zones and flagging of potential Indiana bat roost trees to ensure impacts are avoided to the maximum extent practicable.

2.3.2 Project Operation and Maintenance

Buckeye Wind anticipates owning and operating the Project for its operational life, which is expected to be 25 years. The HCP will cover a 30-year ITP Term (see Section 2.5 – ITP Duration), which includes the operational life and the construction and decommissioning periods. The ITP is anticipated to be in effect for a 30 year period when take could occur.

Project maintenance activities during Project operation include turbine maintenance as needed, vegetative control if necessary, periodic re-grading, and reviewing the site drainage plans. Project maintenance activities in and of themselves will have similar or lesser impacts as compared to construction activities and will employ all applicable avoidance and minimization measures employed during construction (see Chapter 5.0 – Impact Assessment). Buckeye Wind anticipates the risk of take to Indiana bats from Project maintenance activities will be insignificant or discountable.

Project operation will include operating wind turbines that may result in take of Indiana bats. Project operation is the primary reason behind the need for an ITP because it is anticipated that all Indiana bat takings will occur during this period. The impacts of project operation are described and evaluated fully in Chapter 5.0 – Impact Assessment.

As a component of this HCP, Buckeye Wind will employ the avoidance and minimization measures more fully described in Section 6.1 – Avoidance Measures and Section 6.2 – Minimization Measures and generally including:

- Siting of Project components that avoid impacts to sensitive habitat areas, including wooded areas and riparian areas,
- Seasonal clearing of wooded areas,
- Operational adjustments (feathering) that will increase the wind speeds at which the turbines begin to operate, thereby reducing Indiana bat mortality; and,
- Any vegetative controls (See Section 5.2.2.1 –Vegetative Control) performed by Buckeye Wind will be completed during non-active periods for Indiana bats.

2.3.3 Project Decommissioning

Megawatt-scale wind turbine generators typically have a life expectancy of 20 to 25 years. After that time or if turbines are non-operational for an extended period (such that there was no expectation of their returning to operation), they will be decommissioned. Decommissioning will be performed under a decommissioning plan approved by the OPSB that would address removal of Project components/improvements as well as site/land reclamation. The OPSB has included a number of conditions related to decommissioning in its decision to issue a CEPCN to construct the Project. As such, decommissioning of the Project or individual wind turbines will be completed within 12 months after the end of the useful life of the Project or of individual wind turbines. Additionally, the areas disturbed during decommissioning will be re-graded, reseeded, and restored. Decommissioning activities will have similar or lesser impacts as compared to construction and will apply all applicable avoidance and minimization measures employed during construction. Buckeye Wind anticipates that risk of take to Indiana bats and other ESA threatened or endangered species will be insignificant or discountable during decommissioning (see Chapter 5.0 – Impact Assessment). However, the ITP should cover Project decommissioning in the extremely unlikely event that Indiana bat(s) is/are taken during decommissioning activities.

2.3.4 Mitigation and Monitoring Actions

The ITP will cover mitigation actions that will be conducted for the HCP to offset the effects of Indiana bat take anticipated from the Project. Mitigation actions will include habitat protection into perpetuity, restoration and enhancement (if necessary) and monitoring. Habitat management could involve tree/native species plantings, controlling for invasive species and girdling to create potential roost trees. Mitigation will result in benefits to Indiana bats, non-federally listed bats, birds and other wildlife. These types of restoration projects would not be expected to result in take of Indiana bats. Take will be avoided by conducting invasive species control and tree girdling during non-active period for the Indiana bat. However, the ITP should cover Project mitigation in the extremely unlikely event that Indiana bat(s) is/are taken during mitigation activities.

Post-construction mortality monitoring will occur during the ITP Term to ensure compliance with the ITP (see Section 6.0 – Conservation Program). During mortality monitoring all injured or dead Indiana bats will be collected. Injured Indiana bats will be sent to a licensed rehabilitator. If the rehabilitator determines the injured Indiana bat cannot be rehabilitated, it will be euthanized. Dead Indiana bats will be turned over the USFWS. The ITP will cover collection of both Indiana bat carcasses as well as injured Indiana bats during monitoring and euthanasia of injured Indiana bats that cannot be rehabilitated.

2.4 Action Area

50 CFR §402.02 defines "Action Area" as, "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The action area is not limited to the footprint of the action and should consider the effects to the environment resulting from the action. Within a set action area, all activities that can cause measurable or detectable changes in land, air, and water or to other measurable factors that may elicit a response in the species or critical habitat are considered. The action area is not defined by the range of the species that would be impacted, rather it is defined by the impacts to the environment that would elicit a response in the species (USFWS and NMFS 1998).

The action area for this project has been determined to be an area of 32,395 ha (80,051 ac), which includes areas of direct impact and indirect impact from construction, operation, maintenance and decommissioning. It includes all areas that will be physically impacted, as well as areas that may be impacted by noise, dust, vibrations, or downstream movement of sediments. At the time of completion of the HCP only the locations of 52 turbines were known, and an additional 48 were to be sited. The additional 48 turbines will all be sited within the Action Area. The Action Area includes the area where all direct and indirect effects of all 100 turbines would occur.

2.5 ITP Duration

Buckeye Wind anticipates the HCP to be in effect for a 30-year term including construction, operation, maintenance, decommissioning and mitigation. This HCP will establish specific avoidance, minimization and mitigation measures that will be implemented during construction, operation, and decommissioning of the Project. The 30-year period (ITP Term) will include construction and decommissioning periods, in which take is unlikely, and a 25-year operation term during which take is likely to occur.

At the close of the 30-year term, the ITP may be extended with the approval of the USFWS if the authorized take limit is not reached (see Section 7.3.2 – Extension of ITP Term).

2.6 Covered Lands

As described in Section 1.1 – Overview and Purpose of the HCP, the Action Area includes 32,395 ha (80,051 ac) located within portions of Union, Wayne, Urbana, Salem, Rush, and Goshen Townships in Champaign County, OH (Figure 1-1). This HCP and its associated ITP will cover the entire Action Area, including all areas in which Project construction, maintenance, operation, and decommissioning activities will occur.

This HCP/ITP will also cover areas located outside of the Action Area, where mitigation actions will take place. Mitigation actions will take place within 7 miles of a Priority 2 (P2) Indiana bat hibernaculum in OH (see Section 4-1 – Species Status, for definition of Priority 2, and see Figure 2-2 for a map of known hibernacula in the United States).

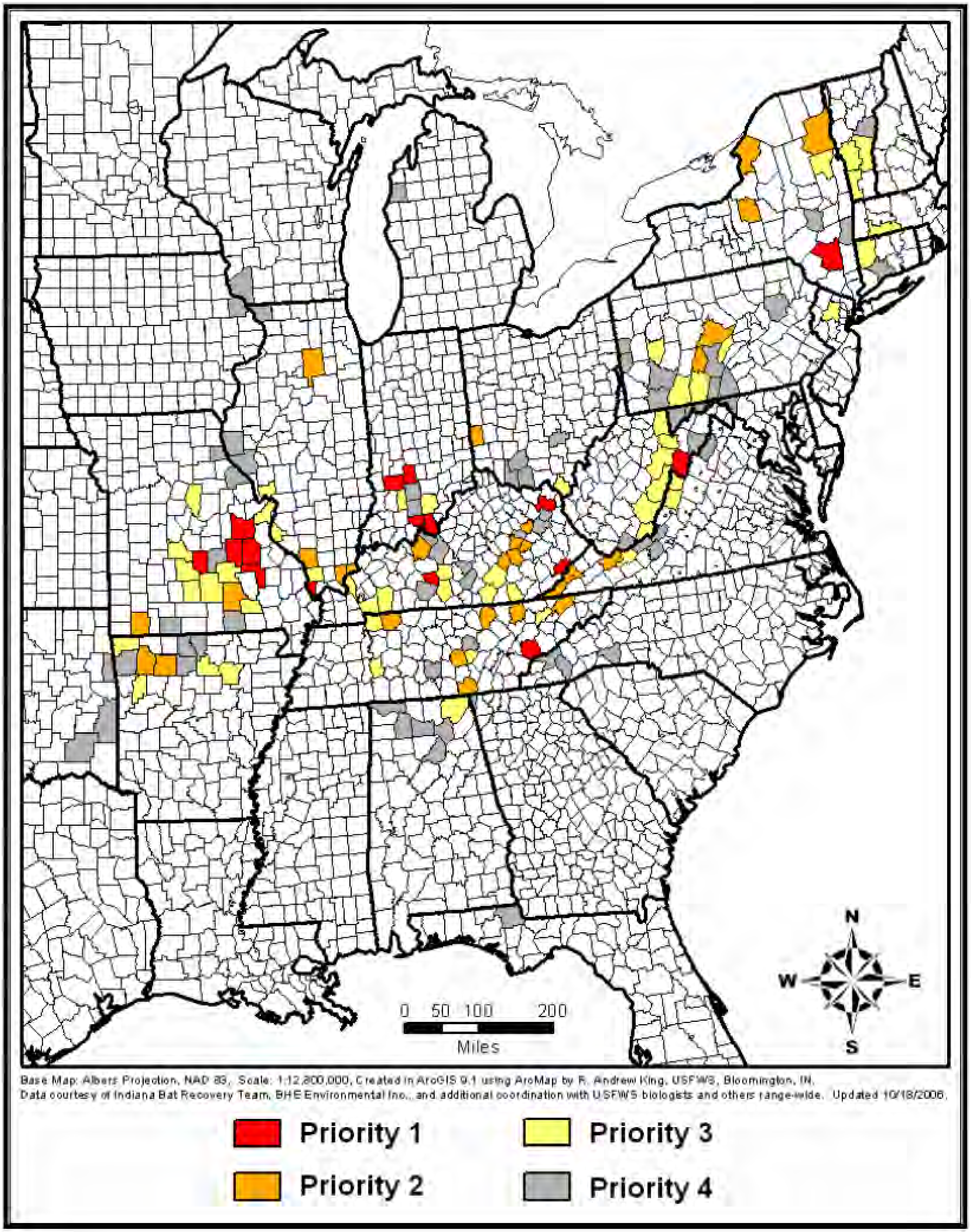


Figure 2-2. Distribution of counties with known Indiana bat hibernacula records and their current priority numbers. Note: For counties with multiple hibernacula with different priority numbers, only the color of the highest priority hibernacula is shown. From USFWS 2007.

2.7 Alternatives Considered

2.7.1 Criteria

In accordance with the ESA [Section 10(a)(2)(A)] and federal regulation [50 CFR 17.22(b)(1), 17.32(b)(1), and 222.22], the following sections describe alternative actions that were considered by Buckeye Wind to reduce impacts to Indiana bats. These sections also set forth the reasons why the Proposed Alterative was selected over other alternatives. The Habitat Conservation Planning Handbook (HCP Handbook; USFWS and National Marine Fisheries Service [NMFS] 1996) states that at least 2 types of alternatives are commonly included in HCPs:

- Any alternative that would reduce incidental take below levels anticipated as a result of Covered Activities; and
- A No-Action alternative, which means that federal action (i.e., issuance of an ITP by the USFWS) would not occur because Covered Activities would not occur, and no HCP would be needed to minimize and mitigate impacts to ESA listed species.

In addition to the No-Action alternative, Buckeye Wind evaluated 2 action alternatives that would avoid and minimize incidental take of Indiana bats. Alternatives were identified and selected in cooperation with the USFWS. Alternative selection was also guided by the biological goals and objectives of the HCP (see Section 1.2 – Biological Goals and Objectives of the HCP) and the purpose and need for the Project (see Section 1.3 – Purpose and Need for the Project). Alternatives were evaluated based on the criteria described in the following sections. Evaluation of alternatives' impacts on other aspects of the natural and human environment is described in the EIS.

2.7.1.1 Conservation of the Indiana Bat

When developing avoidance, minimization, mitigation, and conservation measures associated with each alternative, Buckeye Wind consulted with the USFWS and referred to the 2007 Indiana Bat Draft Recovery Plan to develop measures consistent with the USFWS's recovery goal. Measures that were not consistent with the USFWS's goal for Indiana bat recovery were dropped from further consideration, including those that did not adequately minimize and mitigate incidental take of Indiana bats or enhance scientific understanding of the impacts to Indiana bats from wind development.

2.7.1.2 Effectiveness and Costs of Mitigation and Conservation Measures

Mitigation and conservation measures associated with each alternative were evaluated based on their anticipated effectiveness at offsetting the impact of incidental take of Indiana bats as well as providing measurable and significant conservation benefits to Indiana bats. Funds required to implement mitigation (i.e., land protection and enhancement) and conservation measures (i.e., scientific research on Indiana bats and wind power development) were also considered in the evaluation of alternatives.

2.7.1.3 Effects to Other Wildlife Resources

Avoidance, minimization, mitigation, and conservation measures associated with each alternative were evaluated for their potential to positively affect other bat and avian species at risk from wind development. Long distance migratory bats have been found to be most at risk of collision with wind facilities, particularly during fall migration (NWCC 2010). Avian mortality from collision with wind turbines also has been high at some wind facilities, particularly among nighttime migrating passerines (NWCC 2010). Thus, alternatives were evaluated based on the extent to which they avoided and minimized risks to other bat and avian species (Stantec 2011a).

2.7.1.4 Effects to Wind Project Viability

When considering alternatives to the Project, economic viability is an important evaluation criterion. One of the more important factors that has the greatest influence on project viability includes operational capacity. Based on current technology and scientific knowledge, feathering appears to be an effective method to significantly reduce bat mortality at operating wind facilities. Therefore, alternatives that did not incorporate some amount of feathering were not considered. However, the cut-in speeds used for feathering and the timing of feathering (on both a nightly and seasonal basis) can add significant costs to the project and influence project viability.

Similarly, location has a large influence on project viability. The site selection process used by Buckeye Wind to meet the requirements of the OPSB was based on several constraints, including reducing impacts to sensitive resources, maximizing energy production, and accommodating existing land uses. Buckeye Wind conducted an intensive, science-driven process (detailed in the OPSB CECPN and EIS) to identify a location for its Project that would meet the siting criteria and comply with environmental constraints. Of particular importance in the screening process was the Project's location relative to adequate wind resources, electric transmission lines, land parcels that could accommodate OPSB-defined setback distances, existing land uses, and other environmental restrictions. Alternatives were evaluated based on their ability to meet the conditions of this screening process.

2.7.2 Alternatives Considered but Not Selected

2.7.2.1 No Action No Build Alternative

Under the No Action Alternative, the Project would not be developed, an ITP for Indiana bats would not be issued, this HCP would not be implemented, and existing land uses would be maintained at the sites of proposed turbines and other Project appurtenances. This alternative would not result in incidental take of the Indiana bat or removal of Indiana bat habitat. However, benefits to the species would not be realized without implementation of the conservation measures that are a part of this HCP. No research would be funded to further our understanding of the impacts to Indiana bats and other bats from wind development. The results of such research could be used to increase the effectiveness of minimization and mitigation measures that are a part of this HCP, as well as other HCPs developed for Indiana bats, with the net end result of enhancing the survival probability of the species. Thus, although the No Action Alternative would not result in incidental take of Indiana bats and would reduce future potential impacts to the Indiana bat and its habitat, it also would not result in increased scientific understanding of Indiana bat behavior related to wind power development.

The Project's purpose and need of serving the public interest by providing ample, clean, and renewable energy also would not be met under this alternative. The No Action alternative fails to meet the purpose, intent, and goal set forth by the Ohio AEPS, signed into law by Governor Strickland in May 2008 (49 ORC 4928.64), that mandates that at least 25% of all electricity sold in OH comes from alternative energy resources by 2025. At least half of that standard, or 12.5% of electricity sold, must be generated by renewable resources, and at least half of this renewable energy must be generated in-state. The No Action alternative also fails to meet Executive Order 13212 (dated 18 May 2001), which promotes production and transmission of energy in a safe and environmentally sound manner and mandates that executive departments and agencies take appropriate actions to expedite projects that will increase the production, transmission, or conservation of energy.

Thus, the No Action alternative fails to reduce the dependence of OH on non-renewable energy sources such as coal and imported oil. The No Action Alternative also would fail to provide economic benefit through the creation of jobs. The No Action Alternative would not contribute towards meeting the goals of the "Barack Obama and Joe Biden: New Energy for America" plan, which includes the creation of 5 million new jobs over 10 years and ensures that 10% of our electricity comes from renewable sources by 2012, and 25% by 2025 (Obama for America 2008). Economic benefit also would not be realized by the participating land owners that would receive ongoing income from lease agreements throughout the ITP Term. Refer to Section 1.3 – Purpose and Need for the Project for more information on the economic and environmental benefits of the Project in OH and beyond.

Because the broad economic and environmental benefits would be foregone by not constructing the Project, and because a net conservation benefit for the Indiana bat would not be realized without the implementation of conservation measures that will further the recovery of the species, the No Action Alternative was not considered further.

2.7.2.2 Minimally Restricted Operations Alternative

Under the Minimally Restricted Operations Alternative, the Project would include construction of 100 turbines within the Action Area as described in Section 2.0 – Project Description. However, operational adjustments (i.e., feathering) would be used to reduce incidental take of Indiana bats, such that the speed at which turbines become operational (i.e., cut-in speed) would be increased from manufacturer's setting of 3.0 m/s to 5.0 m/s for all 100 turbines. This cut-in speed would be applied to turbines for the hours of the night during which *Myotis* have been documented to be most active (i.e., the first 1 hr to 6 hr after sunset), during the fall migration period (1 Aug to 31 Oct), which has consistently been the period in which the highest total bat mortality has been documented in post-construction monitoring studies (see Table 4-4).

This Alternative was considered because it met the purpose and need of providing clean, renewable energy to OH and contributed toward meeting the goals of the OH AEPS, Executive Order 13212, and the "Barack Obama and Joe Biden: New Energy for America" plan. This alternative also allowed for an economically viable project for Buckeye Wind and participating land owners.

This Alternative was not selected because, although current data suggest that cut-in speeds of 5.0 m/s and higher substantially reduce bat mortality (between 38% and 93% reductions in bat mortality from that documented at turbines operating at the manufacturer's specified cut-in speeds [Baerwald et al. 2009, Arnett et al. 2010, and Good et al. 2011]). The findings are related to general bat mortality numbers and not specific to Indiana bats. Given the uncertainty that still remains regarding which cut-in speeds are most effective at minimizing mortality of Indiana bats, the USFWS recommended that Buckeye Wind take a more conservative approach and select an alternative that employed higher cut-in speeds, particularly at turbine locations and seasonal periods that the current data suggest are a higher risk to Indiana bats.

Additionally, applying operational adjustments only during the fall migratory period may not provide adequate protection to Indiana bats. To date, the only 3 documented Indiana bat fatalities at a wind facility have occurred during the fall migratory period (Sept 2009 and Sept 2010 at Fowler Ridge, IN [Good et al. 2011] and Sept 2011 at Allegheny Ridge, PA[8]). Thus, the results of post-construction monitoring studies to date indicate that the fall migratory period may represent the period of highest risk to Indiana bats, as it does for long-distance migratory bats and other bat species more commonly found in post-construction mortality studies. However, data suggest there is some level of risk to *Myotis* species during the summer reproductive period (see Section 4.5.5 – Collision Mortality at Wind Facilities and Section 5.1.2.5 – Collision/Barotrauma Mortality for further details).

[8] http://www.fws.gov/northeast/pafo/, accessed November 20, 2011.

Risks to Indiana bats during the summer are also uncertain because no wind facilities have yet been constructed within 8 km (5 mi) of known Indiana bat maternity colonies. Given that Indiana bats are generally thought to fly between 2 m (6.6 ft) and 30 m (98.4 ft) while foraging (LaVal et al. 1976, Humphrey et al. 1977, Russell et al. 2008), it is expected that risks to Indiana bats during the summer are very low. However, until this relationship is more clearly documented, it cannot be assumed that applying feathering during the fall migratory period alone will provide sufficient protection of the Indiana bat. Therefore, this alternative was not selected as the preferred approach to minimize take of Indiana bats.

2.7.2.3 Maximally Restricted Operations Alternative

Under the Maximally Restricted Operations Alternative, the Project would include construction of 100 turbines within the Action Area as described in Section 2.0 – Project Description. However, operational adjustments would be used to eliminate take of Indiana bats, such that all 100 turbines would be non-operational from sunset to sunrise during the entire period over which Indiana bats are active (1 Apr to 31 Oct).

This Alternative was considered because it met the biological objective of avoiding take of Indiana bats. However, because this Alternative would eliminate take of Indiana bats, an ITP would not be necessary and the HCP would not be implemented. Without the HCP, there would be no positive contribution to the recovery of the species through collection of post-construction mortality data, funding of research on bat and wind energy interactions, or protection and enhancement of Indiana bat habitat. Additionally, due to the significant reduction in energy production, this alternative did not meet the purpose and need of the Project to generate ample clean and renewable energy and allow for an economically viable Project. For a discussion of costs of this alternative compared to the proposed alternative, please see Section 6.6.2 – Practical Implementation by Buckeye Wind. For these reasons, this alternative was not selected as the preferred method to reduce take of Indiana bats.

2.7.2.4 The Proposed Alternative

Under the Proposed Alternative, the Project would include construction of 100 turbines within the Action Area as described in Section 2.0 – Project Description. Operational adjustments would be used to minimize take of Indiana bats, such that the operation of all 100 turbines would be restricted using a scientifically informed and risk-based approach that would increase cut-in speeds as a function of the location of the turbines relative to Indiana bat habitat and the time of year. Monitoring and adaptive management would be implemented to ensure take is minimized to the maximum extent practicable and to address uncertainties relative to use of cut-in speeds for minimizing impacts to Indiana bats. This feathering plan is more fully detailed in Section 6.2 – Minimization Measures and was developed in consultation with the USFWS and using the best available science, including published reports on the observed reductions of bat mortality resulting from various levels of operational curtailment and feathering. All Conservation Measures included in Chapter 6.0 were informed by experts at USFWS and Stantec Consulting Services Inc. (Stantec), as well as leading experts in the field of Indiana bat biology and wind turbine interactions, including Dr. Allen Kurta, Dr. Bill Warren-Hicks, Dr. Tim Carter, and Dr. John Hayes.

The Proposed Alternative was selected because it best met the goals of effectively avoiding, minimizing, and mitigating for take of Indiana bats (as described in the previous sections) and the Biological Goals and Objectives of this HCP (See Section 1.2 – Biological Goals and Objectives of the HCP). The Proposed Alternative was also selected because it met the purpose and need of providing clean, renewable energy to OH and the surrounding region and contributed toward meeting the goals of the OH AEPS, Executive Order 13212, and the "Barack Obama and Joe Biden: New Energy for America" plan. This alternative allows for an economically viable project for Buckeye Wind and provides a positive economic and environmental benefit for the community and surrounding region. Refer to Section 1.3 –Purpose and Need for the Project more information on the renewable energy and economic goals of the Project.

2.8 Public Participation

Public participation is similar and parallel to the public participation opportunities for the NEPA process and is described in the EIS. Scoping for the NEPA process was first initiated in the Notice of Intent (NOI) to conduct a 30-day scoping period for a NEPA decision on the proposed HCP and ITP and request for comments published in the Federal Register on 29 January 2010 (75 Fed. Reg. 4840-4842). Formal scoping began for the NEPA analysis on 26 May 2010 when the NOI to prepare an EIS was published in the Federal Register (75 Fed. Reg. 29575-29577). The USFWS also conducted outreach by press releases and public notification to inform interested parties or those in the Action Area or potentially affected by the Proposed Action and requested comments on the scope of the NEPA analysis. Comments resulted in the identification of a number of issues related to the Project and the associated HCP.

The Draft HCP was published in the Federal Register for public review on June 29, 2012 (77 Fed. Reg. 38819-38821) in accordance with NEPA requirements set forth in 40 CFR 1500-1508; 42 U.S.C 4321-4347. Public comments were accepted during a 90-day period following publication of the Federal Register Notice of Availability. One public information meeting was held during the comment period, on July 12, 2012 in Urbana, OH. Comments received were taken into account in assessing Project impacts and potential mitigation and resulted in some modifications in the Final HCP. Responses to substantive comments on the Draft HCP can be found in Appendix K of the EIS.

During the Project development phase and the OPSB application process, Buckeye Wind consulted with state and federal agencies to identify missing information on sensitive resources, including water, wetlands, wildlife, and cultural resources. Agencies consulted to obtain guidance on pre-construction surveys, site assessments, and OPSB process requirements included USFWS, FAA, ODNR DOW, Ohio Historic Preservation Office (OHPO), Ohio Department of Transportation (ODOT), Ohio Environmental Protection Agency (OEPA), Ohio Department of Agriculture (ODA), Ohio Department of Development (ODOD), and Ohio Department of Health (ODOH).

Prior to filing the OPSB application, Buckeye Wind was required to hold a public informational meeting to advise potentially affected persons of the Project. Public input and concerns were gathered to aid in preparation of the OPSB application. Once the application had been submitted and deemed complete, it then was sent to local public officials and made available in area libraries for public viewing; legal notices also were published in area newspapers. At this time, interested parties had the opportunity to be recognized as interveners in the case.

Buckeye Wind held a public informational meeting on 10 June 2008. On 24 April 2009, Buckeye Wind filed its application for a CECPN with the OPSB. A public hearing was held on 27 October 2009, and evidentiary hearings began 28 October 2009.

The Buckeye Wind Project's record of public interaction relative to the OPSB application process is available through the PUCO Docketing Information System.[9]

[9] http://dis.puc.state.oh.us/CaseRecord.aspx?Caseno=08-0666&link=DI

In addition, information has been shared through several organized activities and Buckeye Wind's active engagement in the community: participation in the Champaign County Wind Turbine Study Group (WTSG); participation in bus tours of operating wind energy facilities; official Township Board of Trustee, Planning Board and County Commissioner meetings; presentations to various schools, churches, and clubs; information booths at the County fair; through the Project website; a local office in nearby Bellefontaine, Logan County; and numerous other outreach activities.

In addition, Champaign Wind LLC, a separate EverPower subsidiary, has initiated the OPSB application procedure for the Buckeye II Wind Project, consisting of 56 turbines (no more than 100 total turbines will be constructed for the Buckeye Wind and Buckeye II Wind projects combined). The Buckeye II Wind Project will be transferred to Buckeye Wind prior to construction. A public information meeting for Champaign Wind LLC was held on 24 January 2012. A public hearing was held on 25 October 2012, and evidentiary hearings began 8 November 2012. Champaign Wind LLC is currently waiting a decision by the OPSB regarding its application. Champaign Wind LLC's record of public interaction is available through the PUCO Docketing Information System[10].

[10] http://dis.puc.state.oh.us/CaseRecord.aspx?CaseNo=12-0160-EL-BGN

3.0 ENVIRONMENTAL SETTING AND BIOLOGICAL RESOURCES

3.1 Project Setting

The Action Area is located in the west-central portion of OH, in the Bellefontaine Uplands physiographic region, a sub-region of the Central Ohio Till Plains. This region is characterized by low to moderate relief hills formed by glacial processes. The Action Area is characterized by flat and rolling terrain that is comprised largely of active agricultural lands (producing mostly corn and soybean crops) and pastures, collectively comprising approximately 82% of the Action Area. These areas are interspersed with relatively small, scattered, stands of mixed hardwood forest that have an average size of approximately 4 ha (9 ac) (deciduous forest comprises approximately 8% of Action Area), as well as areas of low to medium intensity developed lands (approximately 1.5% of Action Area) (Homer et al. 2004). A brief summary of the Action Area is provided below.

3.1.1 Land Use

Construction of the Project will involve the leasing of private land in the Action Area predominantly zoned for agricultural purposes. Other current land uses in the Action Area include residential, urban, manufacturing, commercial, transport, recreational, and utilities. Residential development within and around the Action Area consists almost entirely of single-family homesteads along rural roads.

Various registered historic sites are also present within the Action Area. Registered landmarks of historic, religious, archaeological, scenic, natural, or other cultural significance include those districts, sites, buildings, structures, and objects that are recognized by, registered with, or identified as eligible for registration by the national registry of natural landmarks, the Ohio Historical Society, or the ODNR DOW. At least 34 such landmarks within 8 km (5 mi) of the Action Area have been identified. Twenty of these landmarks are in the village of Mechanicsburg, and 9 are in the city of Urbana. The remaining 5 landmarks are located outside of incorporated communities and include landmarks such as Elmwood Place, The Fort, The Piatt Houses, The Carl Potter Mound and the Mount Tabor Church.

3.1.2 Topography

The Action Area is located in the glaciated Till Plains Section of the Central Lowland Physiographic Province. The topography is characterized by gently rolling hills and moderate slopes with elevations ranging from 396 m to 548 m (1,300 ft to 1,800 ft) above mean sea level. Typical of west-central OH, the area experienced both the Illinoian and Wisconsinan glaciers and the surface topography is the result of glacial end moraine deposits (i.e., the Cable and Springfield Moraine complexes; EDR 2009).

3.1.3 Geology

The flat, nearly featureless glaciated till plains of western OH are abruptly interrupted by a hilly area in Logan County and northern Champaign County created by a feature the ODNR, Division of Geological Survey, Ohio Seismic Network described as the "Bellefontaine Outlier Faults." These deep seismic structures are located within the granitic basement rock beneath portions of the Action Area. Campbell Hill, located 20 km (12 mi) north of the Action Area in Logan County, is underlain by the Bellefontaine Outlier and marks the highest point in OH at 472 m (1,549 ft) above mean sea level. This region of OH is referred to locally as the "Bellefontaine Ridge" as a result of these geologic features.

Throughout much of the Action Area, the uppermost bedrock is composed of limestone and dolomite. Some portions of the Action Area are underlain by karst geological features, which are formed by the dissolution of layers of soluble bedrock that create subterranean drainages, caves, and sinkholes.

3.1.4 Soils

Based on the Soil Survey for Champaign County (United States Department of Agriculture Soil Conservation Service (USDA-SCS; USDA-SCS 1971), soils in the Action Area are primarily composed of Celina, Fox, and Miami silt loams. Celina and Miami silt loams are well drained with depth to the water table being 61 centimeters (cm) to 91 cm (24 in to 36 in) below the surface. The Fox silt loams are well drained with depth to the water table being more than 203 cm (80 in) below the surface. All 3 of these soils satisfy the USDA criteria that make up prime farmland (Hull 2009).

3.1.5 Hydrology

The Action Area lies within the Upper Scioto River and Upper Great Miami River drainages, both of which drain to the Ohio River (United States Geological Survey [USGS] 2003). Perennial streams and ditches within the Action Area are generally small; larger streams with deep pools include Dugan Run and the East Fork of Buck Creek (refer to EIS Section 4.4 for further detail on streams in the Action Area).

The Action Area also contains a number of wetlands identified in the National Wetlands Inventory (NWI) database that was updated based on current (i.e., 2005 to 2007) aerial photos by Ducks Unlimited (DU; DU 2009). There are approximately 668.1 ha (1,651 ac) of DU-identified wetlands in the Action Area; most of these are emergent wetlands, characterized by low-lying herbaceous vegetation, or open water. A surface water delineation conducted for the Project (Hull 2009) provided ground-based information on wetlands within 305 m (1,000 ft) of Project components, including the 52 known turbine locations and workspaces, access roads, buried electrical interconnects, overhead electrical interconnects, O&M buildings, storage yard, staging areas, and substation. Hull (2009) documented 8 wetlands totaling roughly 3.0 ha (7.3 ac) in these areas. The EIS Chapter 4.4 provides detailed information on the wetlands in the Action Area delineated by Hull (2009). During the planning and design phases of the additional 48 turbines and associated facilities, similar delineations will be performed. Built components of the Project, including wind turbines, staging areas, the O&M building, and the substation, will be sited to completely avoid wetlands for all 100 turbines and their associated facilities. While wetland impacts can be avoided, it is likely that streams crossings will be required; see Section 5.2.1.2 of the HCP and Section 5.4 of the EIS for a more complete discussion of stream impacts. To the extent they are necessary, Buckeye Wind will secure authorization from the United States Army Corps of Engineers (USACE) for discharge of fill material into jurisdictional streams.

3.1.6 Landcover

Prior to European settlement, the state of OH was approximately 95% forested; rapid settlement in OH resulted in a steady decline of forest cover to a low of 12% in 1940 (ODNR DOW 2011). OH's forestland has been increasing since 1940 and in 2001 it comprised approximately 33% of the state's land area. The amount of forest cover varies widely among the geographic regions of the state. Most counties in the western glaciated farmland region, in which the Action Area is located, are less than 15% forested, with much of the forest occurring in small, isolated patches of 8 ha (20 ac) or less. The northeastern glaciated region has approximately 30% forest cover, with most counties heavily urbanized. The east-central, southeastern, and south-central unglaciated counties (hill country) are the most heavily forested, ranging from 35% to 80% (ODNR DOW 2011).

Based on the National Land Cover Database (NLCD; Homer et al. 2004), summarized in a Geographic Information System (GIS; ArcGIS 9.2, ESRI Redlands, California), the majority (69%) of vegetation in the

Action Area is comprised of the *Cultivated Crop* landcover type (producing mostly corn and soybean crops), 13% is comprised of *Pasture/Hay*, 9% is comprised of *Deciduous Forest*, and 6% is comprised of *Developed Open Space* (Homer et al. 2004). Remaining native landcover types, such as *Grassland/Herbaceous* (i.e., old fields, CRP lands), and *Developed, Low Intensity* each makes up approximately 1% of the Action Area, while *Evergreen Forest*, *Mixed Forest*, and *Emergent Herbaceous Wetlands*, each make up less than 0.1% of the Action Area (Table 3-1, Figure 3-1).

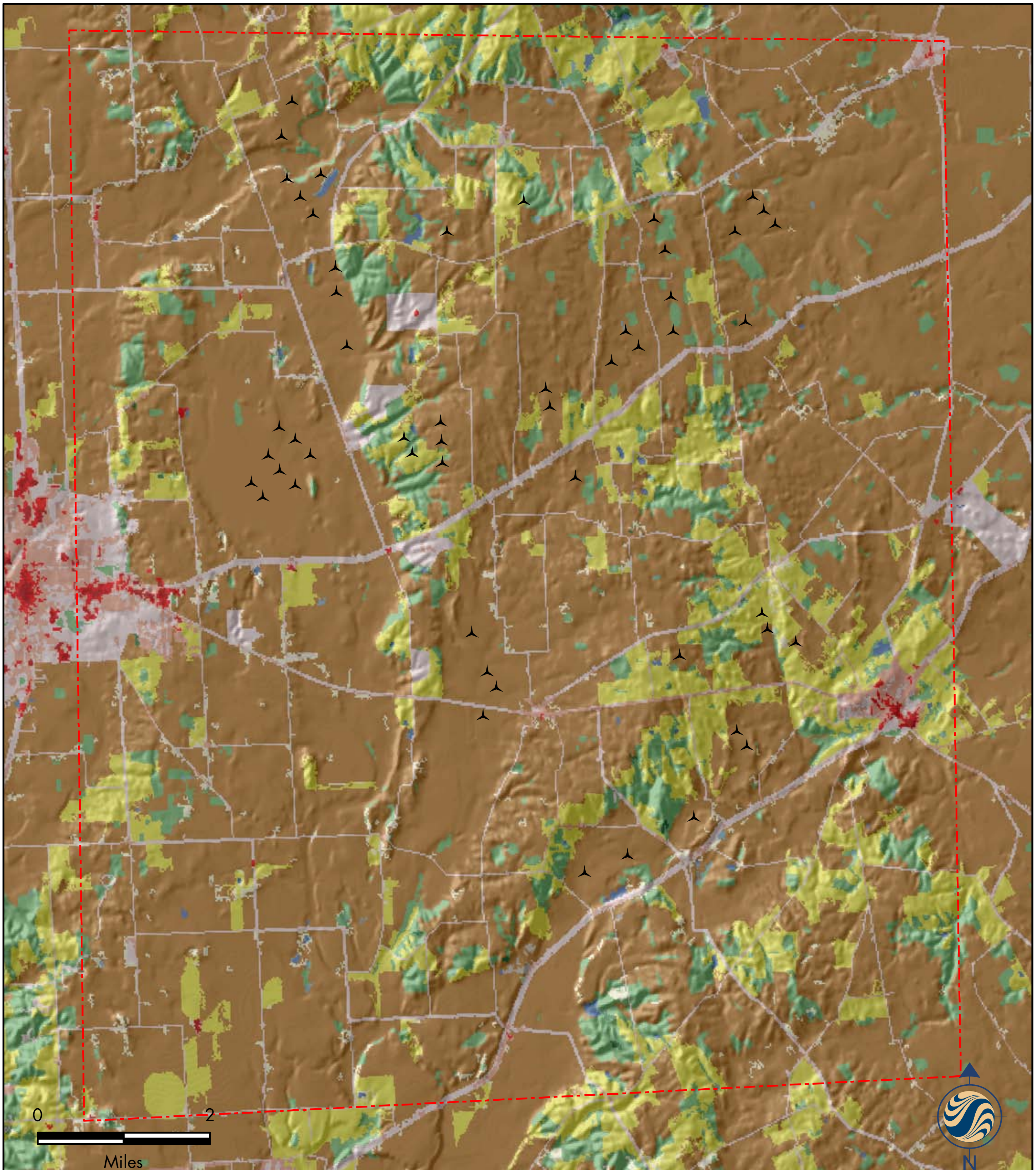
Based on the 2001 NLCD, there are approximately 766 distinct forest patches in the Action Area[11] that average 3.6 ha ± 10.0 ha (9.0 ac ± 24.7 ac) in size and vary from 0.1 ha to 106.47 ha (0.2 ac to 263.09 ac). Eighty-two percent of the forest patches were 4 ha (10 ac) or smaller and only 2% (n=13) were 40 ha (100 ac) or more. The deciduous forest habitat in the Action Area includes mature stands and early-successional scrub-shrub, primarily bordered by agricultural fields, generally even-aged, and dominated by oaks (*Quercus* spp.), maples (*Acer* spp.), hickories (*Carya* spp.), and ash (*Fraxinus* spp.), as determined during the course of the 2008 bat mist-netting surveys in the Action Area (Stantec 2008b) and during ground-based habitat assessments conducted by Buckeye Wind in conjunction with the USFWS in November 2010.

Table 3-1. NLCD landcover types and size (ha and ac) identified in the Buckeye Wind Project Action Area, Champaign County, OH.

Landcover type	Hectares	Acres	Percent of Action Area
Cultivated crops	22,408	55,372	69%
Hay/pasture	4,163	10,287	13%
Deciduous forest	2,744	6,779	9%
Developed, open space	1,962	4,849	6%
Grassland/herbaceous	445	1,099	1%
Developed, low intensity	422	1,042	1%
Open water	84	208	<0.1%
Developed, medium intensity	55	135	<0.1%
Emergent herbaceous wetlands	40	100	<0.1%
Evergreen forest	31	76	<0.1%
Developed, high intensity	26	65	<0.1%
Barren land (rock/sand/clay)	13	33	<0.1%
Mixed forest	2	6	<0.1%
Totals	32,395	80,051	100%

Source: Homer et al. 2004

[11] Excluding portions of 6 forest patches that only partially overlap the Action Area, totaling 0.4 ha (0.9 ac).



Prepared For:

Buckeye Wind, LLC

Prepared By:

Stantec Consulting Services Inc.

www.stantec.com

Legend:

Proposed Turbines

HCP Action Area

Landcover

Barren Land
Cultivated Crops
Deciduous Forest
Developed, High Intensity
Developed, Low Intensity
Developed, Medium Intensity
Developed, Open Space
Emergent Herb. Wetlnds
Evergreen Forest
Hay/Pasture
Herbaceuous
Mixed Forest
Open Water

Figure: 3-1

LANDCOVER IN THE BUCKEYE WIND POWER PROJECT ACTION AREA

Source: 2001 National Land Cover Database; Homer et al. 2004

3.2 Other Wildlife in the Action Area

Vertebrate animals likely to use the Action Area are represented by those often detected in highly fragmented landscapes dominated by agriculture. Many of the animal species expected to occur are common and widely distributed throughout OH. Section 5.6 of the EIS will evaluate impacts from the Project to all wildlife species, both aquatic and terrestrial, and to their habitats. Most of the known biological effects of wind facilities relate to flying animals, i.e., birds and bats. The Buckeye Wind ABPP (Stantec 2011a) will provide details on bird and bat pre-construction surveys and how impacts to bird and non-federally listed bat species will be avoided, minimized, and mitigated.

3.2.1 Federal Threatened, Endangered, and Candidate Species

The Project lies within the range of several federally listed or proposed freshwater mussels, including: the clubshell mussel (*Pleurobema clava*), a federal and OH endangered species; the rabbitsfoot (*Quadrula cylindrica cylindrica*), a federal candidate and OH endangered species; and the snuffbox (*Epioblasma triquetra*), a federal and OH endangered species. The clubshell, rabbitsfoot, and snuffbox were once suspected to potentially occur in the Action Area in the Little Darby Creek. However in January 2011 the USFWS removed these 3 species from the list of federally listed or proposed species potentially present in Champaign County because current distribution and habitat data for the Little Darby Creek within Champaign County indicate it is not suitable for these species. Therefore, because no suitable habitat for these 3 mussel species exists within Champaign County and no suitable habitat will be impacted, this Project will have no effect on these species and they will not be considered further in this HCP (see EIS Section 5.7). The mitigation site lies within the range of the snuffbox mussel; however, the distribution of this species does not include the mitigation area. Therefore, there will be no effect on this species (M. Seymour, USFWS, personal communication).

The Action Area lies within the range of the rayed bean (*Villosa fabalis*), a freshwater mussel species currently listed as federally endangered (USFWS 2012b) and OH endangered. Suitable habitat for the rayed bean is still thought to be present in Champaign County. The rayed bean is generally known from smaller, headwater creeks but records exist in larger rivers. They are usually found in or near shoal or riffle areas of rivers and in the shallow, wave-washed areas of lakes. They occur only in water bodies that provide perennial water flow. Substrates typically include gravel and sand. The rayed bean is often associated with, and buried under the roots of vegetation such as water willow (*Justicia americana)* and water milfoil (*Myriophyllum* spp.).

The rayed bean is known from the Big Darby Creek watershed, of which the Little Darby Creek is a tributary. Portions of the Little Darby Creek that could be impacted by road and utility line crossings associated with the Project are ephemeral and do not contain features necessary to support mussel populations (Hull 2010). A field assessment in November 2008 found the Little Darby Creek crossing point to be dry (Hull 2009). The stream reach for this part of the Little Darby Creek was scored as 46 using the Headwaters Habitat Evaluation Index (HHEI), indicating that the reach is Class II intermittent headwaters habitat and the substrate is dominated by cobble and sand. Thus, the required perennial base flow and the preferred substrates of the rayed bean are not present in this reach of Little Darby Creek. Additionally, the rayed bean is often associated with the root masses of aquatic plants, which are not present in this reach (Hull 2009).

The rayed bean has the potential to occur in other perennial streams with suitable habitat within the Action Area. For perennial stream corridors that have the required base flow and substrate to support rayed bean mussels and will be crossed by access roads, crane paths and/or collection lines, a survey may be performed to detect the presence or absence of the rayed bean mussel. If rayed bean are determined to be present, in-water work will be avoided either through directional drilling, access road re-routing, arched bridge structures or temporary crossings (see Section 5.2.1.2 – Impacts to Aquatic Habitats). Additionally, Buckeye Wind will directionally drill beneath or otherwise avoid in-water work for any Ohio designated Exceptional Warmwater Habitat or Cold Water habitat streams[12] in the Action Area (i.e., underground crossings for electric collection lines) to avoid and minimize impacts to aquatic habitats. If no survey is performed, presence will be assumed and in-water work will be avoided as if rayed bean was determined to be present. If a survey is performed and no presence is detected, the stream will be crossed in accordance with the approaches outlined in Section 5.2.1.2 – Impacts to Aquatic Habitats.

Buckeye Wind has undertaken several steps to prevent adverse effects to water quality. An erosion and sediment control plan and Stormwater Pollution and Prevention Plan (SWPPP) will be developed and implemented for the entire Project, which will control potential sedimentation, siltation, and run-off that could negatively affect mussels and other aquatic life. Most mussel species require good water quality and erosion and sediment control measures implemented through the NPDES permit will preserve the existing water quality level. The SWPPP plan is developed and implemented by the general contractor and has not been developed, so it is not possible to know exactly where certain erosion and sediment control practices will be utilized. However, based on previous wind farm construction experience, typical erosion and sediment control best management practices may include: silt fences, filter socks, swales, temporary and permanent mulching and seeding, infiltration berms, inlet and outlet protection, construction entrances, and orange construction fencing to protect wetlands located near disturbance areas. The ODNR Division of Soil and Water Resources' Rainwater and Land Development Manual will be used as a guide to determine the appropriate erosion and sediment control measures and the post-construction storm water practices to be used at the Project. The NPDES permit will also include restoration measures that will ensure that disturbed ground is stabilized, preventing ongoing erosion and sedimentation of storm water run-off. These restoration measures consist of revegetation (typically using native species; and depending upon the land use), regrading and permanent swales or catch basins as needed.

In summary, as a result of the avoidance measures and erosion and sediment control measures that will be implemented by Buckeye Wind and enforced by its NPDES permit during construction and decommissioning to avoid and minimize impacts to wetlands and streams, impacts to aquatic habitat will be minimal. There will be no effect on the rayed bean from construction, operation, maintenance, or decommissioning of the Project.

Similarly, mitigation lands are located within the range of the rayed bean. Streams that support suitable habitat for rayed bean mussel as described above will not be subjected to in-water disturbance, clearing of forested riparian vegetation, or other disturbance to the bed or banks of streams. Mitigation actions involving tree planting and invasive species control along stream corridors that provide suitable rayed bean habitat will be conducted using hand tools so as not to disturb the stream bank. If crossings of streams are

[12] According to Ohio Revised Code 3745-1-07, Exceptional Warmwater Habitat streams are capable of maintaining an exceptional or unusual community of warmwater aquatic organisms with the general characteristics of being highly intolerant of adverse water quality conditions and/or being rare, threatened, endangered or species of special status. This is the most protective use designation assigned to warmwater rivers and streams in Ohio. A Coldwater Habitat stream is capable of supporting populations of coldwater aquatic organisms on an annual basis and/or put-and-take salmonid fishing. These water bodies are not necessarily capable of supporting the successful reproduction of salmonids and may be periodically stocked with these species. Both are afforded special protections under Ohio's CWA provisions.

required at mitigation sites for vehicle access, arched bridge structures or temporary crossings that do not impact the stream bed or bank will be implemented or existing crossings will be used. Road building, earth grading and other activities that would result in ground disturbance and resulting soil erosion and sedimentation will not occur for mitigation activities. Thus, suitable habitat for rayed bean will not be impacted, there will be no effect on this species, and the rayed bean will not be addressed further in this HCP.

Additional information on these species and other state listed and sensitive species that occur in the Action Area and mitigation area will be discussed in detail in Section 5.7 of the EIS and in Appendix A, Table 1 of the ABPP (Stantec 2011a).

3.2.1.1 Eastern Massasauga Rattlesnake

The Action Area also lies within the range of the eastern massasauga rattlesnake (*Sistrurus catenatus*), a federal candidate species and OH endangered species. Eastern massasaugas use both upland and wetland habitat at different times during the year and therefore require wetland areas immediately adjacent to upland grassland. Early successional herbaceous or scrub-shrub wetlands are used primarily during the fall, winter, and spring. During the winter, massasaugas hibernate in low wet areas, primarily in crayfish burrows, but may also use other structures. The presence of a water table at or near the surface is an important component of a suitable hibernation area. During the summer, male and non-gravid female massasaugas use open, upland grassland or prairie habitat that may be intermixed with scattered trees or shrubs. Adjacent lowland and upland habitat, with variable elevations between, are critical as the snakes travel back and forth seasonally between habitats.

There are no known occurrences of eastern massasauga rattlesnakes in the Action Area (M. Seymour, USFWS, personal communication). However, the species is known to occur outside of the Action Area within Champaign and Clark counties (M. Cota, USFWS, personal communication). Therefore, a desktop habitat assessment was conducted using recent aerial photographs, NWI wetland mapping, and field delineated wetland boundaries to determine if suitable habitat for the massasauga is present within the Action Area. Specifically, emergent or scrub-shrub wetlands located immediately adjacent to upland grassland (e.g., native grassland, pasture, hayfield) were identified as potential habitat. Potential habitat areas identified during the desktop assessment were field-verified to determine if suitable habitat is present in the Action Area. The desktop assessment revealed that the majority of the small number of wetlands present in the Action Area do not have any adjacent grassland, and at those sites that do, the grassland present is very limited. Furthermore, while wetlands are present within the Action Area, there are no wetland impacts proposed as a result of construction, operation and decommissioning of the Project (refer to EIS Section 5.4 for further information on avoidance of wetland impacts). The only potential suitable habitat was a 20 ac wetland in the western portion of the Action Area. A habitat evaluation was conducted by USFWS and OH state eastern massasauga experts on 10 January 2012. It was determined that this 20 ac wetland contains suitable habitat for the eastern massasauga. Project activities and infrastructure will completely avoid this wetland and no loss of habitat would occur as a result of the Project. Additionally, Buckeye Wind worked with USFWS and ODNR DOW to relocate an access road that was previously located in close proximity to the wetland.

In order to avoid potential impacts to the eastern massasauga, a presence/absence survey approved by the USFWS and ODNR DOW may be conducted at the wetland. The survey would be conducted by a USFWS and ODNR DOW permitted and approved eastern massasauga herpetologist. If no eastern massasaugas are detected during the survey, no further avoidance and minimization measures will be necessary to be implemented for the Project. If presence is detected, or if a survey is not conducted before Project construction, presence will be assumed and the following measures will be implemented:

Construction

- To the extent practicable, all construction and decommissioning activities will be conducted between 15 Nov and 1 Mar.
- Any temporary ground disturbance for construction activities, as well as any construction of crane paths or buried or overhead interconnect will occur at least 50 ft from the delineated wetland.
- Trenched Silt fences will be installed between the planned Project facilities and the eastern massasauga habitat. These silt fences will be located at least 40 ft from the wetland.
    - An USFWS and ODNR DOW approved and state permitted herpetologist will survey for snakes during installation of the silt fencing to ensure there are no eastern massasauga present that could be impacted. If installation of the silt fencing occurs between 15 Nov and 1 Mar, the ODNR DOW permitted herpetologist will not be present.
    - When active construction activities are nearby, the buried silt fencing will be evaluated daily and maintained in a good upright condition until all construction activities in the area are complete.
- Speed limits within ½ mile around suitable habitat will be maintained at 10 mph.
- Wildlife crossing signs approved by the USFWS and ODNR DOW will be posted within ½ mile of the wetland. The signs will alert drivers to be aware of potential for road encounters with wildlife.
- Gates will be installed at the entrance points from public roads onto the access roads in proximity to the wetland.
- Construction personnel shall be made aware of the possible presence of eastern massasauga in the Action Area, that the eastern massasauga is protected by OH Revised Code (ORC), and that the snake is venomous and should not be handled. Personnel will be provided information on how to identify the eastern massasauga, including at minimum photos and description of defining features. Any snake that cannot be positively identified as not being an eastern massasauga should be completely avoided.
- If an eastern massasauga is encountered or suspected in the Action Area during construction, all work in or near the location of the eastern massasauga encounter should stop and the permitted and approved herpetologist should be immediately notified to ensure no potential risk to the snake occurs. ODNR DOW and USFWS should be contacted immediately for further direction.

Operation and Maintenance

- Speed limits within ½ mile around the wetland will be maintained at 10 mph.
- Wildlife crossing signs approved by USFWS and ODNR DOW will be posted within ½ mile of the wetland. The signs will alert drivers to be aware of potential for road encounters with wildlife.
- Gates will be installed at the access point from public roads onto the access roads in proximity to the wetland.
- O&M personnel shall be made aware of the possible presence of eastern massasauga in the Action Area, that the eastern massasauga is protected by ORC, and that the snake is venomous and should not be handled. Personnel will be provided information on how to identify the eastern massasauga, including at minimum photos and description of defining features. Any snake that cannot be positively identified as not being an eastern massasauga should immediately be reported to the site manager.
    - If an eastern massasauga is encountered, and at risk of impact from operation or maintenance activities, an ODNR DOW permitted herpetologist that is approved by the USFWS and ODNR DOW, will be enlisted to remove the snake from risk. The USFWS and ODNR DOW will be contacted within 24 hours.

Decommissioning

- Silt fencing will be installed between the wetland and decommissioning activities in the same way as during construction. All other avoidance measures implemented during construction will also be implemented during decommissioning.
  - An USFWS and ODNR DOW approved and state permitted herpetologist will survey for eastern massasauga during installation of the silt fencing to ensure there are no snakes present that could be impacted. If installation of the silt fencing occurs between 15 Nov and 1 Mar, the ODNR DOW permitted herpetologist will not be present.
  - When active decommissioning activities are nearby the buried silt fencing will be evaluated daily and maintained in a good upright condition until all decommissioning activities in the area are complete.

If at any point during the construction, operation, or decommissioning of the Project an eastern massasauga is observed, it will be photo documented if possible and the OH field office of the USFWS and the ODNR DOW will be notified immediately or within 24 hours. If the species is encountered, Buckeye Wind will work with the USFWS and ODNR DOW to determine if any other avoidance and minimization measures are needed.

The mitigation area lies within the range of the eastern massasauga; however, the distribution of the species does not include the mitigation area and no impacts are anticipated.

With implementation of the avoidance and minimization measures outlined above, including relocation of an access road near the wetland, Buckeye Wind believes that construction, operation maintenance and decommissioning of the Project is not likely to adversely affect the eastern massasauga. Any potential impacts to this species would likely be insignificant and discountable and this species will not be evaluated further in this HCP.

3.2.2 Other Sensitive Species

3.2.2.1 Non-federally listed bats

The Indiana bat is the only federally endangered or threatened species likely to be incidentally taken by the Project, and is therefore the only species to be covered by the ITP issued in association with this HCP. For information on non-federally listed bats, including long-distance migratory bat species, see Chapter 4.0 of the ABPP (Stantec 2011a) and Section 4.6 of the EIS.

One additional bat species that occurs in the Action Area has been petitioned for federal listing: the northern long-eared bat (*Myotis septentrionalis*, petitioned by the Center for Biological Diversity [CBD] 2010). Further, a status assessment of the little brown bat (*M. lucifugus*) is being completed to determine if threats to the species warrant listing. Proposed listing considerations for both species center around concern related to the potentially devastating effects of white-nose syndrome (WNS) on these species. While the eastern small-footed bat (*M. leibii*) was also petitioned for federal listing by the CBD, this species was not detected during mist net surveys in the tri-county area, and suitable habitat for the species does not exist within the Action Area; therefore, no potential impacts are anticipated for this species. The northern long-eared bat and eastern small-footed bat were added to the USFWS Region 3 federal list of Species of Concern, an informal term indicating species which Region 3 feels might be in need of conservation activities. All bats are listed as Species of Concern by ODNR DOW, with the exception of the Indiana bat which is listed as state endangered.

Both the northern long-eared bat and little brown bat were documented in the Action Area during summer mist-netting and fall swarming surveys conducted in 2009 (see Section 3.2.3 – Pre-construction Bat Surveys

Conducted). Although the northern long-eared bat, little brown bat, big brown bat and tri-colored bat are not included as covered species under this HCP, avoidance and minimization measures implemented to reduce impacts to Indiana bats, as described in Section 6.1 – Avoidance Measures and Section 6.2 – Minimization Measures, are expected to also substantially reduce mortality of these and other cave-hibernating bat species. Mitigation and conservation measures, as outlined in Section 6.3 – Mitigation Measures and Section 6.4 – Conservation Measures, that will be implemented as part of the HCP are also expected to offset potential take and enhance the reproductive potential and survival of species that share hibernacula, summer foraging, and roosting areas with the Indiana bat, including the northern long-eared bat and little brown bat. Additionally, conservation measures implemented under the HCP, including research on bat-wind interactions, may increase the effectiveness of avoidance and minimization measures and decrease risk to cave-hibernating bat species over time.

While the USFWS has suggested that Buckeye Wind consider including the northern long-eared bat and little brown bat as covered species in this HCP, Buckeye Wind has determined that such coverage is not feasible at this time. Should the northern long-eared bat, little brown bat, or other species likely to be impacted by the Project be proposed to be listed as an endangered or threatened species under the ESA during the 30-year ITP Term, Buckeye Wind will immediately enter into discussion with the USFWS to determine if an HCP amendment is appropriate. If take of these proposed species is likely, Buckeye Wind will seek to amend the HCP and ITP to include coverage for those proposed species, or other avenues for take coverage will be explored (see Section 7.2.1.1 – Listing of New Species under ESA for additional information on the HCP amendment process). Criteria for establishing take limits will be dependent on population information, mortality rates, and data on the effectiveness of various management actions available at the time that the species is determined to be listed.

Buckeye Wind also anticipates that 2 factors will contribute greatly to assessing impacts of the Project to the northern long-eared bat and/or little brown bat. First, Buckeye Wind is aware that USFWS is supporting efforts to develop a Regional HCP for the Indiana bat and other ESA threatened and endangered species and may also include the northern long-eared bat and the little brown bat. The approaches established in that Regional HCP process could offer useful input to the assessment of impacts to currently non-federally listed species. In addition, Buckeye Wind anticipates that post-construction monitoring results from this Project will provide data pertaining to the level of impact this Project might have on northern long-eared bats and little brown bats and how much the minimization measures implemented for Indiana bat impacts might reduce impacts to those species. Buckeye Wind expects that consultation with the USFWS would benefit from input derived from the Regional HCP and/or Project-specific post-construction monitoring results, and that this information could inform a HCP amendment process.

In the case that the northern long-eared bat or little brown bat is listed before an amendment is obtained, or before other take coverage is authorized, Buckeye Wind will take the appropriate actions pursuant to the ESA to avoid take.

3.2.2.2 Bald and Golden Eagles

Although “non-purposeful” take permits for bald eagles (OH threatened) or golden eagles may be issued under a new BGEPA take permit rule (50 CFR § 22.26 and § 22.27), Buckeye Wind is not pursuing this permit at this time because the Project is not expected to result in eagle take. Effects on bald and golden eagles are fully addressed within the ABPP and EIS.

Low numbers of migrating eagles were observed during pre-construction surveys; 1 bald eagle and 1 golden eagle were observed during each fall and spring 2008 raptor migration survey, and none was observed during the fall 2007 survey (i.e., 2 total bald eagles, 2 total golden eagles). The USFWS provided Buckeye Wind with documentation that private landowners observed 2 juvenile eagles within the southwestern portion of the Action Area during the spring and summer 2011. Additionally, a local newspaper reported and ran a photo of an adult bald eagle within the Action Area during fall 2009. The USFWS further investigated specific areas from the local reports of bald eagle activity and potential nests by conducting an on-site visual field inspection. No bald eagle nests or activity were observed (M. Cota, USFWS, personal communication).

Based on the best available scientific information, there is low potential for harm to breeding or nesting eagles as a result of the Project. Bald eagle nesting sites often occur in mature riparian habitat near lakes, large rivers, or sea coasts (USFWS 2009c), which do not occur in the Action Area. Features influencing nest location include distance to nearest water; diversity, abundance, and vulnerability of prey base; and absence of human development and disturbance. No bald eagles or golden eagles were observed during breeding bird surveys conducted at 90 observation points located within and in the vicinity of the Action Area and these points were each sampled 4 times during May, June, and July 2008. No known eagle nests occur within the Action Area and the nearest known eagle nest site is approximately 15.3 km (9.5 mi) from the Project boundary in Logan County along the Mad River (M. Seymour, USFWS, personal communication). Migrant and winter bald eagles also favor aquatic habitats with abundant food sources and roost in forested areas (USFWS 2009c). Habitat in the Action Area is not likely to attract significant numbers of eagles during the non-breeding season. In the Avian Knowledge Network database, no winter bald eagle records were found for Champaign County for December through February from 1991 to 2011 (Munson et al. 2011). However, should new information regarding eagle use of the Action Area become available from post-construction Breeding Bird surveys conducted by Buckeye Wind in accordance with ODNR Protocol, or from other verifiable information from public agencies during the 30-year term of the ITP, Buckeye Wind will work with USFWS to determine if potential risk exists and if an ITP under BGEPA is appropriate.

Recent post-construction monitoring studies at wind facilities (other than the Altamont Pass Wind Resource Area, CA) indicate that mortalities of eagles are very low; no bald or golden eagle mortality has been documented at wind projects in the eastern United States to date, though there have been reports of bald eagle fatalities in Ontario, Canada, MT and 2 in WY.

Buckeye Wind has taken steps to proactively avoid or minimize impacts to eagles. These measures are summarized briefly below and are described in more detail in Chapter 5.0 of the ABPP (Stantec 2011a). Collector lines will be buried where feasible, which will minimize the potential risk of electrocution and collision to eagles and other birds. It is anticipated that approximately 50.0% of the estimated 113.5 km (70.5 mi) of 34.5 kV interconnects for the 100-turbine Project will be buried underground. Under the Redesign Option, approximately 90.5% of the estimated 95.4 km (59.3 mi) of 34.5 kV electrical interconnect lines would be buried underground. Above-ground collector lines will be equipped with insulated and shielded wire to avoid electrocution of eagles and other birds. All above-ground electrical facilities will be designed in accordance with the Avian Power Line Interaction Committee (APLIC) guidelines developed jointly with the USFWS (APLIC 2006), where possible and as dictated by Dayton Power and Light (DPL) construction guidelines[13]. New distribution poles, where possible and as dictated by DPL

[13] While Buckeye Wind would own the wires that carry electricity from the turbines, the above-ground collection lines, including distribution poles, will be owned and maintained by DPL and subject to DPL construction guidelines. While it is likely that DPL will utilize APLIC guidelines, or similar, and Buckeye Wind will encourage the use of APLIC guidelines,

construction guidelines, will be designed and maintained so that they are insulated in order to protect eagles from electrocution for, at least, the duration of the ITP. Should insulating of lines associated with new poles not be possible, perch deterrents will be installed to prevent eagle perching activity. Measures will be implemented to avoid and reduce scavenging opportunities for raptors and eagles around the turbine locations.

The mitigation site is within the range of the bald eagle. However, no nests are currently known to occur within the mitigation site. Additionally, migrating or wintering bald eagles that pass through the mitigation area are not likely to be taken by mitigation activities. Therefore, no effect on bald eagles is expected from mitigation activities.

3.2.2.3 Migratory Birds

The construction and operation of wind facilities can result in both direct (immediate) and indirect (separate in time) impacts to migratory birds, which are protected by the MBTA. Bird mortality at wind facilities is well documented by recent studies, with some facilities resulting in greater impacts to particular species or species groups than others. The majority of avian fatalities at wind turbines have primarily involved nocturnally migrating songbirds, although mortality at wind facilities has been much lower than that caused by other tall man-made structures and other sources of anthropogenic avian mortality (Erickson et al. 2005). In addition to direct impacts, bird species may be indirectly affected by wind facilities as a result of displacement caused by habitat alteration, habitat loss, or human disturbance (Dewitt and Langston 2006).

In order to evaluate potential effect on migratory birds within the Action Area, a series of pre-construction studies were designed based on work plans developed in consultation with the USFWS and ODNR DOW to evaluate bird resources in the Initial Project Area. Study work plans were discussed and shared with the USFWS and ODNR DOW beginning in fall 2007. Several meetings were held in 2007 and 2008 to receive and discuss agency comments, several field visits were conducted with agency representatives, and members of both the ODNR DOW and the USFWS participated in several of the field studies. Agency comments and feedback were subsequently incorporated into final study protocols.

The following baseline migratory bird studies were conducted, which are included as appendices to the EIS:

- Radar studies to document nocturnally migrating birds and bats in fall 2007;
- Diurnal raptor migration surveys in fall 2007 and spring and fall 2008;
- Breeding bird surveys in spring and summer 2008; and
- Sandhill crane (*Grus canadensis*) migration surveys in fall 2008.

These baseline studies were completed to characterize the distribution, relative abundance, behavior, and site use of species of migratory birds. As part of the Tier Three evaluations these baseline studies were used to identify to what extent, if any, the development of the Project would expose these species to risk and what additional studies or modeling were needed to assess those risks. The ABPP fully describes the results of these surveys.

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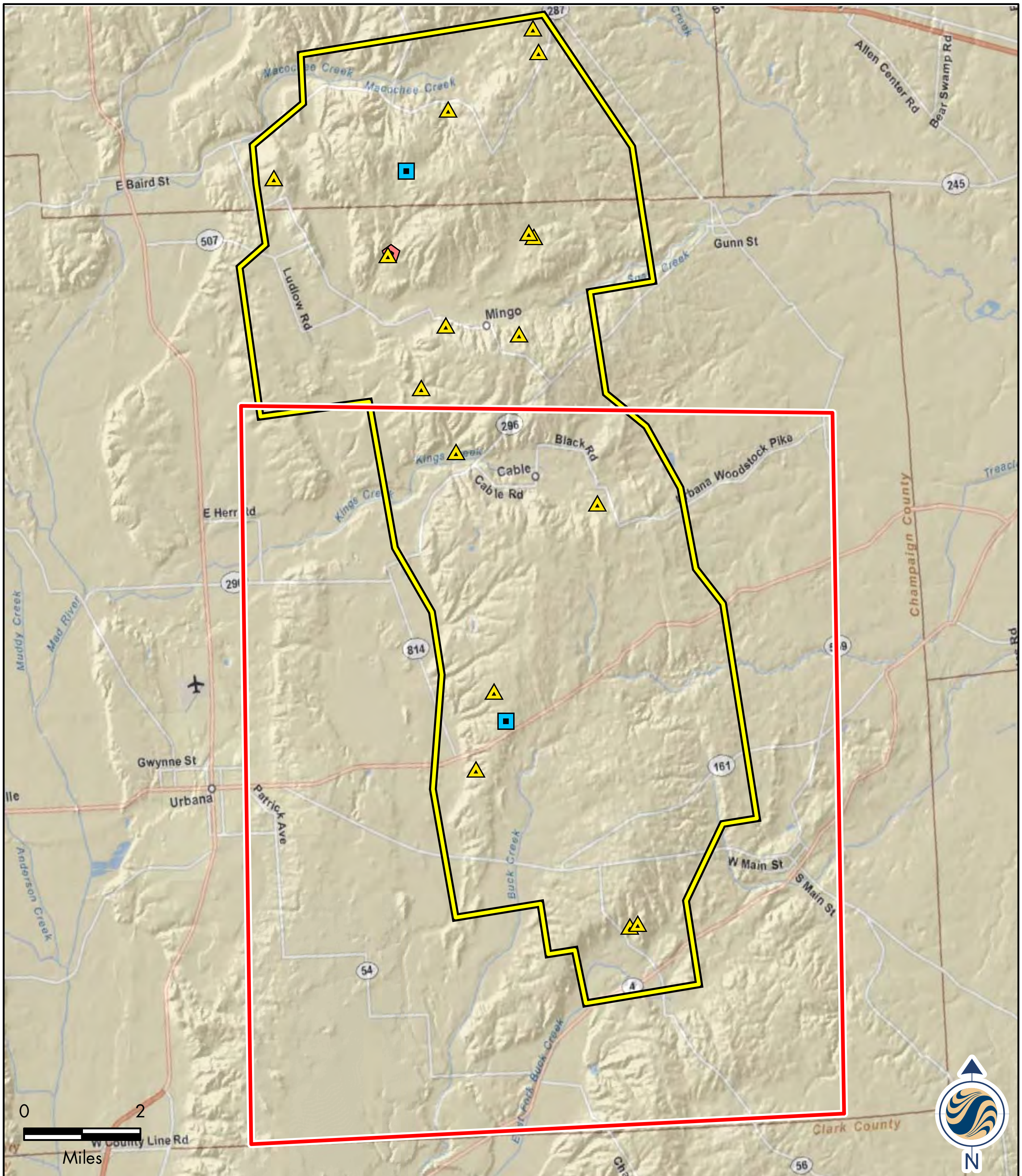
it is not possible for Buckeye to commit to such measures. In the Redesign Option, above-ground collection lines will not be used, except for in very limited circumstances (see Section 1.1 – Overvew and Purpose of the HCP).

Buckeye Wind has taken steps to proactively avoid or minimize impacts to migratory birds. These measures are described in more detail in Chapter 5.0 of the ABPP (Stantec 2011a). Further, the ABPP describes post-construction monitoring and adaptive management that will be conducted to document mortality levels of migratory birds and the triggers for implementation of measures to further reduce bird mortality.

3.2.3 Pre-Construction Bat Surveys Conducted

The following sections describe bat surveys that were conducted inside the initial study area, which included the Action Area (see Figure 3-2), and areas north of the Action Area (Stantec 2008a, Stantec 2008b, Stantec 2009a). The purpose of these surveys was to examine bat use within the initial study area and determine presence or probable absence of Indiana bats. As described in Section 1.1 – Overview and Purpose of the HCP, the initial study area was subsequently reduced due to documented presence of Indiana bats at the northern extent of the initial study area. The following bat surveys were conducted with all protocols developed cooperatively and in coordination with the ODNR DOW and the USFWS Ohio Ecological Services Field Office:

- Bat acoustic surveys using 6 acoustic detectors at 2 MET towers in fall 2007 and spring through fall 2008;
- Bat mist-netting surveys in summer 2008;
- Surveys to detect potential hibernacula at 14 known or suspected karst areas in 2008; and,
- Bat swarming surveys at 2 cave openings in fall 2008.



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Legend:
- Action Area
- Initial Study Area
- Bat Detector Location
- Mist Net Location
- Swarm Survey Location

Figure: 3-2

BUCKEYE WIND POWER PRE-CONSTRUCTION SURVEY LOCATIONS

3.2.3.1 Acoustic Bat Surveys

Acoustic bat call sequences were recorded using 6 Anabat SD1 detectors (Titley Electronics Pty Ltd.) at 2 MET towers from 28 August 2007 to 29 October 2007 (Stantec 2008a) and 29 March 2008 to 3 September 2008 (Stantec 2009a). One MET tower was located in the central portion of the Action Area, and another was located within the initial study area, but 6.2 km (3.8 mi) north of the Action Area. Three acoustic bat detectors were placed at each of the "North" and "South" MET towers (Table 3-2) at heights of 2 m (7 ft; "Tree"), 20 m (66 ft "Low"), and 40 m (131 ft "High") agl.

A total of 1,522 bat call sequences were recorded over 226 detector-nights during fall 2007, for a mean nightly detection rate of 6.7 call sequences per detector per night (s/d/n) (Stantec 2008*a*; Table 3-2). The majority of recorded bat call sequences (48%) were identified to the unknown (UNKN) guild, followed by those identified to the big brown bat (*Eptesicus fuscus*)/silver-haired bat (*Lasionycteris noctivagans*) /hoary bat (*Lasiurus cinereus*) (BBSHHB) guild (34%), the eastern red bat (*Lasiurus borealis*)/tri-colored bat (*Perimyotis subflavus*) (RBTB) guild (18%), and the *Myotis* (MYSP) guild (<1%). Twenty-six percent of call sequences across all guilds, and only 1 MYSP call sequence, were recorded at detectors at the 40 m (131 ft) height.

Table 3-2. Distribution of bat acoustic detections by guild at 2 60-m MET towers at the Buckeye Wind Power Project, Champaign County, OH, and initial study area, 28 August 2007 to 29 October 2007.

	Guild				
Detector	**Big brown silver-haired hoary bat (BBSHHB)**	**Red bat tri-colored bat (RBTB)**	**Myotis (MYSP)**	**Unknown (UNKN)**	**Total**
North High: 40 m (131 ft)	101	5	1	69	176
North Low: 20 m (66 ft)	134	13	3	125	275
North Tree: 2 m (6.5 ft)	1	3	1	83	88
South High: 40 m (131 ft)	119	3	0	100	222
South Low: 20 m (66 ft)	45	2	1	32	80
South Tree: 2 m (6.5 ft)	110	253	0	318	681
Total	510	279	6	727	1,522
Guild Composition	34%	18%	<1%	48%	NA

A total of 18,715 bat call sequences were recorded over 774 detector-nights during spring through fall 2008, for a mean nightly detection rate of 23.7 s/d/n (Stantec 2009a; Table 3-3). The majority of calls recorded across all detectors (60%) were identified to the big brown/silver-haired bat (BBSH) guild (separated from the BBSHHB guild in 2008), followed by the UNKN (32%), RBTB (4%), MYSP (3%), and hoary bat (HB; 1%) guilds. Four percent of call sequences across all guilds, and 1% of MYSP call sequences were recorded at detectors placed at 40 m (131 ft) agl. Mean nightly detection rate was variable across seasons, with the highest rates recorded during the fall sampling period.

Table 3-3. Distribution of bat acoustic detections by guild at 2 60-m MET towers at the Buckeye Wind Power Project, Champaign County, OH and surrounding vicinity, 29 March 2008 to 3 September 2008.

	Guild							
					Unknown			
Detector	Big brown silver-haired (BBSH)	Hoary (HB)	Red bat tri-colored bat (RBTB)	Myotis (MYSP)	High frequency (HFUN)	Low frequency (LFUN)	Unknown (UNKN)	Total
North High: 40 m (131 ft)	91	9	20	4	35	112	1	272
North Low: 20 m (66 ft)	495	17	173	21	249	318	32	1,305
North Tree: 2 m (6.5 ft)	7,891	44	333	546	1,586	1,312	200	11,912
South High: 40 m (131 ft)	120	29	25	4	44	161	1	384
South Low: 20 m (66 ft)	343	24	70	4	102	304	3	850
South Tree: 2 m (6.5 ft)	2,298	25	96	24	423	1,046	80	3,992
Total	11,238	148	717	603	2,439	3,253	317	18,715
Guild Composition	60%	1%	4%	3%	13%	17%	2%	

3.2.3.2 Bat Mist-Netting Surveys

A total of 298 bats were captured during mist-netting surveys that were conducted on 75 net-nights between 17 June 2008 and 25 July 2008 (Stantec 2008b). Mist-net sampling effort was conducted in portions of both the current Action Area and the initial study area to the north. While the initial study area to the north was originally assessed, it was later excluded from the Action Area when the presence of Indiana bats was detected in 2008 as described in Section 1.1 – Overview and Purpose of the HCP.

The average capture rate was 4.0 bats per net per night (b/n/n). A total of 7 bat species were captured, with big brown bats consisting of 66% of all captures, followed by northern long-eared bats (13%), eastern red bats (12%), little brown bats (6%), hoary bats (1%), tri-colored bats (1%), and Indiana bats (1%) (Table 3-4). Reproduction of all 7 species was documented through the capture of reproductive females. Two reproductive adult female Indiana bats and 1 non-reproductive adult male Indiana bat were captured and radio-tagged north of the Action Area, with the closest capture location approximately 7.8 km (4.8 mi) north, in Logan County.

Table 3-4. Bat species captured during summer 2008 mist-netting in the Buckeye Wind Power Project Action Area and initial study area, Champaign and Logan Counties, OH (values in parentheses represent juvenile bats; values not in parentheses represent adults).

Species	Males	Females	Unknown	Total (% of total)
Big brown bat	51 (39)	87 (19)	1	197 (66%)
Northern long-eared	21	16 (1)	0	38 (13%)
Eastern red bat	8 (4)	12 (8)	4	36 (12%)
Little brown bat	12 (2)	4	0	18 (6%)
Hoary bat	0	1 (2)	0	3 (1%)
Tri-colored bat	1	2	0	3 (1%)
Indiana bat	1	2	0	3 (1%)
All Species	94 (45)	124 (30)	5	298

3.2.3.3 Bat Swarming Surveys

Bat swarming surveys were conducted in fall 2008 at 2 cave openings (Sanborn's Cave and a nearby, unnamed cave) located approximately 6.3 km (3.9 mi) north of (outside) the Action Area and within the initial study area (Stantec 2009a). At total of 884 bats were captured during 5 capture events from 15 September 2008 to 27 October 2008 using harp traps placed at cave openings and a mist-net across a nearby stream during 1 capture event. Northern long-eared bats were the most common species captured during swarming surveys (74%), with males representing 58% of all northern long-eared bats captured. The second most frequently captured species was the little brown bat, representing 23% of all bats captured (Table 3-5). Males represented the majority (82%) of all little brown bats captured. The least frequently captured bats were tri-colored bats (2%) and big brown bats (1%). No Indiana bats were captured during the fall 2008 swarming surveys. A survey of 14 areas with known or suspected karst geologic features was also conducted in the vicinity of the Action Area during 2008; no features capable of hosting bats were documented at any of the areas surveyed.

Table 3-5. Bat species captured during fall 2008 swarming surveys at Sanborn's Cave and a nearby, unnamed cave located in Logan County, OH, approximately 6.3 km (3.9 mi) north of the Buckeye Wind Power Project Action Area.

Species	Males	Females	Unknown	Total (% of total)
Northern long-eared	380	250	23	653 (74%)
Little brown bat	164	37	0	201 (23%)
Tri-colored bat	9	9	0	18 (2%)
Big brown bat	10	2	0	12 (1%)
All Species	563	298	23	884

3.2.3.4 Other bat surveys within Action Area

Fifty bats were captured during summer 2009 bat mist-net surveys conducted for an unrelated wind power project in an area that overlapped with the Action Area. Mist-netting was conducted at 17 net sites, 136 net nights, from 15 June 2009 to 6 July 2009 (Jackson Environmental Consulting Services, LLC, 2009) (Table 3-6).

Table 3-6. Bat species captured during summer 2009 for an unrelated wind power project that is completely within the Buckeye Wind Power Project Action Area.

Species	Males	Females	Unknown	Total (% of total)
Northern long-eared	7	9	1	17 (34%)
Big brown bat	7	15	0	22 (44%)
Indiana bat	0	4	1	5 (10%)
Eastern red bat	2	2	0	4 (8%)
Little brown bat	0	2	0	2 (4%)
All Species	16	32	2	50

4.0 COVERED SPECIES: THE INDIANA BAT (*MYOTIS SODALIS*)

The Indiana bat is a small (7 g to 10 g), insectivorous bat. It was not described as a separate species until 1928 (Miller and Allen 1928) from a specimen collected in Wyandotte Cave, Crawford County, IN. The Indiana bat can be distinguished from other *Myotis* (particularly the little brown bat) by its short, inconspicuous toe hairs; smaller foot (8 millimeters [mm; 0.31 inch (in)] instead of 9 mm to 10 mm [0.35 in to 0.39 in] in the little brown bat); keeled calcar; more uniformly colored fur; and its pinkish colored pug-nose (Whitaker and Hamilton 1998). Albino and partially white bats have rarely been encountered during hibernacula surveys (Brack et al. 2005).

The range of the Indiana bat includes the eastern and mid-western United States, from IA, OK, and WI, northeast to VT, and south to northwestern FL and northern AK (Barbour and Davis 1969). Although the species has a large distribution, the majority of the wintering population occurs in the limestone cave regions of IN, KY, and MO. More recently, large colonies have been found in abandoned underground mines in IL and OH.

4.1 Species Status

Since its description as a separate species, Indiana bat populations have experienced marked population declines. The species was listed as being in danger of extinction in 1967 under the Endangered Species Preservation Act of 1966 (32 Fed. Reg. 4001, 11 March 1967) because of large decreases in population size and an apparent lack of winter habitat (USFWS 1983, 1999). It was later listed as federally endangered under the ESA in 1973.

The Indiana bat is also listed as endangered in the state of Ohio under Ohio Revised Code 1531.25. The first Indiana bat maternity colony was discovered in Ohio in 1974 (ODNR DOW n.d.). In 2007, 2009 and 2011, approximately 7,600, 9,300 and 9,900 Indiana bats, respectively, were observed hibernating in Ohio (Table 4-1). These population estimates represent 1.6%, 2.2% and 2.3% of the 2007, 2009 and 2011 rangewide Indiana bat population, respectively.

A final ruling on critical habitat for the Indiana bat was established on 24 September 1976 (41 Fed. Reg. 41914) and included 11 caves and 2 mines. Designated critical habitat occurs in 6 states and includes: Blackball Mine (LaSalle County, IL), Big Wyandotte Cave (Crawford County, IN), Ray's Cave (Greene County, IN), Bat Cave (Carter County, KY), Coach Cave (Edmonson County, KY), Cave 021 (Crawford County, MO), Caves 009 and 017 (Franklin County, MO), Pilot Knob Mine (Iron County, MO), White Oak Blowhole Cave (Blount County, TN), and Hellhole Cave (Pendleton County, WV). No USFWS-designated Indiana bat critical habitat occurs in the Action Area or anywhere else in OH.

The first Indiana Bat Recovery Plan, published by the USFWS in 1983, outlined the Indiana bat's habitat requirements, critical habitat, potential causes for declines, and recovery objectives. In 1999, the USFWS published the *Agency Draft Indiana Bat (Myotis sodalis) Revised Recovery Plan* (USFWS 1999). In 2007, the USFWS completed an extensive literature search and provided updated information on the Indiana bat in the revised *Indiana Bat (Myotis sodalis) Draft Recovery Plan: First Revision* (hereafter 2007 Draft Recovery Plan; USFWS 2007). Like its predecessor, the 2007 Draft Recovery Plan focused on protection of hibernacula but also increased the focus on summer habitat and proposed use of 4RUs: Ozark-Central, Midwest, Appalachian Mountains, and Northeast (Figure 4-1). A combination of preliminary data on population discreteness and genetic differentiation (mostly associated with the Northeast RU), differences in population trends, and broad-level differences in macrohabitats and land use were used to delineate RU boundaries (USFWS 2007).

The Indiana bat population is not panmictic; i.e., movements of individuals and gene flow seem to be generally restricted to RU boundaries (USFWS 2007, see Section 4.4.3.2 – Migration Direction and Behavior). Since the Project is located in the Midwest RU, Project-related impacts are expected to occur in the Midwest RU population. However, due to paucity of data across the Indiana bat range, discussion of the Indiana bat and Project impacts will rely on Indiana bat information collected from all RUs as appropriate.

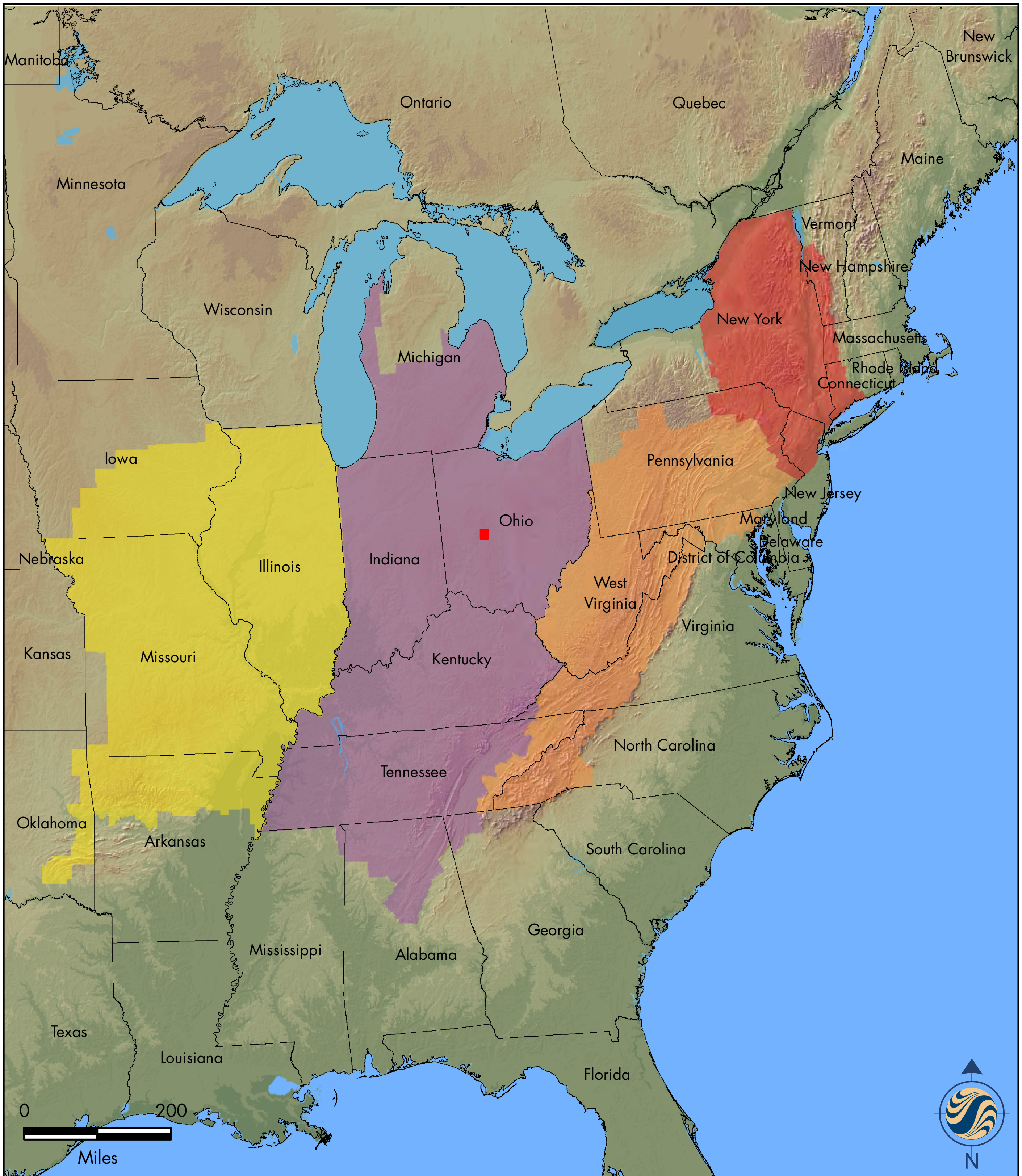
The 2007 Draft Recovery Plan revised Indiana bat priority criteria for hibernacula to be defined as follows:

- Priority 1 (P1): Essential to recovery and long-term conservation of Indiana bats. P1 hibernacula typically have (1) a current and/or historically observed winter population equal to or more than 10,000 Indiana bats and (2) currently have suitable and stable microclimates. P1 hibernacula are further divided into 1 of 2 subcategories, "A" or "B," depending on their recent population sizes.
  - Priority 1A (P1A) hibernacula are those that have held 5,000 or more Indiana bats during 1 or more winter surveys conducted during the past 10 years.
  - Priority 1B (P1B) hibernacula are those that have sheltered equal to or greater than 10,000 Indiana bats at some point in their past, but consistently have contained fewer than 5,000 Indiana bats over the past 10 years.
- Priority 2 (P2): Contributes to recovery and long-term conservation of Indiana bats. P2 hibernacula have a current or observed historic population of 1,000 or greater but fewer than 10,000, and an appropriate microclimate.
- Priority 3 (P3): Contribute less to recovery and long-term conservation of Indiana bats. Priority 3 hibernacula have current or observed historic populations of 50 to 1,000 Indiana bats.
- Priority 4 (P4): Least important to recovery and long-term conservation of Indiana bats. P4 hibernacula typically have current or observed historic populations of fewer than 50 Indiana bats.

In 2009, the first species-specific Five-Year Review was conducted for the Indiana bat since its listing (USFWS 2009a).

From 1965 to 2001, there was an overall decline in the rangewide population of the Indiana bat (USFWS 2007). Despite the discovery of many new, large hibernacula during this time, the rangewide population estimate dropped approximately 57% from 1965 to 2001. Since the advent of systematic survey efforts to estimate population numbers, some specific drivers have been clearly associated with positive and negative population trends at some of the largest hibernacula (e.g., changes in cave air flow and temperatures, and human disturbance levels), but the underlying causes of population change at other hibernacula remain unknown.

Contrary to the apparent long-term trend of decreasing population numbers of Indiana bats, the estimated rangewide population increased from 328,526 Indiana bats in 2001 to 467,947 Indiana bats in 2007 (USFWS 2012, Table 4-1). During the 2 biennial survey periods from 2003 to 2005 and 2005 to 2007, the rangewide population increased by 16.9%, and 10.0%, respectively. Despite lack of standardization in measuring and reducing sources of variability in estimates, observer error, and lack of statistical accuracy, the USFWS regarded the apparent upward trend from 2003 to 2005 to be reliable due to a high level of surveyor consistency and obvious, large increases at some high-priority hibernacula in IL, IN, KY, and NY during that time (USFWS 2007).



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Legend:
- Action Area

Indiana Bat USFWS Recovery Units
- Appalachian Mountains
- Midwest
- Northeast
- Ozark-Central

*Source: USFWS 2007

Figure: 4-1

INDIANA BAT
(Myotis sodalis)
USFWS RECOVERY UNITS

Table 4-1. Population estimates for the Indiana bat (*Myotis sodalis*) by USFWS region, state, and year with percent change in population from 2009 and percent of 2011 rangewide total (USFWS 2012).

USFWS Region	State	2003	2005	2007	2009	2011	Change from 2009	Percent of 2011 Total
Region 2	Oklahoma	5	2	0	0	13	100+%	0.00%
Region 3	Indiana	183,337	206,610	238,068	213,170	222,820	4.50%	52.50%
	Missouri	17,752	16,102	15,895	13,688	13,647	-0.30%	3.20%
	Illinois	43,647	55,090	53,823	53,342	55,956	4.90%	13.20%
	Ohio	9,831	9,769	7,629	9,261	9,870	6.60%	2.30%
	Michigan	20	20	20	20	20	0.00%	0.00%
	Total	254,587	287,591	315,435	289,481	302,313	4.40%	71.20%
Region 4	Kentucky	49,544	65,611	71,250	57,325	70,329	22.70%	16.60%
	Tennessee	9,802	12,074	8,906	12,721	12,786	0.50%	3.00%
	Arkansas	2,228	2,067	1,829	1,480	1,206	-18.50%	0.30%
	Alabama	265	296	258	253	261	3.20%	0.10%
	N. Carolina	0	0	0	1	1	0.00%	0.00%
	Total	61,839	80,048	82,243	71,780	84,583	17.80%	19.90%
Region 5	New York	32,529	41,745	52,779	34,045	16,052	-52.90%	3.80%
	Pennsylvania	931	835	1,038	1,031	518	-49.80%	0.10%
	W. Virginia	11,443	13,417	14,745	17,965	20,358	13.30%	4.80%
	Virginia	1,158	769	723	730	863	18.20%	0.20%
	New Jersey	644	652	659	416	5	-98.80%	0.00%
	Vermont	472	313	325	64	3	-95.30%	0.00%
	Total	47,177	57,731	70,269	54,251	37,799	-30.30%	8.90%
	Rangewide Total:	363,608	425,372	467,947	415,512	424,708	2.20%	100.00%

The first observed Indiana bat rangewide decline since 2001 was documented from 2007 to 2009 when the overall Indiana bat population declined by approximately 11% (i.e., loss of approximately 52,435 Indiana bats) (USFWS 2012). In 2009, the Midwest RU contained two-thirds (67.8%) of the rangewide Indiana bat population followed by the Ozark-Central RU (16.5%), Northeast RU (8.3%) and Appalachian Mountains RU (7.4%). Between 2007 and 2009, the Indiana bat population in the Appalachian Mountains RU increased 27.1% (8,273 Indiana bats), whereas populations in the other 3 RUs declined (Midwest: 13.6%, 38,433 Indiana bats; Ozark-Central: 4.4%, 3,037 Indiana bats; and Northeast: 55.7%, 19,238 Indiana bats) (USFWS 2012). The observed decline (55.7%) from 2007 to 2009 in the Northeast RU was primarily the result of Indiana bat mortality associated with the onset and spread of WNS (A. King, USFWS, personal communication), described in detail in Section 4.1.1 – White-Nose Syndrome.

The overall population decline within the Midwest RU between 2007 and 2009 (a net loss of approximately 38,433 Indiana bats) was attributable to reductions reported for 1 hibernaculum in KY and 4 hibernacula in IN. WNS had not been detected at these sites. Following the 2009 winter surveys, the USFWS's Bloomington Field Office (BFO) compared the results of traditionally derived ocular survey estimates to those derived from counting Indiana bats in digital photographs of the same hibernating clusters of Indiana bats (Meretsky et al. 2010; A. King, USFWS, personal communication). This cluster-by-cluster comparison revealed that the traditional survey estimates had significantly underestimated the total number of Indiana bats hibernating in several of the largest Indiana bat hibernacula in IN (e.g., Ray's, Wyandotte, and Grotto Caves) in 2009 and subsequently exaggerated the decline in the Midwest RU to some degree (USFWS 2010; A. King, USFWS, personal communication). The BFO's analysis indicated that a significant proportion of the observed decline in the Midwest RU between 2007 and 2009 was directly attributable to error inherent with the traditional survey techniques employed at hibernacula in IN. The USFWS and its partners continue to investigate potential causes that may have contributed to any unexpected or unusual population declines and continue to research and develop new survey techniques in an ongoing effort to improve both the accuracy and consistency of their bat population estimates throughout the species' range.

The USFWS released population estimates for 2011 in January, 2012 (USFWS 2012c). Estimated Indiana bat population size increased 2.2%, from 415,512 individuals in 2009 to 424,708 individuals in 2011. In the Midwest Recovery Unit, estimated Indiana bat population size increased 8.3%, from 281,909 individuals in 2009 to 305,297 individuals in 2011. Increases in Indiana bat population size were observed in all RUs except the Northeast RU, which experienced a 53.5% decline in estimated Indiana bat population size. It is likely that the decrease observed in the Northeast RU is a result of WNS (see section 4.1.1). However, changes in population size estimates can also be due to sources of error including: changing field methods, uneven counting among years, and incomplete understanding of movements between hibernacula. The use of digital photography has likely increased count accuracy; biologists began using this method in 2007 and it is likely that increased use over time will result in more standardized estimates (USFWS 2012). Therefore, patterns of estimated population size changes could be attributable to changes in count methods. Still, there are years in which a hibernaculum cannot be counted even though it is a scheduled year, resulting in assumptions about hibernaculum size. Also, not all hibernacula are known and can be counted (USFWS 2012c).

Finally, it is likely that WNS is affecting population size estimates. The observed decline in the Northeast RU was an expected result. However, while some Indiana bat hibernacula in the Northeast RU experienced severe declines, others have shown a population increase. There are several explanations for this observation. First, this could be a result of a true increase in population size, similar to patterns observed prior to the onset of WNS, at unaffected or previously-affected hibernacula (Thogmartin et al. 2012). Or, Indiana bats could be switching hibernacula: individuals could move during the winter in response to a specific WNS disturbance, or could consolidate into higher-quality hibernacula between years in response to a WNS disturbance from the previous year (Herzog and Reynolds 2012, Hicks et al. 2012, Thogmartin et al. 2012). In summary, there are many sources of error, although accuracy is generally thought to be increasing during each subsequent count year (USFWS 2012a).

The 2007 Draft Recovery Plan identified the Recovery Priority for the Indiana bat as an 8, meaning there is a moderate degree of threat and high recovery potential for the species. The Recovery Priority was changed to a 5 in the 5-year Review (USFWS 2009a) in light of WNS, meaning there is a high degree of threat and a low recovery potential for the species. In order to achieve the intermediate recovery goal of reclassifying the Indiana bat as federally threatened instead of endangered, the 2007 Draft Recovery Plan identified the following draft Reclassification Criteria:

1. Permanent protection of 80% of P1 hibernacula in each RU;
2. A minimum overall population number equal to the 2005 estimate (457,000); and
3. Documentation of a positive population growth rate over 5 sequential survey periods.

The Indiana bat will be considered for complete delisting when the above draft Reclassification Criteria have been met and the following additional criteria have been achieved:

1. Permanent protection of 50% of P2 hibernacula in each RU;
2. A minimum overall population number equal to the 2005 estimate, and
3. Continued documentation of a positive population growth rate over an additional 5 sequential survey periods.

According to the 2007 Recovery Plan, if future research on summer habitat requirements indicates the quality and quantity of maternity habitat is threatening recovery of the species, the USFWS will amend the Reclassification Criteria as follows.

1. Reclassification to Threatened
    a. Permanent protection of a minimum of 80% of P1 hibernacula in each RU, with a minimum of 1 P1 hibernaculum protected in each unit.
    b. A minimum overall population estimate equal to the 2005 population estimate of 457,000.
    c. Documentation that shows important hibernacula within each RU have a positive annual population growth rate over the next 10-year period (i.e., 5 survey periods).

2. Complete Delisting
    a. Permanent protection of a minimum of 50% of P2 hibernacula in each RU.
    b. A minimum overall population estimate equal to the 2005 population estimate of 457,000.
    c. Documentation that shows a positive population growth rate within each RU over an additional 5 sequential survey periods (i.e., 10 years).

4.1.1 White-Nose Syndrome

The 2007 Draft Recovery Plan does not address Indiana bat population decreases that have occurred as a result of WNS, a disease that is responsible for the death of millions of hibernating bats in the United States from 2006 to 2012 (USFWS 2009a, USFWS 2012a). Recent studies have determined that WNS is associated with a newly-described psychrophilic (cold-loving) fungus (*Geomyces destructans*) that grows on exposed tissues (i.e., noses, faces, ears, and/or wing membranes) of the majority of affected bats. The skin infection caused by *G. destructans* is thought to act as a chronic disturbance during hibernation (USGS 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 *G. destructans* is the primary cause of death (Lorch et al. 2011). 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). No other bacterial or viral agents have been detected through necropsies (CBD 2010).

WNS was first documented in bats in Schoharie County, NY, and mortality was confirmed at 4 sites in eastern NY in winter 2006-2007. WNS continued to spread and by the end of winter 2008-2009, all known WNS-affected hibernacula were in states located within USFWS Region 5 (R5; the Northeast Region). However, by March 2010 the presence of *G. destructans* had been confirmed or suspected in USFWS Regions R2 (Southwest), R3 (Midwest), R4 (Southeast), and R5 (Figure 4-2). Currently, WNS has been confirmed in 18 states and is suspect in an additional 2 states (Figure 4-2). The origin of WNS remains uncertain, although anthropogenic introduction of the disease, via commerce or travel from Europe, is a plausible hypothesis (Frick et al. 2010). In Ohio, WNS was confirmed in 2011 in a P4 hibernaculum in Lawrence County, Ohio, and in 2012 in Preble County, OH, home to a P2 Indiana bat hibernaculum. WNS has also been confirmed in Summit, Geauga, Cuyahoga, and Portage counties, OH (Jennifer Norris, ODNR, personal communication).

In Canada, WNS was documented in southern Ontario and Quebec in 2010 and New Brunswick and Nova Scotia in 2011 (Ontario Ministry of Natural Resources [OMNR] 2010, Figure 4-2). In Europe, WNS has been detected in southwestern France (Puechmaille et al. 2010), Switzerland, Hungary, and Germany (Wibbelt et al. 2010). However, no mass casualties have been detected among Europe's infected bats (Puechmaille et al. 2010, Wibbelt et al. 2010). Wibbelt et al. (2010) hypothesize that *G. destructans* is present throughout Europe and that bats in Europe may be more immunologically or behaviorally resistant to *G. destructans* than their North American congeners because they potentially coevolved with the fungus.

WNS is causing unprecedented mortality among at least 6 species of hibernating bats in North America (Frick et al. 2010): eastern small-footed bat, little brown bat, northern long-eared bat, tri-colored bat, big brown bat, and Indiana bat (USGS 2010). Other species affected include the cave myotis (*Myotis velifer*) and gray bat (*M. grisescens*). Until recently, Indiana bats were the only federally listed species known to be affected by WNS. However, in spring 2010 WNS was confirmed in 5 gray bats, also listed as federally endangered, in Shannon County, MO (Bat Conservation International [BCI] 2010a). All 25 species of bat in the United States that rely on hibernation may potentially be affected by WNS (USGS 2010). An estimated 5.7 to 6.7 million bat fatalities have occurred since WNS was first recorded in 2007 (USFWS 2012a); infected hibernacula are experiencing annual population decreases ranging from 30% to 99%, with a mean of 73% throughout eastern North America (Frick et al. 2010). Total mortality averaged 95% at closely monitored WNS hibernaculum that had multiple years of infection in NY, MA, and VT in 2009 (A. Hicks, New York State Department of Environmental Conservation, personal communication, as cited by Turner and Reeder 2009).

While it has been estimated that WNS is spreading at a rate of 24.1 km (15 mi) to 32.2 km (20 mi) per year (Turner and Reeder 2009), the recent documentation of WNS across large and disjunct geographic areas indicates that the spread is more rapid and far-reaching than originally thought. The mechanisms for persistence and transmission of the fungus during summer and fall months are currently unknown, but the spread of the fungus to new geographic regions and between species may result from social and spatial mixing of individuals across space and time, particularly at winter hibernacula (Frick et al. 2010).

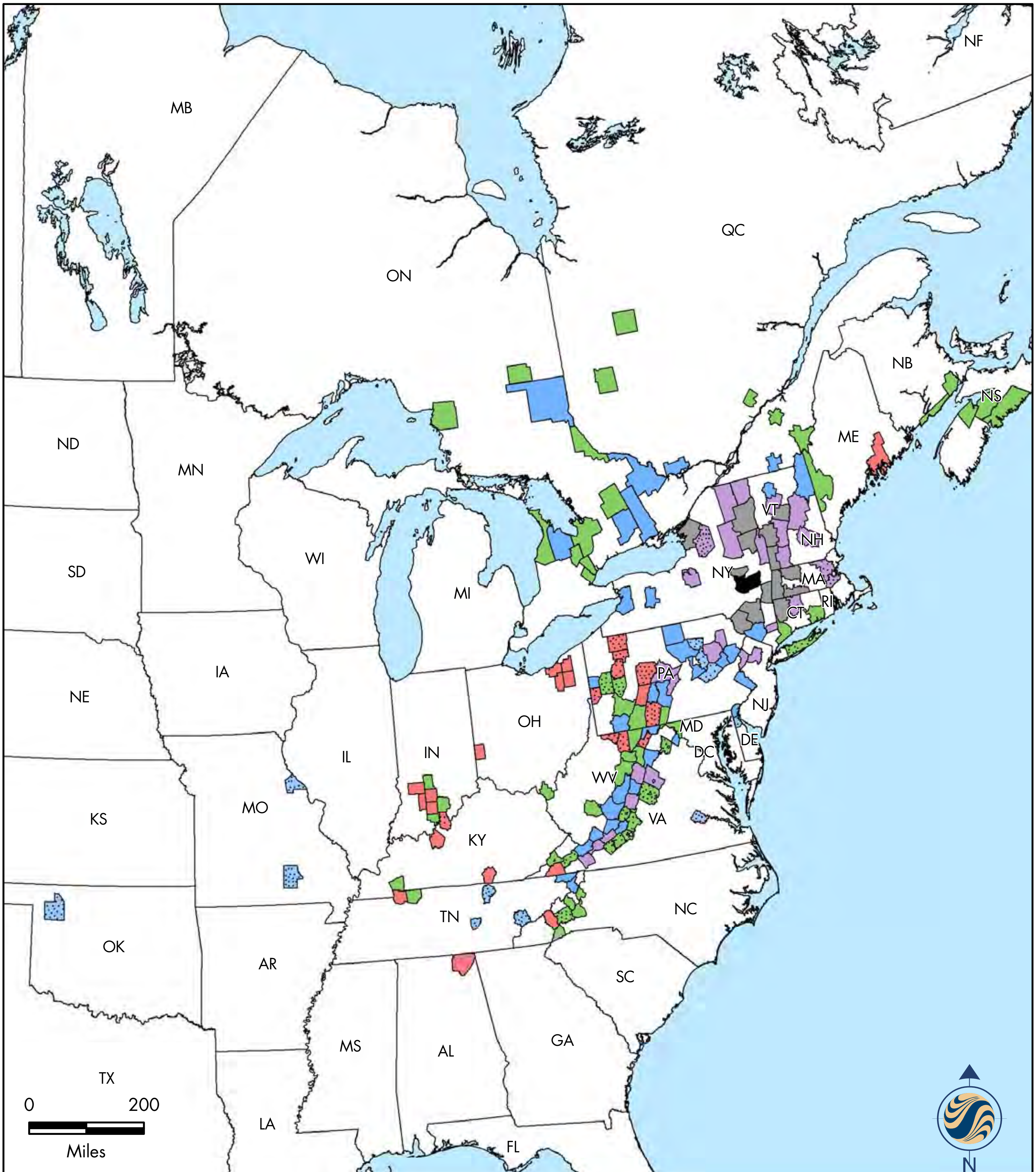
Laboratory experiments have observed bat-to-bat transmission of *G. destructans* (Lorch et al. 2011). Additionally, the fungus has been collected from soils of affected hibernacula, indicating that environmental factors may play a role in WNS transmission (BCI 2010b). Further discussion of WNS and its potential future impact on Indiana bats and the ESA listing of other bat species with regard to this HCP is included in Section 5.1.2.6 – Biological Significance of Incidental Take and Section 7.2.1 Changed Circumstances.

The disease may also be impacting bat populations by lowering the reproductive rates of surviving colony members (Frick et al. 2009). Most of the affected bat species, including the Indiana bat, exhibit life history strategies which are dependent on relatively high survival rates and long-lived individuals. Because reproductive rates are naturally low among affected bat species, populations are not adapted to fluctuate significantly over time and consequently will not recover from WNS quickly (USGS 2010). Given the extremely rapid proliferation of WNS over a large geographic area in just 4 winter seasons, it is likely that similar declines will occur at hibernacula in other states in the coming years. WNS and other causes of population decline will also be discussed in Section 4.5 – Current Threats.

In 2007, before widespread WNS mortality of Indiana bats had been documented, hibernacula in the USFWS's Region 5 states (primarily NY) contained approximately 70,269 Indiana bats or 15% of the total 2007 rangewide population. Since 1965, the NY hibernating populations of Indiana bats steadily increased and in 2007 they represented 11% of the rangewide population (USFWS 2009a). By the end of winter 2008-2009, WNS had been documented in each major NY Indiana bat hibernacula. The 35% decline in the NY Indiana bat population observed from 2007 to 2009 is assumed to be a direct result of WNS-related mortality (A. King, USFWS, personal communication). The loss of 18,734 Indiana bats in NY from WNS during this period represented a loss of approximately 4% of the 2007 rangewide population (Table 4-1). As of winter 2010-2011, 74 hibernacula supporting 37.7% of the 2011 Indiana bat rangewide population were known or suspected of being infected by WNS (A. King, USFWS, personal communication).

Thogmartin et al. (2012) used a modeling approach to examine Indiana bat population trends before and after the occurrence of WNS, between 1983 and 2005, and between 2006 and 2009. They estimated population trends for each hibernaculum and aggregated these trends based on hibernaculum proximity (and therefore assumed population interactions), while attempting to account for uncertainty in the count data, by using hierarchical Bayesian methods. Thogmartin et al. (2012) found that "The range-wide population of Indiana bat appears to have been in a stationary state for at least 2 decades before the onset of WNS. WNS has caused regional decline of Indiana bats in the northeast US and has halted population increase in the Appalachians, but the species-wide population has not credibly declined. Thus, as of 2009, the disease does not appear to be sufficiently prevalent across the core portion of the species range to alter species staus." Prior to 2005, Indiana bat populations in the Ozark-Central RU were declining, populations in the Appalachian RU and Northeast RU were increasing, and populations in the Midwest RU were stable. Further, there was an increasing population trend going from west to east. After the onset of WNS, the Ozark-Central RU continued to decline, the Appalachian RU continued to increase, the Northeast RU declined, and the Midwest RU continued to be stable as of 2009 (although an increase was detected in the Midwest RU, the wide confidence intervals surrounding the estimates seem to suggest some uncertainty in the trend).

The authors detected a 10.3% decrease in Indiana bat population size range-wide (Thogmartin et al. 2012). However, while this result was not statistically significant, the authors conclude that WNS is having an appreciable influence on the status and trends of Indiana bat populations.



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Legend:

- 2006-2007 - Confirmed
- 2007-2008 - Confirmed
- 2008-2009 - Confirmed
- 2008-2009 - Suspect
- 2009-2010 - Confirmed
- 2009-2010 - Suspect
- 2010-2011 - Confirmed
- 2010-2011 - Suspect
- 2011-2012 - Confirmed
- 2011-2012 - Suspect

Source: USFWS, ODWC, BCI. Updated 3/20/12

Figure: 4-2

COUNTIES WITH WHITE-NOSE SYNDROME RECORDS 2006 to 2012

4.2 Distribution

4.2.1 Winter Distribution

Indiana bat winter populations occur within cavernous limestone in the karst regions of the east-central United States (Figure 4-3), with the largest historical populations occurring in KY, IN, and MO. More recently, however, large colonies have been found in abandoned underground mines in IL and OH. Currently, the USFWS has designated critical winter habitat at 11 caves and 2 non-coal mines: 6 in MO, 2 each in KY and IN, and 1 each in IL, TN, and WV (USFWS 2007).

Over 86% of the estimated rangewide population in 2009 was known from hibernacula in just 4 states: IN (51.3%), KY (13.8%), IL (12.8%), and NY (8.2%). Most of the other Indiana bats hibernated in WV (4%), MO (3%), TN (3%), and OH (2%). Fifty percent of the 2009 rangewide population hibernated in 5 sites in 3 states: IN (Ray's, Wyandotte, and Jug Hole Caves), IL (Magazine Mine), and KY (Bat Cave, Carter County). Wyandotte Cave in southern IN had the largest hibernating population in 2009, with 45,516 Indiana bats (12% of the 2009 rangewide total; A. King, USFWS, personal communication). One hundred percent of the known population in 2009 hibernated in 211 sites in 16 states, with 85 sites containing fewer than 50 Indiana bats and 46 sites containing 10 or fewer Indiana bats (A. King, USFWS, personal communication).

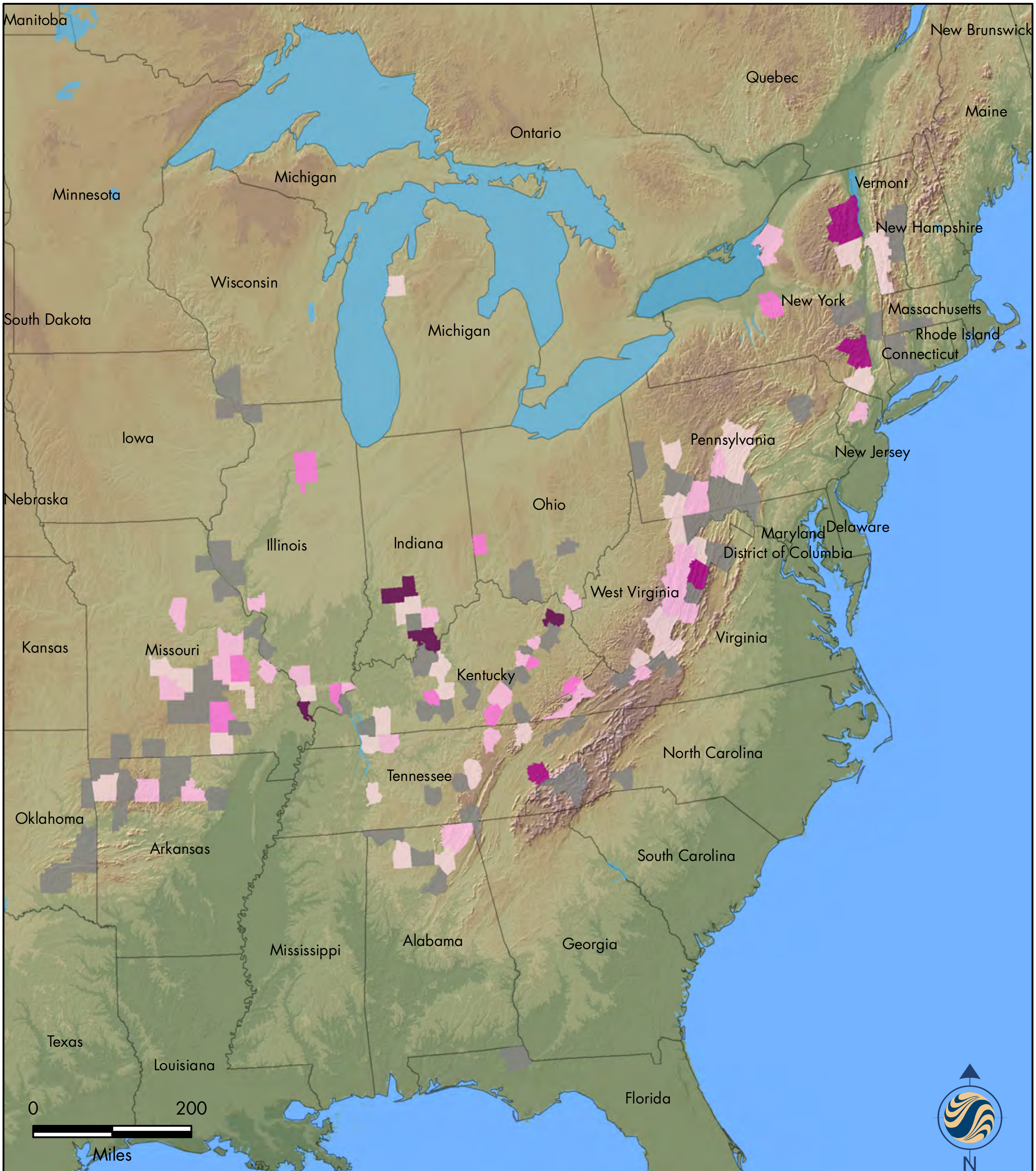
During the 1960s and 1970s, the vast majority (75%) of the known rangewide population of Indiana bats hibernated in the southern portion of the species' winter range (i.e., KY and MO; Clawson 2002). However, by 2001 60% of remaining Indiana bats occupied hibernacula in the northernmost portion of the winter range (Table 3 in USFWS 2007). Winter populations in KY and MO have experienced the most marked decreases in size since rangewide monitoring began. Although few specific drivers of this apparent population shift have been thoroughly investigated, unsuitable hibernacula temperatures (Elliott and Clawson 2001, Tuttle and Kennedy 2002, Elliott 2008) and regional climate change are either known or generally suspected as having played a role (USFWS 2007).

4.2.2 Summer Distribution

The first maternity colony was discovered in the summer of 1971 in east-central IN when a bulldozer pushed over a dead American elm (*Ulmus americana*) that sheltered approximately 50 Indiana bats, of which 8 were captured and identified as Indiana bats (Cope et al. 1974). Because maternity colonies are difficult to locate and are dispersed over large areas, the USFWS estimated that only a fraction of the maternity colonies presumed to exist have been documented (perhaps only 6% to 9%), based on the rangewide population estimates derived from hibernacula surveys (USFWS 2007). In 2006, the USFWS had records of 269 maternity colonies that were considered to be locally extant in 16 states. Of these, 54% (146 colonies) were discovered (mostly during mist-netting surveys) within the previous 10 years (USFWS 2007; Figure 4-4).

Summer colonies of Indiana bats occur as far north as MI, NY, and VT; as far south as AL, MO, NC, and TN; and as far west as IA. Although Indiana bat maternity colonies occur throughout much of the eastern United States (e.g., WV, VA, PA, NY), they appear to be relatively more abundant in the Midwest or more central portion of the range (i.e., IN, IL, southern IA, southern MI, and northern MO; USFWS 2004). Additionally, the more rugged, unglaciated portions of the Midwest (Ozarks/southern MO, parts of southern IL, and south-central IN) appear to have fewer maternity colonies per unit area of forest than the upper Midwest (USFWS 2007). Based on current records, the core Indiana bat summer range includes southern IA, northern MO, northern IL, northern IN, southern MI, and western OH.

Such regional differences in the relative abundance of maternity colonies may be attributed to the geographic distribution of important hibernacula and by regional differences in climate and elevation. During the summer, higher latitudes and elevations typically are cooler and wetter and temperatures are more variable, adding significantly to the cost of reproduction (Brack et al. 2002). Britzke et al. (2003) found that Indiana bat maternity colonies in western NC and TN were less frequently encountered in mountainous terrain and that the colonies encountered there were usually smaller in size.



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Legend:

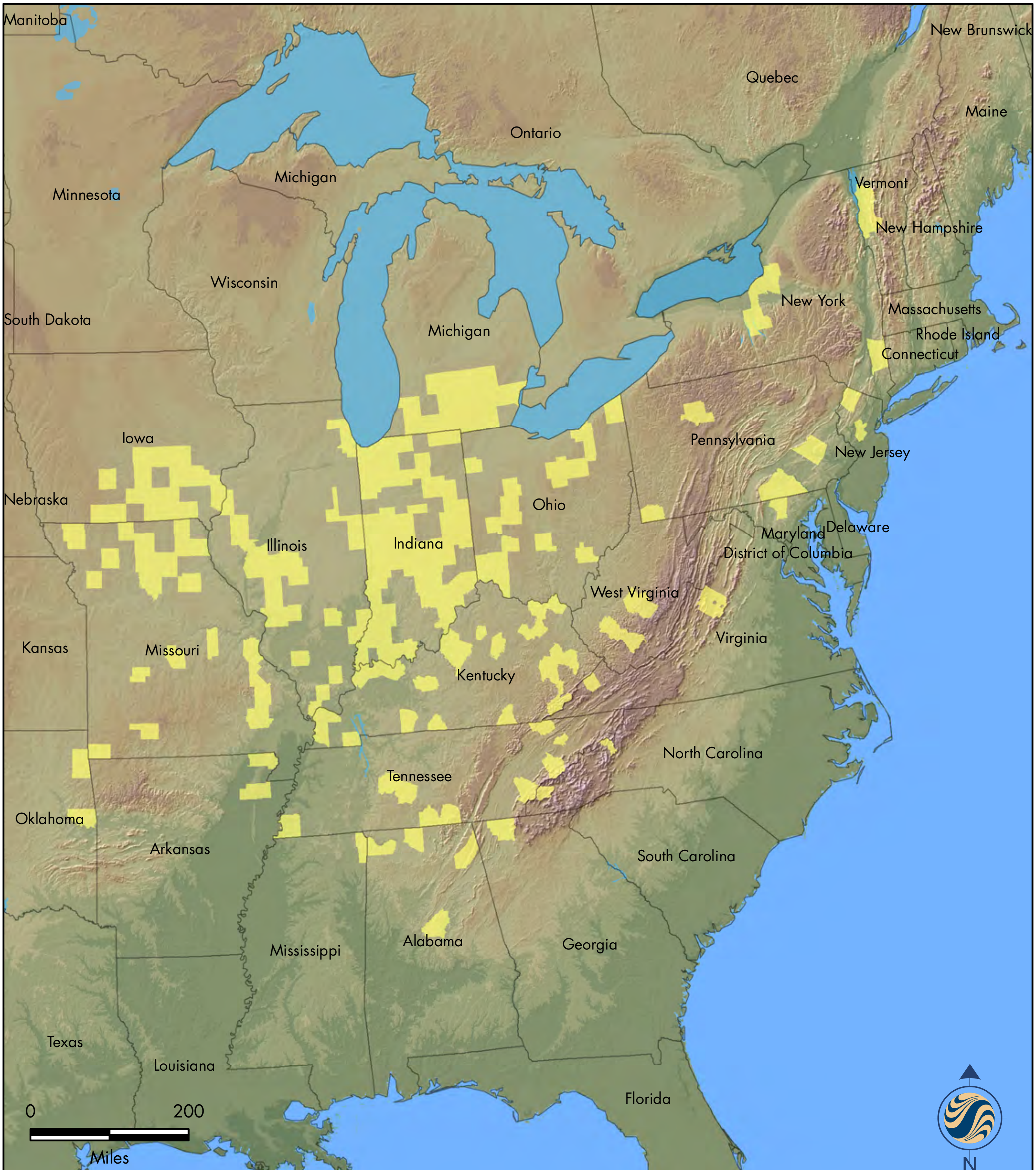
2009 Indiana Bat Population

- 1 - 100
- 101 - 2000
- 2001 - 10000
- 10001 - 20000
- 20001 - 57000
- 0

Source: A. King, USFWS, 2010

Figure: 4-3

INDIANA BAT
(Myotis sodalis)
WINTER 2009
COUNTY POPULATION



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Legend:

Indiana Bat Summer Records

Source: USFWS 2007, ODNR, and Butchkoski and Turner 2006, 2008

Figure: 4-4

INDIANA BAT
(Myotis sodalis)
SUMMER RECORDS

4.2.3 Distribution in Ohio

There is no Indiana bat critical habitat in OH. There are few known major hibernacula in the state for Indiana bats or other bats. The extant population of hibernating Indiana bats in OH is known from 2 underground mines: the Lewisburg Limestone Mine in Preble County (P2, the largest known Indiana bat hibernaculum in OH) and the Ironton Mine (P3) in Lawrence County. Four other hibernacula in 3 counties (Hocking, Brown, and Highland) have been designated as P4 (i.e., current or observed historic populations of fewer than 50 Indiana bats), but currently have no known hibernating Indiana bats[14] (USFWS 2007).

The closest known Indiana bat hibernaculum to the Action Area is the Lewisburg Limestone Mine, located approximately 100 km (62.5 mi) to the southwest. The 2007 Indiana bat winter population from the Lewisburg Limestone Mine and the Ironton Mine was estimated to be 7,629 individuals, a 21.9% decrease from the estimated 9,769 in 2005 (USFWS 2007). However, a February 2009 census of the Lewisburg Limestone Mine documented a winter population of 9,007 (Environmental Solutions and Innovations [ESI] 2009). The Lewisburg Limestone Mine is categorized as a P2 hibernaculum (i.e., population >1000 but <10,000) by the USFWS. The Lewisburg Limestone Mine also hosts hibernating populations of about 15,000 other non-federally listed bats; in addition to the Indiana bat, the 2009 census documented 13,799 little brown, 1,681 tri-colored, 356 northern long-eared, and 88 big brown bats, for a total census of 24,931 hibernating bats.

Data collected every 2 years since the Ironton Mine was discovered show annually fluctuating Indiana bat populations (e.g., winter counts were 276, 254, 224, 333, 208, and 150 Indiana bats recorded in 2011, 2009, 2007, 2005, 2003, and 1999, respectively) (A. King and M. Seymour, USFWS, personal communication).

Band return records indicate that Indiana bats that migrate through and/or summer in OH overwinter in hibernacula in southern states. Barbour and Davis (1969) reported that several Indiana bats banded at Bat Cave and Mammoth Cave in KY were recovered in west central OH. Indiana Bats migrating from KY and IN to southern MI may pass through OH on their northward migration, based on band recovery data summarized in Gardner and Cook (2002), Kurta and Murray (2002), and Winhold and Kurta (2006), as well as 3 unpublished band returns documented by A. Kurta (Eastern Michigan University, personal communication). These include records of 19 Indiana bats passing through OH (see further discussion and Figure 4-6 in Section 4.4.3 Migration).

More recently, 2 Indiana bats captured during summer mist-netting activities in Logan and Champaign Counties, OH, were recovered during hibernacula surveys in KY. One adult female banded in Logan County in 2008 was recaptured approximately 218 km (136 mi) southeast in Bat Cave in Carter Caves State Park, KY, during the following winter, and 1 adult female banded in Champaign County in summer 2009 was recaptured approximately 308 km (191 mi) southwest in Goochland Cave in the Daniel Boone National Forest, KY, during winter 2009-2010 (J. Kiser, Stantec, personal communication; K. Lott, ODNR, personal communication). A little brown bat that was captured during summer 2008 mist-netting surveys in Logan County was also found in a mixed-species cluster with Indiana bats during a winter 2009-2010 survey of Smoke Hole Cave, KY approximately 310 km (193 mi) southwest, also in the Daniel Boone National Forest, KY (J. Kiser, Stantec, personal communication; K. Lott, ODNR, personal communication).

[14] It is noted that a comprehensive survey of all possible hibernacula in OH has not been conducted. Additional Indiana bat hibernacula may exist.

Although the summer distribution of Indiana bats has historically been poorly documented, summer mist-netting efforts in recent years in OH related to pre-permitting activities for proposed wind power projects have resulted in a number of newly documented Indiana bat maternity colonies in previously undocumented portions of their summer range OH (M. Seymour, USFWS, personal communication). Indiana bat summer records in western OH were known from Greene, Montgomery, Miami, and Preble counties prior to 2008. Additional summer reproductive records were documented in Champaign, Hardin, and Logan counties, OH (hereafter "tri-county area"), in 2008 and 2009.

Based on data provided by the ODNR, 26 Indiana bats (24 adult females and 2 adult males) were captured in 2008 and 2009 during pre-construction mist-netting surveys for various proposed wind power projects (including this Project) along the Bellefontaine Ridge (Stantec 2008b, K. Lott, ODNR, personal communication). Of these 26 Indiana bats, 19 (17 females and 2 males) were radio-tagged and 17 (15 females and 2 males) were successfully tracked to 36 day-roost trees. Seven additional day-roost locations were estimated using triangulation, for a total of 43 day-roost locations. Home ranges could only be calculated for 12 of the 19 Indiana bats (11 female and 1 male), due to lost radio transmitters or lack of access to properties where the Indiana bats traveled or roosted. Using the minimum convex polygon (MCP) method (Mohr 1947), the average home range size was 1,256 ha ± 900 ha (3,104 ac ± 2,223 ac). The average sample size of radio telemetry locations used to estimate home range size was 94 locations ± 57 locations (range from 34 locations to 208 locations).

Seventy emergence counts (i.e., visual counts of the number of bats exiting a single roost tree for the night) were conducted at 27 of the identified roost trees between 1 June and 24 July in 2008 and 2009. Emergence counts on nights when at least 1 bat was observed emerging from the roost (n=65) averaged 17 bats ± 17 bats (range from 1 bat to 83 bats). While some of the emergence counts were conducted on the same night at multiple roost trees used by the same maternity colony, the majority were counts conducted at a single tree on a single night (K. Lott, ODNR, personal communication).

4.2.4 Distribution in the Action Area

Mist-netting surveys conducted for the Project in 2008 resulted in no Indiana bats captured in the Action Area (refer to Figure 1-2 for the Action Area boundary). Two reproductive females and 1 non-reproductive male were captured approximately 7.8 km (4.8 mi) to the north of the Action Area within the initial study area (Figure 1-2). Based on the results of the 2008 survey, the Project boundary was adjusted to avoid impacts to these Indiana bats (see Figure 1-2). Specifically the northern Project boundary was moved to the south so that it was at least 8 km (5 mi) from the closest Indiana bat capture. No part of the current Action Area is located within Logan County.

During mist-netting conducted for an unrelated wind development project in 2009 (that studied an area that was entirely within the Buckeye Wind Action Area), a total of 5 Indiana bats were captured in the Action Area. Due to the sensitive nature of data on ESA endangered species locations, the ODNR or USFWS were not able to provide raw data on the 5 Indiana bat captures in the Action Area, and therefore their roost or telemetry locations will not be provided in this HCP. However, pertinent data from those telemetry surveys were provided and included in the analysis for this HCP. The following paragraphs provide information that describes the locations of these Indiana bats within the Action Area based on information provided by the ODNR and USFWS.

One adult lactating female Indiana bat was captured in June 2009 in the central portion of the Action Area and flew 10.1 km (6.3 mi) southeast following her capture. Her roost tree was located approximately 2.3 km (1.5 mi) east of the Action Area, where her transmitter signal was subsequently lost. Five emergence counts were conducted at her roost tree with an average emergence count size of 32.6 bats ± 12.8 bats. No home range was calculated for this female due to an insufficient sample size of radio locations.

Three additional adult lactating female Indiana bats were captured and radio-tagged in late June 2009 at a single mist net site in a riparian woodlot in the northernmost portion of the Action Area. An additional Indiana bat at this net site escaped as it was being removed from the net; therefore, no data were collected for this individual. Radio telemetry data from the 3 female Indiana bats were used to generate home ranges. The combined MCP home range for these 3 females was 1,099.3 ha (2,716.5 ac). Ninety-three percent of the combined MCP (1,024.5 ha [2,531.6 ac]) was situated inside the Action Area, and the remaining 7% was north of the Action Area. The portion of the combined MCP that overlapped the Action Area occupied 3% of the total Action Area.

Radio telemetry was also used to track these 3 females to roost trees where emergence counts were conducted to estimate their maternity colony sizes. For the 3 Indiana bats, 3 roost trees were identified in the Action Area (not including 1 temporary roost that was used by 1 of the females during night of capture). All 3 Indiana bats used the same roost tree on 6 nights, which had an average emergence count size of 21.0 bats ± 12.9 bats and a maximum of 38 bats. Average emergence count sizes at the other 2 roost trees were 7.3 ± 3.6 (n = 4) and 2.3 ± 0.6 (n = 3).

The potential summer population of Indiana bats in the Action Area was estimated using data from the 3 Indiana bats radio tracked in the Action Area in 2009, as well as 7 adult female Indiana bats captured and radio-tagged in 2008 and 2009 during summer mist-netting surveys in the tri-county area[15]. Summer population estimates in the Action Area were based on 76 emergence counts[16] at 23 roost trees in the tri-county area, the home range sizes (estimated from nighttime telemetry) of the female Indiana bats using those roost trees, and the number of maternity colonies the Action Area could support.

Data from Indiana bats captured in the tri-county area in 2008 and 2009 were also used to model Indiana bat habitat suitability in the Action Area. A partitioned Mahalanobis D^2 model (Watrous et al. 2006, Meinke et al. 2009) based on 1,124 nighttime radio-locations and 43 roost locations from 12 radio-tagged Indiana bats was used to create a predictive habitat suitability model (refer to Appendix B for a detailed description of methods and results). Spatial characteristics of forest patches, habitat heterogeneity, slope, elevation, and distance to stream, wetland, and forested stream were measured in a GIS within a 2-km buffer (representing the average foraging distance) of each pixel in the Action Area. The distances (D^2) between the vector of environmental conditions measured at each pixel and the mean vector of environmental conditions at known Indiana bat roosting and foraging locations were rescaled using a Chi-square distribution, converted to probability values, and divided into 4 quartiles. These 4 quartiles, named Category 1, Category 2, Category 3, and Category 4, represented most to least suitable habitat.

Indiana bat foraging habitat suitability was strongly associated with the configuration and spatial relationships of forested patches; the 3 most important variables were the degree of forest fragmentation,

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[15] Although a total of 24 adult female and 2 male Indiana bats were captured in the tri-county area in 2008 and 2009, only 17 females and 2 males were radio tagged, only 12 females and 2 males were tracked to roost trees, and only 10 females had home range information and emergence count numbers sufficient to generate a summer population estimate.

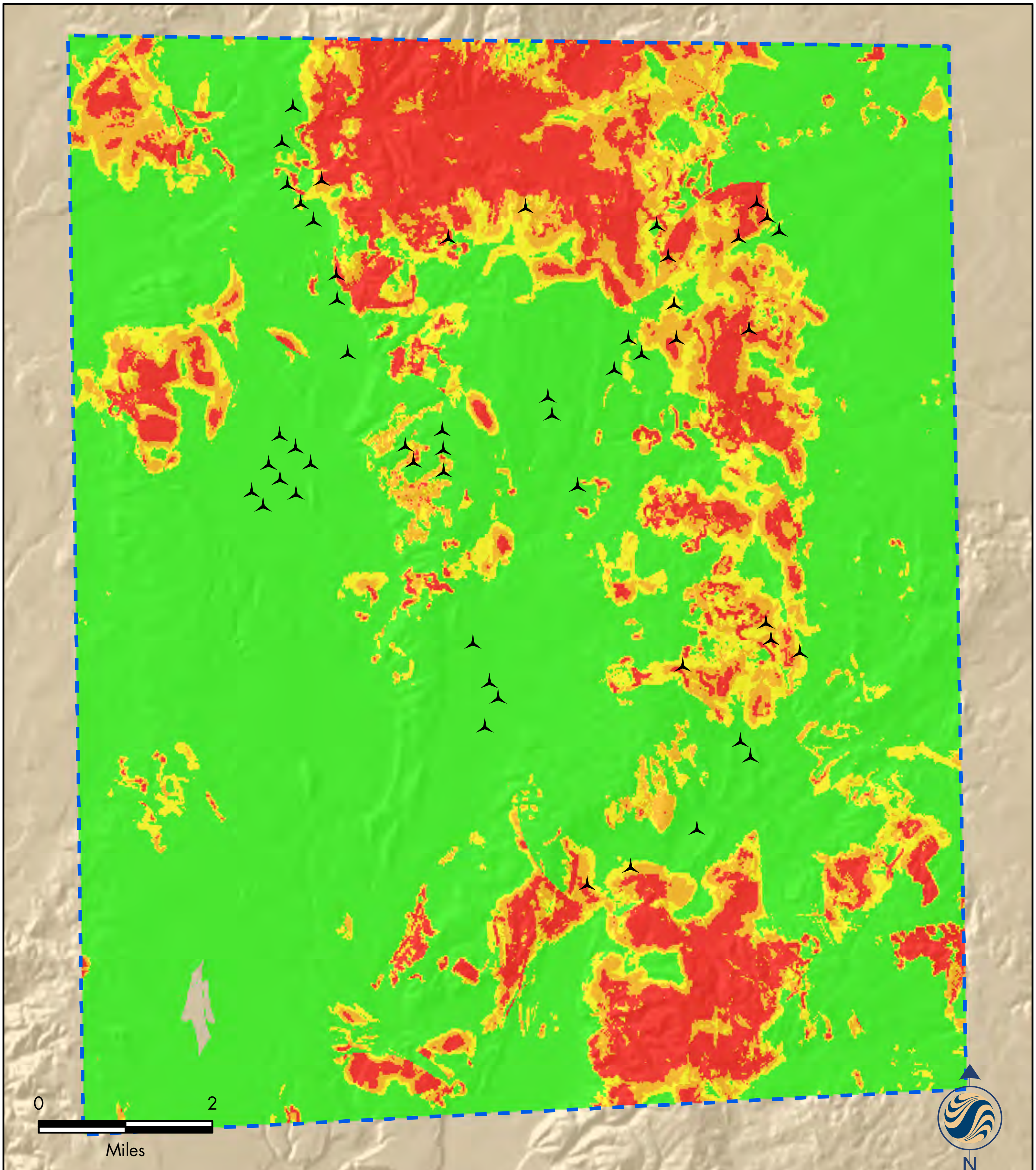
[16] This sample size was derived by treating observations of multiple radio-tagged females exiting the same roost tree as individual emergence counts.

the connectedness of forest patches, and the total core area of forested habitat. This differed from roosting habitat suitability, which was driven largely by distance to forested streams, distance to streams, and distance to the nearest forest edge. Twelve percent of the Action Area (4,016.1 ha [9,923.9 ac]) was categorized as having the highest suitability (i.e., Category 1) for Indiana bat roosting and foraging activities (Figure 4-5). When considering both foraging and roosting suitability, the spatial arrangement of forest patches, proximity to water sources, and amount of forested area were the most important habitat components. A full account of the assumptions, model inputs, analysis methods, and results contributing to the population size and habitat suitability estimates are presented in Appendix B.

The number of maternity colonies that the Action Area could support was estimated based on the amount of suitable habitat in the Action Area and the calculated home range sizes of Indiana bats in the tri-county area, following similar methods as those used in 2 recent USFWS BOs for Indiana bats (USFWS 2005a, 2005b). Even though active Indiana bat home ranges were only documented within the northernmost 3% of the Action Area, Indiana bats were assumed to have the potential to occur in suitable habitat throughout the Action Area to take the most conservative approach when estimating risk. Because portions of the Action Area are dominated by large expanses of agriculture or urban areas that are likely unsuitable for Indiana bat roosting and foraging activities, the amount of habitat considered suitable for Indiana bat roosting and foraging activities was reduced. Habitat in Categories 1, 2 and 3 were considered suitable for roosting, foraging, commuting and migrating (although Category 3 is 87% non-forested), and Category 4 was considered unsuitable for roosting and foraging (but suitable for migratory Indiana bat use). Categories 1, 2, and 3 habitats collectively comprised 9,847 ha (24,331 ac), which is equal to approximately 30% of the total Action Area size (see Appendix B for further detail).

Based on simultaneous emergence counts conducted at known Indiana bat roost trees within or near the Action Area, a minimum Indiana bat population size of 99 was documented in Summer 2009. Using a combination of these site-specific, empirical data, models predicting and quantifying suitable habitat within the Action Area and conservative assumptions based on relevant literature and professional judgment, and after increasing the estimated population by 8% to account for males (based on the proportion of males captured in mist-netting surveys in 2008 and 2009 in the tri-county area), the estimated mean summer Indiana bat population ranged from 10.1 to 2,271.4 Indiana bats. The range of estimated summer population size results from inherent uncertainty in estimating maternity colony size based on emergence counts and home range sizes. This inherent uncertainty was addressed using a probabilistic framework to represent uncertainty in model input (refer to Appendix A for a detailed description of methods and results). The results likely overestimate the actual number of Indiana bats using the Action Area during summer because the total home range area used by multiple Indiana bats from the same maternity colony was not available, and therefore individual home ranges were treated as approximations of total maternity colony home range size. Since the size of an area used by all members of a maternity colony is larger than that used by each individual colony member, this likely overestimated the number of maternity colonies the Action Area. However, this method allows for the highest numbers of maternity colonies to be present in the Action Area and provides some indication of the potential size of the local population of resident Indiana bats. This conservative approach was appropriate given the inherent uncertainty in estimating maternity colony size based on emergence counts and home range sizes.

Data from the 2008-2009 Indiana bat winter census (A. King, USFWS, personal communication) were used to estimate the number of Indiana bats likely to pass through the Action Area during spring and fall migration (i.e., the migratory population within the Action Area). Assumptions about the distances and directions of travel during migration were derived from literature, expert opinion, and band returns from Indiana bats captured in the Action Area (refer to Appendix A for a detailed description of methods). These data were used to estimate the numbers of Indiana bats likely to pass through the Action Area during migration, which ranged from approximately 2,900 Indiana bats to 5,800 Indiana bats.



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Legend:
Proposed Turbines
HCP Action Area
Foraging/Roosting Suitability
1 (Highest)
2
3
4 (Lowest)

Source: Stantec habitat suitability modeling based on data provided by ODNR

Figure: 4-5

INDIANA BAT
(Myotis Sodalis)
FINAL HABITAT
SUITABILITY MODEL

4.3 Demographics

Similar to most common bats of temperate regions, female Indiana bats give birth to 1 young each year (Mumford and Calvert 1960, Humphrey et al. 1977, Thomson 1982) and the birth rate of males to females appears to be essentially even (Hall 1962, Myers 1964, and LaVal and LaVal 1980). Many studies of common bats of temperate regions show that within a species, the proportion of breeding females may vary dramatically among populations and between years, and this variation is typically due to weather (e.g., amount of rainfall and temperature) (Racey and Entwistle 2000, Barclay et al. 2004). Based on captures of 63 adult female Indiana bats during mist-netting surveys in southern MI from 1978 to 2001, Kurta and Rice (2002) reported 89% of adult females were in reproductive condition (pregnant, lactating, or post-lactating). At a maternity colony in south-central IN, at least 93% and 82% of female Indiana bats during 2 consecutive years of study produced volant young (Humphrey et al. 1977).

Kurta and Rice (2002) reported that most births occurred in mid- to late-June, with lactation occurring throughout July and lasting 3 to 5 weeks, and pups becoming volant between early July and early August. The timing of reproductive events for Indiana bats in IN was essentially identical to that reported for females in southern MI (Humphrey et al. 1977), despite MI Indiana bats having longer migrations and cooler ambient temperatures (Kurta and Rice 2002). Age structure and survival rates among different life stages of Indiana bats are poorly understood due in part to the lack of accurate techniques for aging individuals (Anthony 1988, Batulevicius et al. 2001 as cited by USFWS 2007). Based on 1 season of observation of 1 maternity colony, Humphrey et al. (1977) estimated that neonatal mortality was 8%.

The only comprehensive estimates of Indiana bat demographic rates currently available were developed by Humphrey and Cope (1977) based on sampling of unknown-age Indiana bats over a 23-year period at hibernacula. These data suggested that although survival rates following weaning are unknown, the lowest survival occurred in the first year after banding. Humphrey and Cope (1977) also suggest a differential survival rate between the sexes as adults may occur. The authors hypothesized that there are 2 distinct survival phases of adult Indiana bats: 1) annual survival rates from 1 year to 6 years after banding were constant at approximately 75.9% and 69.9% for females and males, respectively; and 2) from 6 years to 10 years after banding, there was a lower, constant annual survival rate of 66.0% and 36.3% for females and males, respectively. Following 10 years, the survival rate for females dropped to only 4%; the authors suggested the lower rate may have been attributable to increased costs of migration and reproduction during old age, or due to sampling error, as a very small number of females remained alive after 10 years. However, Indiana bats have been known to live much longer, with the oldest known Indiana bat captured 20 years after it was first banded (LaVal and LaVal 1980).

More recently Boyles et al. (2007) reanalyzed a subset of the Humphrey and Cope (1977) data with a newer, more flexible, and less biased Cormack-Jolly-Seber model. The Boyles et al. (2007) estimate suggested that apparent survival is considerably higher than estimated by Humphrey and Cope (1977) the first year after banding and lower the second year after banding. Subsequent to the first 2 years after banding, survival estimates were similar, but slightly lower than those reported by Humphrey and Cope (1977). The authors caution, however, that their results, while useful, cannot be taken as true survival rates for Indiana bats because of limitations in the data.

4.4 Life History

In their 2007 Draft Recovery Plan, the USFWS (2007) provided an in-depth discussion of Indiana bat life history and a timeline for the annual chronology of significant life history events. The below sections will summarize this information and will include relevant additional or updated information on Indiana bat life history that has become available since the publication of the 2007 Draft Recovery Plan.

It should be noted that while the USFWS defines spring migration as occurring from 15 Mar to 15 May and fall migration from 15 Aug to 15 Oct in their 2007 Draft Recovery Plan, these dates are not static and can vary based on annual variability, weather conditions, location, or other factors. Given what is known about the geographic and annual variation in the exact timing of these activities, the USFWS has had recent internal discussions regarding the applicability of these dates across the range of the Indiana bat (M. Seymour, USFWS, personal communication). As such, in various places throughout this document descriptions of the annual chronology of Indiana bat life history may vary with respect to the exact timing of different events. Where appropriate, factors that influence this variability will be discussed.

4.4.1 Hibernation

As stated previously, Indiana bats overwinter in 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 have been shown to provide winter habitat throughout the range of the species (USFWS 2007). Depending on local weather conditions, Indiana bats enter hibernation from late September to early November, this timing may vary based on the sex of Indiana bats (males may enter hibernation later than females) and latitude where the site is located. Although most Indiana bats enter hibernation by the end of November (mid-Oct in northern areas; Kurta et al. 1997), populations of hibernating Indiana bats may increase throughout fall and into early January at some southern hibernacula (Clawson et al. 1980).

Scientific understanding of appropriate microclimates within Indiana bat hibernacula have changed over time. Historically, it was thought that ambient cave temperatures below 10° Celsius (C; 50°F) with occasional drops below freezing were suitable for Indiana bats (Hall 1962, Henshaw 1965, Humphrey 1978). More recently, Tuttle and Kennedy (2002) found mid-winter temperatures between 3°C and 7.2°C (37.4°F and 45°F) at major hibernacula where Indiana bat populations were stable or increasing, while populations roosting outside this range were unstable or had declined. Mid-winter temperatures at hibernacula containing the highest concentrations of Indiana bats ranged between 6°C and 7°C (42.8°F and 44.6°F) according to Brack et al. (2005). Regardless of which temperature range is most accurate, stable, low temperatures allow Indiana bats to maintain reduced metabolic rates and conserve fat reserves until spring, when outside temperatures increase and insects (food) are more abundant (Humphrey 1978, Richter et al. 1993). As with cave temperatures, relative humidity also influences hibernation site suitability for Indiana bats. According to Hall (1962), Humphrey (1978), and LaVal et al. (1976 as cited by USFWS 2007), humidity at roost sites during hibernation is usually above 74% but below saturation.

Cave configuration determines internal microclimates, with larger, more complex cave systems with multiple entrances more likely to provide suitable habitat for the Indiana bat (Richter et al. 1993, LaVal and LaVal 1980, Tuttle and Stevenson 1978). Most Indiana bats hibernate in caves or mines that tend to have large volumes, large rooms, and extensive vertical relief and passages, often below the lowest entrance. Cave volume and complexity help buffer the cave environment against rapid and extreme shifts in outside temperature, and vertical relief provides a range of temperatures and roost sites (USFWS 2007).

Indiana bats usually hibernate in large, dense clusters ranging from 300 Indiana bats per square foot (LaVal and LaVal 1980) to 484 Indiana bats per square foot (Clawson et al. 1980, Hicks and Novak 2002), although cluster densities as high as 500 Indiana bats per square foot have been recorded (Stihler 2005 as cited in USFWS 2007). While the Indiana bat characteristically forms large clusters, small clusters and single Indiana bats also occur (Hall 1962, Hicks and Novak 2002). It is not uncommon for Indiana bats to hibernate in mixed-species groups and they have commonly been observed clustered with little brown bats and other species (Myers 1964, LaVal and LaVal 1980, Kurta and Teramino 1994). Species observed clustering with the Indiana bat in the southern United States include the little brown bat, northern long-eared bat, eastern small-footed bat, and gray bat (J. Kiser, Stantec, personal communication).

4.4.2 Spring Staging and Emergence

During the later stage of hibernation, bats arouse more often and may move towards the entrance of the cave (USFWS 2007). In Barton Hill mine in NY in early April, Indiana bat clusters shifted roost sites as the bats moved toward a "staging area" near the entrance (A. Hicks, NYSDEC, personal communication 2002, as cited in USFWS 2007). Staging is defined as the departure of bats from hibernacula in the spring, including processes and behaviors that lead up to departure (USFWS 2007).

The period during which bats exit their hibernaculum is referred to as spring emergence. Female Indiana bats begin to exit hibernacula in late March to early April, followed by the males (Hall 1962, Cope and Humphrey 1977, LaVal and LaVal 1980). Timing of spring emergence may vary across their range and depending on latitude, annual weather conditions, health of emerging bats, sex of bats, weather conditions, and location of hibernacula. Spring emergence of bats having less body mass and stored energy reserves may occur earlier than healthier bats because they are driven by the need to replenish their fat reserves. However, most Indiana bats have left their hibernacula by late April (Hall 1962). Exit counts from several hibernacula in southern PA and Big Springs Cave in Tucker County, WV, suggest that peak emergence from hibernation is mid-April for these 2 areas (Butchkoski and Hassinger 2002; Rodrigue 2004, as cited in USFWS 2007). Spring surveys of the interior of Barton Hill Mine in NY documented substantial numbers of Indiana bats through April and into mid-May; however, by the end of May only one-tenth of the population remained (A. Hicks, NYSDEC, personal communication, as cited in USFWS 2007).

Bats may remain in close proximity to the hibernaculum for a short period of time, which is referred to as spring staging. Few studies have documented roost tree requirements during this time. In KY, Gumbert (2001) tracked 10 males and 3 females to roost trees during April and May 1998 and 1999. Shortleaf pine (*Pinus echinata*) was used most often during spring (and in all seasons, in fact), followed by mockernut hickory (*Carya tomentosa*) and shagbark hickory (*C. ovata*). Indiana bats used hickories and oaks in greater proportions, and pines in lower proportions, during the spring season than in summer and fall. Spring roost trees were of a slightly larger diameter than those used in summer and fall. Live trees were used in similar proportions in the spring and fall, whereas no live trees were used as roosts in the summer. All identified spring roost trees were within 4.47 km (2.78 mi) of the hibernaculum (mean = 1.99 km [1.24 mi]), and distances between roost trees and the hibernaculum were similar for the summer (mean = 1.86 km [1.16 mi]) and fall (mean = 1.87 km [1.16 mi]) seasons.

Spring emergence roosting refers to roosting behavior that occurs when Indiana bats exit hibernacula and head towards their summer habitat. The distribution of Indiana bats expands during the spring and summer when Indiana bats migrate from their hibernacula and travel to their summer ranges. Roosting may occur at multiple locations while Indiana bats are traveling between hibernacula and summer habitat, or Indiana bats may fly directly to summer habitat rarely stopping to roost along the way (Butchkoski and Turner 2006, Britzke et al. 2006, Hicks et al. 2005).

During the mid-spring period, female Indiana bats in the Lake Champlain Valley in VT and NY used live roost trees (primarily shagbark hickories) more commonly than previous research had shown, according to Britzke et al. (2006). Live trees may have been more heavily used because they provided more sheltered environments and thermal advantages over dead trees (Humphrey et al. 1977), which may have been particularly important during the unpredictable spring weather that characterizes the Lake Champlain

Valley (Britzke et al. 2006). Spring roost trees used in the Lake Champlain Valley were similar to those documented for summer roosting and include shagbark hickory, American elm, quaking aspen (*Populus tremuloides*), sugar maple (*Acer saccharum*), black locust (*Robinia pseudoacacia*), white ash (*Fraxinus americana*), American beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), red maple (*Acer rubrum*), and eastern hemlock (*Tsuga canadensis*). Currently, spring emergence roosting behavior and the types of roost trees used during this life history stage are not known for the midwestern and southern populations of Indiana bats.

4.4.3 Migration

4.4.3.1 Migration Distance and Duration

The distribution of Indiana bats expands during the spring and summer when bats migrate from their hibernacula and travel to their summer ranges. Indiana bats are considered migratory (LaVal and LaVal 1980) because they make seasonal movements between hibernacula and maternity roosts. However, their migratory distances are not comparable to the long-distance and cross-continental migratory movements made by foliage- and tree-roosting Lasiurine species (Griffin 1970, Fleming and Eby 2003). Migration distances vary greatly across the species' range, with documented migration distances greatest in the Midwest RU and least in the Northeast RU (Figure 4-6, Table 4-2). Twelve female Indiana bats from maternity colonies in MI migrated an average of 477 km (296 mi) to their hibernacula in IN and KY, with a maximum migration of 575 km (357 mi) (Winhold and Kurta 2006). Gardner and Cook (2002) also reported long-distance migrations for Indiana bats traveling between summer ranges and hibernacula. Shorter migration distances are also known to occur in the Midwest RU. Twenty-seven Indiana bats banded, during summer, at multiple locations in IN have subsequently been relocated in hibernacula (26 were in hibernacula in IN and 1 was in in KY)[17]. For these bats, the distance between summer capture locations and hibernacula ranged from 8 km to 209 km (5 mi to 130 mi); the average distance was 84 km (52 mi) (L. Pruitt, USFWS, personal communication). This is contrasted by relatively short migration distances documented in the Northeast RU; the maximum migration distances for 111 Indiana bats from NY and NJ caves or mines between 2001 and 2007 was 68 km (42 mi) (Figure 4-6, Table 4-2). Recent radio telemetry studies of 130 spring emerging Indiana bats (primarily females) from 6 NY hibernacula found that 75% of these bats were later detected and all migrated less than 68 km (42 mi) to their summer habitat (Butchkoski et al. 2008). Migration distances for Indiana bats in the Appalachian RU appear to be longer than those in the Northeast RU (maximum distance reported for an adult female to date is 173 km [107 mi; Butchkoski and Turner 2008]), but not as long as those in the Midwest RU (see migration distances reported for PA, MD, VA, and WV in Table 4-2). Few data are available to determine migration distances in the Ozark-Central RU.

Some male and non-reproductive female Indiana bats do not migrate as far as reproductive females and instead remain in the vicinity of their hibernaculum throughout the summer (Gardner and Cook 2002, Whitaker and Brack 2002). Mist-netting studies conducted from 1978 to 2002 in southern Michigan showed that only 11% of the adults captured were males (64 adult females, 8 adult males, and 15 juveniles; Kurta and Rice 2002).[18] Males captured in southern MI likely migrated over 400 km (249 mi) from hibernacula in southern IN and KY, based on several band return records for Indiana bats captured in this area (Kurta and Murray 2002).

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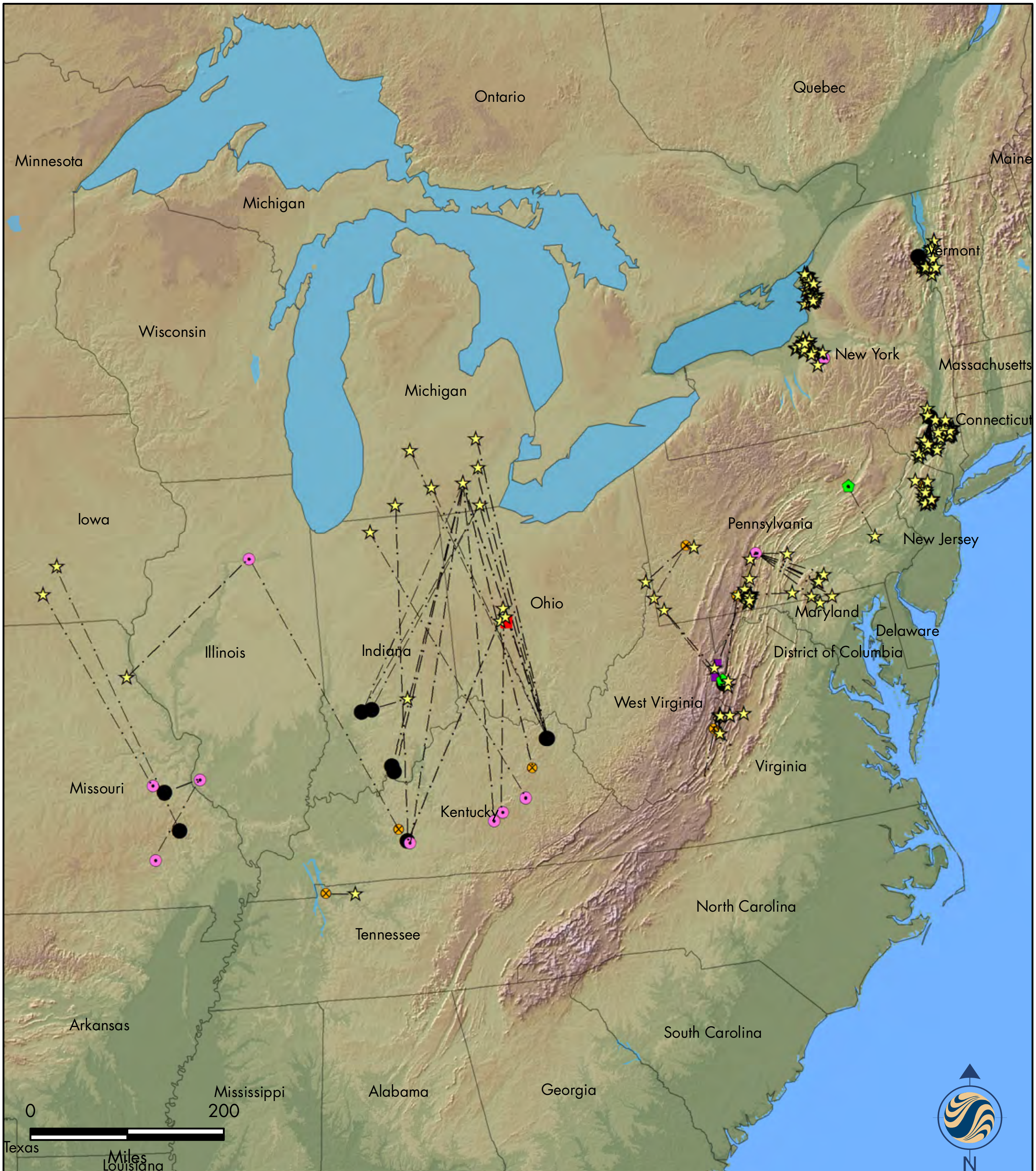
[17] These band returns are not displayed in Figure 4-6 due to lack of available information.

[18] However, the authors cautioned that 11% may have underestimated the proportion of adult males in the summer population because netting preferentially occurred near maternity roosts (Kurta et al. 1996, 2002) and male Indiana bats often do not roost with females during the maternity period (Gardner et al. 1991a).

Migration is an energetically expensive and risky undertaking (Fleming and Eby 2003), and bats may try to minimize the time spent in transit (Winhold and Kurta 2006). Spring radio telemetry studies have documented migrating Indiana bats traveling in relatively direct flight patterns towards their summer ranges shortly after they emerge from hibernacula (Butchkoski and Turner 2006, Britzke et al. 2006). According to Hicks et al. (2005), a comparison between the range of initial bearings and the final bearings for 82 reproductive female Indiana bats radio tracked to 65 maternity colonies in NY from 2000 to 2005 showed that Indiana bats followed more or less direct routes from the hibernacula to their summer ranges. Based on a combination of aerial and ground-based tracking, Indiana bats tracked from a hibernaculum in PA flew almost straight lines to their roost trees 135 km to 148 km (83 mi to 92 mi) away in MD (Butchkoski and Turner 2005).

The total time required for migration is a function of both flight speed and the amount of time spent migrating on a nightly basis, which is influenced by energetic constraints, among other factors. Winhold and Kurta (2006) estimated the time Indiana bats spent migrating between MI and the karst regions of IN and KY (average distance of 477 [296 mi]) and determined that the longest migrations documented for Indiana bats took approximately 3 days to 9 days. Thus, Indiana bats migrating the maximum recorded distance (i.e., 575 km) could complete the trip in only 7 days to 11 days, even when migrating for only 4 hours per night (Winhold and Kurta 2006).

Radio-tagged Indiana bats recently followed by aircraft during their spring migration in NY and PA usually maintained flight speeds between 13 kilometers per hour (km/hr) and 20 km/hr (8 mph and 12 mph), with 1 Indiana bat perhaps traveling at 24 km/h (15 mph; Butchkoski and Turner 2005; C. Herzog, in litt., as cited by Winhold and Kurta 2006). This is consistent with flight speeds measured for Indiana bats released in an open field (20 km/h [12.4 mph], Patterson and Hardin 1969) and close to the speed predicted for an 8 g bat using the allometric equation (Norberg and Rayner 1987 as cited by Winhold and Kurta 2006).



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Legend:

- Summer_Records
- HCP Action Area
- Approximate Migration Path
- Priority 1 Cave
- Priority 2 Cave
- Priority 3 Cave
- Priority 4 Cave
- Unknown Cave

Source: Multiple, refer to Table 4-2 in HCP

Figure: 4-6

INDIANA BAT

(Myotis sodalis)

MIGRATION RECORDS

1971 to 2010

Table 4-2. Records of migration distances (km) for Indiana bats (*Myotis sodalis*) by state and site from 1971 to 2010 (records are for adult females, unless otherwise noted).

State(s)	Site(s)	Max distance (km)	Record type[a]	Date banded or tagged	Date retrieved	Number successfully recovered or tracked[b]	Source
OH-TN	Greene County, OH to Fentress County, TN	426	BR	Summer 2007	Winter 2008	1 adult female	K. Lott, USFWS, personal communication
OH – OH	Pickaway County, OH to Lawrence County, OH	112	BR	Summer 2009-2010	Winter 2011	2	K. Schultes, Wayne National Forest, personal communication to A. Boyer, USFWS
OH-KY	Pickaway County, OH to Bat Cave, KY	153	BR	Summer 2010	Winter 2011	2 (1 juvenile male, 1 adult female)	K. Lott, USFWS, personal communication
OH- KY	Franklin County, OH to Bat Cave, KY	177	BR	Summer 2008	Winter 2011	2 (1 juvenile male, 1 adult male)	K. Lott, USFWS, personal communication
OH- KY	Pickaway County, OH to Saltpeter Cave, KY	153	BR	Summer 2010	Winter 2011	2 (1 adult male, 1 adult female)	K. Lott, USFWS, personal communication
OH-KY	Hamilton County, OH to Bat Cave, KY	172	BR	Summer 2008	Winter 2011	1	K. Lott, USFWS, personal communication
IN – IN, KY	Unknown	209	BR	Unknown	Unknown	27	L. Pruitt, USFWS, personal communication to M. Seymour, USFWS
KY-OH	Champaign County, OH to Bat Cave, KY	218	BR	Summer 2008	Winter 2008-2009	1	J. Kiser, Stantec, personal communication; K. Lott, ODNR, personal communication
KY-OH	Logan County, OH to Goochland Cave, KY	308	BR	Summer 2009	Winter 2009-2010	1	J. Kiser, Stantec personal communication; K. Lott, ODNR, personal communication

Table 4-2. Records of migration distances (km) for Indiana bats (*Myotis sodalis*) by state and site from 1971 to 2010 (records are for adult females, unless otherwise noted).

State(s)	Site(s)	Max distance (km)	Record type[a]	Date banded or tagged	Date retrieved	Number successfully recovered or tracked[b]	Source
MI-KY, IN	Eaton County, MI to Jug Hole, Cave Branch, Colossall, Waterfall, Batwing, Ray's, Bat	575	BR	Spring 2004	Winter 2004-2005	7	Winhold and Kurta 2006
MI-IN	Lenawee County, MI to Grotto Cave, IN	388	BR	Summer 2004	Winter 2006-2007	1 male (juvenile at summer site)	A. Kurta, Eastern Michigan University, personal communication
MI-IN	Lenawee County, MI to Ray's Cave, IN	399	BR	Summer 2006	Winter 2006-2007	1 female (juvenile at summer site)	A. Kurta, Eastern Michigan University, personal communication
MI-KY	Lenawee Co. MI to Saltpeter Cave, Carter County, KY	406	BR	Summer 2007	Fall 2009	1adult female	A. Kurta, Eastern Michigan University, personal communication
Multiple Midwest States	Multiple	520	BR	Multiple	Multiple	Unknown	Gardener and Cook 2002 (includes Bowles 1981, R.L. Clawson and J. E. Gardner unpubl. data, Kurta 1980, Kurta and Murray 2002, LaVal and LaVal 1980, Walley 1971)
NJ	Hibernia	29	RT	Spring 2006	NA	13 of 15	Chenger 2006
NY	Barton Hill	39	RT	Spring 2002	NA	19 of 24	Britzke et al. 2006; C. Herzog, NYSDEC, personal communication, movebank.org
NY	Glen Park	28	RT	Spring 2005	NA	2 males and 24 females total	C. Herzog, NYSDEC, personal communication, movebank.org, R. Niver USFWS, personal communication

Table 4-2. Records of migration distances (km) for Indiana bats (*Myotis sodalis*) by state and site from 1971 to 2010 (records are for adult females, unless otherwise noted).

State(s)	Site(s)	Max distance (km)	Record type[a]	Date banded or tagged	Date retrieved	Number successfully recovered or tracked[b]	Source
NY	Jamesville	52	RT	Spring 2006	NA	11 of 16	C. Herzog, NYSDEC, personal communication, movebank.org
NY	Williams Complex	56	RT	Spring 2001	NA	0[b] of 4	Sanders and Chenger 2001
NY	Williams Complex	68	RT	Spring 2004, 2005, 2007	NA	42 of 60	C. Herzog, NYSDEC, personal, communication, movebank.org
PA	Glen Lyon Mine	117	RT	Spring 2006	NA	1	Butchkoski and Turner 2006
PA	Hartman Mine/Canoe Creek	55	RT	Spring 2003	NA	1[b]	Chenger 2003
PA	Hartman Mine/Canoe Creek	76	RT	Spring 2008	NA	4 of 6	Butchkoski and Turner 2008
PA MD	Hartman Mine/Canoe Creek PA to MD	148	RT	Spring 2005	NA	5[b] of 6	Butchkoski and Turner 2005
PA	Long Run Mine	96	RT	Spring 2007	NA	4[b] of 6	C. Butchkoski, PGC, personal communication
PA	Long Run Mine	89	RT	Spring 2010	NA	2[b]	C. Butchkoski, PGC, personal communication
PA	South Penn/Allegany Tunnel	97	RT	Spring 2000	NA	3[b] of 4	Sanders and Chenger 2000
PA	South Penn/Allegany Tunnel	32	RT	Spring 2007	NA	15	J. Chenger, BCM, personal communication, Butchkoski and Turner 2008
PA WV	Greene County, PA to Randolph County, WV Cave	141	BR	Summer 2007	Winter 2007-2008	1	Butchkoski and Turner 2008

Table 4-2. Records of migration distances (km) for Indiana bats (*Myotis sodalis*) by state and site from 1971 to 2010 (records are for adult females, unless otherwise noted).

State(s)	Site(s)	Max distance (km)	Record type[a]	Date banded or tagged	Date retrieved	Number successfully recovered or tracked[b]	Source
PA WV	Greene County, PA to Cliff Cave, WV	173	BR	Summer 2007, 2008	Spring 2009	1	Butchkoski 2009
PA WV	South Penn/Allegany Tunnel, PA to Hellhole Cave, WV	138	BR	Spring 2007	Winter 2009-2010	1 male	J. Chenger, BCM, personal communication; C. Stihler, WVDNR, personal communication; C. Butchkoski, PGC, personal communication
PA WV	Hartman Mine/Canoe Creek, PA to Hellhole Cave, WV	214	BR	Fall 2007	Winter 2009-2010	1 male	J. Chenger, BCM, personal communication; C. Stihler, WVDNR, personal communication; C. Butchkoski, PGC, personal communication
VA	Clarks and Star Chapel Caves	80	RT	Spring 2005	NA	12[b] of 13	McShea and Lessig 2005
WV	Pendleton and Tucker Counties WV to Hellhole	32	BR	Summer 2009	Winter 2009-2010	7	C. Stihler, WVDNR, personal communication

[a] Record type: BR = band return and RT = radio telemetry study.

[b] Indicates that at least 1 bat was only partially tracked and lost before the presumed summer range could be confirmed.

4.4.3.2 Migration Direction and Behavior

There is some evidence that Indiana bats in the Appalachian RU and Northeast RU follow landscape features while migrating. Based on observations of 22 Indiana bats tracked during spring telemetry studies in PA from 2000 to 2006, bats appeared to go out of their way to follow tree lines, including riparian buffers along streams through otherwise developed areas, and avoided open areas (Turner 2006). Similarly, 12 Indiana bats tracked in western VA during spring migration generally followed ridges in the area, which run northeast-southwest, with only 1 bat flying east (i.e., into the Shenandoah Valley) and none flying west (i.e., over the higher mountain ridges into WV), suggesting that Indiana bats were using these corridors as migration flyways (McShea and Lessig 2005). J. Chenger (Bat Conservation and Management [BCM], personal communication) also reported that several Indiana bats tracked during spring migration from the South Penn Tunnel in south central PA appeared to be moving along U.S. Route 220, also known as the Appalachian Throughway, which follows a generally northeast-southwest direction in line with the Appalachian Mountains. Indiana bats radio tracked from the Jamesville Quarry Cave near the city of Syracuse, NY avoided the urban area and flew around the city rather than over it while migrating to their summer ranges (C. Herzog, NYSDEC, personal communication).

Indiana bats in the Midwest RU, where the Project is located, appear to primarily migrate from hibernacula in KY and IN to summer ranges to the north based on band recovery information (Gardner and Cook 2002, Whitaker and Brack 2002, Winhold and Kurta 2006; Figure 4-6). Band recovery data for Indiana bats captured in OH are consistent with this migration pattern (Barbour and Davis 1969; J. Kiser, Stantec, personal communication; K. Lott, ODNR, personal communication). However, the south to north spring migration trend is not evident in the Northeast or Appalachian RU, where Indiana bats in spring emergence telemetry studies have been documented fanning out in many directions to summer ranges that are in relatively close proximity to hibernacula (Table 4-2, Figure 4-6). Any assumptions about migration behavior for Indiana bats in the Ozark-Central RU would be difficult to make given the lack of migration data for that geographic region.

Despite the lack of consistency in migration data across Indiana bat RUs, limited genetics data seem fairly consistent with the patterns of movement that have been documented across geographic areas. Genetic samples (mtDNA) extracted from wing membrane punches collected from hibernating Indiana bats from 13 widely dispersed hibernacula were found to have genetic variance among samples. This was best explained by dividing sampled hibernacula into 4 separately defined population groups, as follows:

- Midwest included sampled populations in AR, MO, IN, KY, OH, Cumberland Gap, Saltpeter Cave in southwestern VA, and Jamesville Quarry Cave in Onondaga County, NY;
- Appalachia included White Oak Blowhole Cave in east TN, and Hellhole Cave in WV;
- Northeast 1 (NE1) included Barton Hill Mine and Glen Park Caves in northern NY (Essex and Jefferson Counties, respectively); and
- Northeast 2 (NE2) included Walter Williams Preserve Mine in Ulster County, NY (M. Vonhof, Western Michigan University, personal communication as cited by USFWS 2007).

While there was some level of male- and/or female-mediated gene flow occurring among 3 of the 4 defined groups (Midwest, Appalachia, and NE2), there was no apparent gene flow for either sex between the NE1 group and the other groups. These findings indicate that genetic bottlenecks in NE1 and NE2 may be the result of relatively recent colonization of the Northeast within historical times (estimated at 153 years before present for NE1) by a small number of individuals (USFWS 2007). This is also consistent with Hall's (1962) taxonomic studies of over 1,000 museum specimens collected from throughout the Indiana bat's range, which documented noticeable variation in morphometric and pelage characteristics in the northeast population. Hall concluded that "the establishment of populational ranges restricts gene flow within the species" and that "this apparently has not been in effect long enough to allow race differentiation to occur."

4.4.4 Summer Life History

4.4.4.1 Maternity Roosts

Female Indiana bats are pregnant when they arrive at their maternity roosts as early as April and as late as early May (Humphrey et al. 1977, Kurta and Rice 2002). Reproductive females occupy roost sites under the exfoliating bark of dead, dying, or live trees, and occasionally in narrow cracks of trees located in both upland and riparian forest (Gardner et al. 1991a, Callahan 1993, Kurta et al. 1993, Kurta et al. 2002, Carter 2003, Britzke et al. 2006). However, some reproductive females have been found in artificial roost sites. Ritzi et al. (2005) found adult females in a utility pole crevice and bird-house style bat boxes in IN. A rocket-style bat box was used by a group of females after the reproductive period in IL (Carter et al. 2001). Indiana bats in PA have been documented using a large artificial bat house (the "bat condo"), and various bat boxes and artificial roosts (Butchkoski and Turner 2006). Maternity colonies have also been found in buildings, including an abandoned church and nearby garage in PA (Butchkoski and Hassinger 2002), 2 houses in NY (USFWS 2007), and a barn in IA (Chenger 2003). In comparison, more than 400 roost trees have been documented for female Indiana bats (USFWS 2007).

Roost trees used by female Indiana bats have been described as either primary or alternate, depending on the number of bats that are consistently occupying the roost site (Kurta et al. 1996, Callahan et al. 1997, Kurta et al. 2002). In MO, Callahan (1993) defined primary roost trees as those with bat exit counts of more than 30 bats on more than 1 occasion; however, this number may not be applicable to small-to-moderate sized maternity colonies (Kurta et al. 1996).

Primary roosts usually receive direct solar radiation for more than half the day and are almost always located in either open canopy sites or above the canopy of adjacent trees (Kurta et al. 1996; Callahan et al. 1997; Kurta et al. 2002; J. Kiser, Stantec, personal communication). Primary roosts are usually not located in densely forested areas, but rather occur along forest edges or within gaps in forest stands (USFWS 2007).

Alternate roost trees can occur in either open or closed canopy habitats. Indiana bats from the same maternity colony may use between 10 trees and 20 trees throughout the summer, but usually only 1 to 3 of these are considered primary roosts where the majority of bats roost for part or all of the summer (Callahan 1993, Callahan et al. 1997). Alternate roost trees are typically used by individuals or small groups for only 1 day or a few days. Indiana bats typically switch roosts every 2 to 3 days, with the frequency of switching affected by reproductive condition of the female, roost type, weather conditions, and time of the year (Kurta et al. 2002, Kurta 2005). Indiana bats have shown site fidelity to summer roosting areas, individual roost trees (if they remain suitable), travel corridors, and foraging areas (Garner and Gardner 1992, Kurta et al. 2002, Winhold et al. 2005).

Maternity colonies typically contain 25 Indiana bats to 100 Indiana bats, but as many as 384 individuals have been documented emerging from a roost tree (Kiser et al. 2002). Recent studies at 1 of the large (>300 bats) colonies in IN found evidence that Indiana bats and little brown bats will share roost trees, so determining exact number of any species at a roost is nearly impossible (T. Carter, Ball State University, personal communication). Over 33 species of trees have been documented to be used as maternity roosts, but 87% of these are ash (*Fraxinus spp.*), elm (*Ulmus spp.*), hickory (*Carya spp.*), maple (*Acer spp.*), poplar (*Populus spp.*), and oak (*Quercus spp.*) (Murray and Kurta 2004). Most trees used by reproductive females are deciduous, but hemlock (*Tsuga* spp.) and pitch pine (*Pinus rigida*) have been used in western NC and eastern TN, and white pine has been used in VT (Britzke et al. 2003; Watrous et al. 2006; J. Kiser, Stantec, personal communication).

Although roost trees are ephemeral, they are reused from year to year as long as they continue to provide conditions necessary for females to raise their young. Roost trees are often damaged during severe weather events (e.g., by being blown over or by having bark blown off), but it appears Indiana bats can adapt to such situations by relocating to other suitable roost trees quickly. Some researchers believe that frequent roost switching behavior serves the purpose of keeping bats familiar with the locations of other suitable roost trees in the event that preferred roosts are damaged, parasite loads become heavy, and/or competition for roosting areas becomes prohibitive (Ritzi et al. 2005, Willis and Brigham 2004, Barclay and Kurta 2007).

Roost trees used by Indiana bats vary in size. The minimum tree size (diameter at breast height [dbh]) reported for a male roost is 6.4 cm (2.5 in; Gumbert 2001) and 11 cm (4.3 in) for a female roost (Britzke 2003). Primary maternity roosts are always found in larger diameter trees, usually more than 22 cm (8.7 in) dbh (Murray and Kurta 2004). Larger diameter trees provide thermal advantages to reproductive females and their pups by giving them more room to move around while locating appropriate temperatures.

4.4.4.2 Foraging and Traveling Behavior

Numerous foraging habitat studies have been completed for the Indiana bat throughout much of the species range. These studies have found Indiana bats forage in closed to semi-open forested habitats and forest edges located in floodplains, riparian areas, lowlands, and uplands (Humphrey et al. 1977, LaVal et al. 1977, Brack 1983, Gardner et al. 1991b, Garner and Gardner 1992, Butchkoski and Hassinger 2002, Romme´ et al. 2002, Murray and Kurta 2004, Sparks et al. 2005*a*). Indiana bats typically emerge from roosts between 19 minutes and 71 minutes after sunset to begin nightly foraging bouts (Brack 1983, Viele et al. 2002, Sparks et al. 2005*a*).

Indiana bats may fly linear distances between 0.5 km and 8.4 km (0.3 mi and 5.2 mi) while traveling from their roost trees to foraging areas, but most distances are about half the maximum, or approximately 4.0 km (2.5 mi) (Murray and Kurta 2004, Sparks et al. 2005*a*). For 21 radio-tagged Indiana bats captured in and around the Action Area in 2008 and 2009, the average distance between roost trees and telemetry points was 1.1 km ± 0.9 km (0.7 mi ± 0.5 mi), and the maximum distance was 5.6 km (3.5 mi) (K. Lott, ODNR, personal communication). This was similar to the average distance of 1.0 km (0.6 mi) traveled between roost trees and the geometric centers of foraging areas for 5 adult female post-lactating Indiana bats tracked over 16 nights in IL (Garner and Gardner 1992). The average distance in the same IL study for 14 Indiana bats, including pregnant, lactating, and post-lactating females, males, and juveniles, was 2.3 km (1.4 mi).

Differences in commuting distances between summer foraging and roosting areas may be attributed to rangewide differences in habitat type, interspecific competition, and landscape terrain (USFWS 2007). Because Indiana bats typically do not cross large, open areas and instead follow tree lines or other habitat features that provide protective cover, Indiana bats may have to travel further distances in areas where connectivity of suitable habitat is limited. For example, Murray and Kurta (2004) found that Indiana bats increased their commuting distance by 55% to follow tree-lined paths rather than fly over large agricultural fields, some of which were at least 1 km (0.6 mi) wide. Further studies by Kurta (2005) and Winhold et al. (2005) found that for at least 9 years, this colony used the same wooded fenceline as a commuting corridor that connected forested areas situated in a largely agricultural area. Similarly, in a study area where over 60% of the landscape was either agricultural fields or urbanized areas, 12 of 13 foraging sites used by a colony were dominated by forest (Kurta et al. 2002).

Carter (2003) found that Indiana bat roost selection in southern IL in a large, open swamp was dependent on roost tree proximity to the forest edge near a dead tree zone created by the high water level. Indiana bats rarely used trees more than 50 m (164 ft) from the forest edge. Once Indiana bats emerged at dusk, they flew directly into the forest and were not seen flying in the more open portion of the swamp. Indiana bats have also been documented using protective cover along linear features not associated with tree cover, such as treeless channelized ditches (USFWS 2007).

Two radio telemetry studies in IL and IN assessed the types of habitats used by adult females while foraging compared to available habitat. Floodplain forest was the most preferred habitat in IL (Gardner et al. 1991b, Garner and Gardner 1992), and woodlots were used more often than other available habitats in IN (Sparks 2003; Sparks et al. 2005*a*, 2005*b*). Although it was difficult to document due to the errors inherent in conducting radio telemetry on a rapidly moving species, it appeared that Indiana bats likely were foraging most often along forest-field edges rather than over open fields when they used open habitats (Sparks et al. 2005*b*). While visual observations suggest that foraging over open fields or bodies of water more than 50 m (150 ft) from a forest edge did occur, it appeared to be less common than foraging within forested sites or along edges (Brack 1983, Menzel et al. 2001).

These findings are consistent with data collected within and in the vicinity of the Action Area. Stantec compiled data provided by the ODNR from 12 (11 females and 1 males) radio-tagged Indiana bats that were captured in 2008 and 2009 during mist-netting surveys in Champaign, Logan, and Hardin counties. Forty-three roost trees and 1,124 night time telemetry locations were documented for these 12 Indiana bats. Figure 4-7 shows the distance from each telemetry location to the edge of forested habitat (defined by all pixels classified as either deciduous, mixed, or conifer forest in the 2001 NLCD) (Homer et al. 2004). When the NLCD data layer was compared to a 2009 aerial photo (USDA National Agriculture Imagery 2010), the forest habitat classified by the NLCD included sizeable forested stands, fragmented small forested patches, as well as some streamside vegetation and hedgerows. The average distance from telemetry locations to a forested edge was 60 m ± 110 m (198 ft ± 361 ft), and 85% of telemetry locations were less than 170 m (559 ft; mean ± 1 SD) of a forest edge. All 1,124 telemetry locations were within 701 m (2,300 ft) of a forest edge.

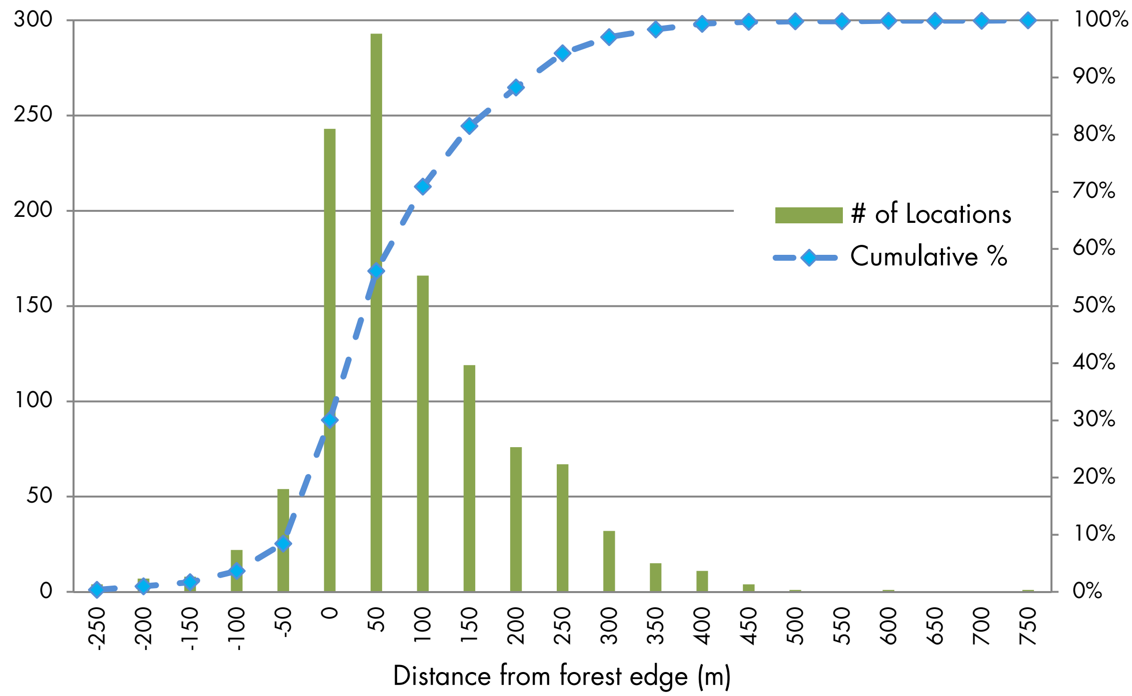

Figure 4-7. Distance from 1,124 nighttime telemetry locations from 11 female and 1 male Indiana bats captured in 2008 and 2009 during mist-netting surveys in Champaign, Logan, and Hardin counties, OH, to the edge of forested habitat (defined by all pixels classified as either deciduous, mixed, or conifer forest in the 2001 NLCD; Homer et al. 2004; 30 m resolution).

Previous studies have reported that Indiana bats typically fly between 2 m and 30 m (6 ft to 100 ft.) agl while foraging (Humphrey et al. 1977, Brack 1983, Gardner et al. 1989). Brack (1983) observed Indiana bats foraging around the crowns of scattered large trees in otherwise open habitats. Similarly, J. Kiser (Stantec, personal communication) also observed a female Indiana bat for approximately 20 min foraging along the edge of a dense forest and around the crowns of isolated trees with a maximum height of 15 m (49 ft) in and adjacent to a golf course in Jefferson County, NY.

This is also consistent with unpublished data collected by Stantec during acoustic bat surveys conducted for proposed wind power projects using Anabat detectors (Titley Electronics Pty Ltd.). Anabat detectors are frequency division detectors that divide the frequency of ultrasonic calls made by bats by a factor of 16 so that they are audible to humans, which are then recorded for subsequent analysis. The number of *Myotis* call sequences recorded during acoustic surveys at 19 proposed wind power projects using 96 detectors in 6 states (ME, NH, NY, OH [including the Action Area], VT, and WV) from 2005 to 2009 are presented in Figure 4-8. SAS procedure REG (SAS Institute Inc., Cary, North Carolina) was used to generate a least squares regression line based on 34,030 *Myotis* call sequences recorded at detectors deployed between 2 m to 50 m (7 ft to 164 ft) agl. Seasons were defined as spring 1 April to 31 May; summer 1 June to 31 July; and fall 1 August to 31 October.

Results indicated that, for every 1-m increase in detector height, activity rate (number of files recorded per detector per night) decreased by 0.44 (*Myotis* call per detector night). *Myotis* activity at 50 m (164 ft) was approximately 3% of activity at 2 m (7ft; Figure 4-8). There was no significant difference in vertical trends in activity between spring, summer, and fall, so data were pooled across seasons. Although *Myotis* calls were not identified to species, it may be reasonable to assume that the observed pattern is representative of

Indiana bat activity patterns. These data indicate that the vast majority of observed *Myotis* activity occurred below the lowest extent of the rotor-swept zone of Project turbines (i.e., 50 m); it should be noted that acoustic activity was not sampled above this height, so the activity patterns within the rotor-swept zone are not known.

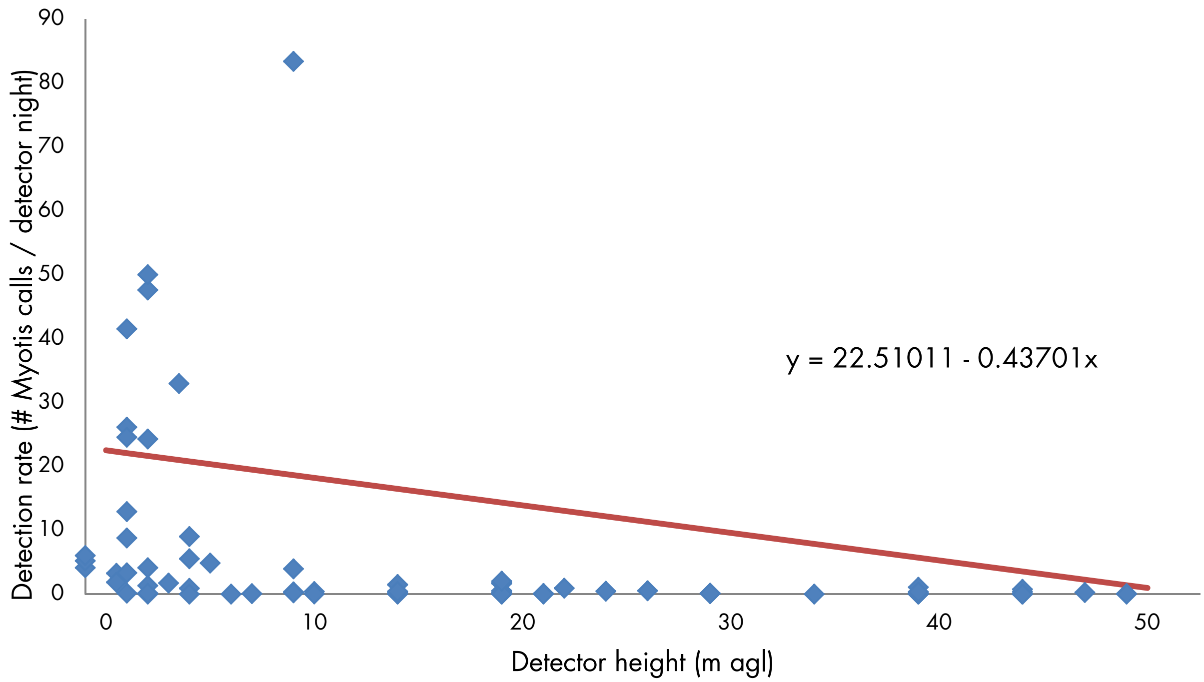

Figure 4-8. Detection rate (number of call sequences recorded per detector-night) for *Myotis* from acoustic data collected by Stantec at 19 proposed wind power projects (96 Anabat detectors) in 6 states (ME, NH, NY, OH [including the Action Area], VT, and WV) from 2005 to 2009.

Indiana bats are opportunistic foragers, feeding on a variety of small insects. The diet of Indiana bats varies depending upon habitat, geographic location, season, sex, and age of the foraging bat (Belwood 1979, Brack and LaVal 1985, Kurta and Whitaker 1998). Some geographic variations in diet have been noted, with Indiana bats from southern portions of the range consuming more terrestrial-based insects (Lepidoptera [moths] and Coleoptera [beetles]), while those from the northern localities prefer aquatic-based insects (Diptera [flies] and Trichoptera [caddisflies]) (USFWS 2007). Variations in diets of Indiana bats may occur from year to year within the same colony, and Indiana bats may take advantage or be "selectively opportunistic" when other types of insects are plentiful (Murray and Kurta 2002).

Nightly foraging activity is usually interrupted by periods of rest, referred to as night roosting. Most Indiana bats use trees as night roosts (Butchkoski and Hassinger 2002, Murray and Kurta 2004), although they occasionally utilize artificial roosts or "bat boxes" (Butchkoski and Hassinger 2002), concrete bridges (Kiser et al. 2002), or other structures. Night roosts are thought to provide Indiana bats a resting place between foraging bouts, promote digestion and energy conservation, provide retreats from predators and inclement weather, provide places to ingest food transported from nearby feeding areas, function as feeding perches for sit-and-wait predators, and serve as places to promote social interactions and information transfer (Ormsbee et al. 2007).

4.4.5 Home Range

Indiana bats are thought to occupy distinct home ranges (Garner and Gardner 1992), or areas in which they engage in several important behaviors such as foraging, commuting, night-roosting, and drinking. Relatively few studies have described home ranges for Indiana bats and have often based home range estimates on a small number of individuals. Given the challenges of tracking a rapidly moving animal over large geographic areas, it is difficult to estimate home range. Further limiting the value of home range estimates is the fact that different methods of home range estimation (i.e., MCP, adaptive or fixed kernel methods) can affect the size and shape of estimated home ranges, limiting comparability among studies (Lacki et al. 2007). Despite these limitations, home range estimates can provide meaningful information about how bats are using available habitat.

Home range size varies between the sexes and with varying reproductive status of females (Lacki et al. 2007). The average home range size for 1 adult male and 11 adult female Indiana bats captured in 2008 and 2009 in the tri-county area (1,256 ha ± 900 ha [3,104 ac ± 2,223 ac]) was substantially larger than other home range estimates that have been reported for Indiana bats at both hibernacula and summer roosting areas (Table 4-3). This difference is likely at least partially attributable to the use of differing methods to estimate home range, which can have a large impact on estimated size (Worton 1989, Burgman and Fox 2003, Lacki et al. 2007); therefore, variation in home range sizes reported among different studies should be interpreted with care. Differences may also be attributable to dissimilarity in habitat type, landscape configuration, and availability of resources among the various study areas; due to the differences among estimates in terms of including only males, females, or both sexes; or due to differences in seasonal timing of data collection (e.g., some described home ranges during fall swarming).

Table 4-3. Estimates of home range size (ha and ac) for Indiana bats (*Myotis sodalis*) by state and method of home range estimator.

State	Home range size				Home range estimator	Number of bats	Source
	Hectares		Acres				
	Mean	SD or SE	Mean	SD or SE			
Kentucky	156	101[a]	385	250[a]	MCP	15	Kiser and Elliot 1996
Virginia	361	78[b]	892	193[b]	MCP	11	Brack 2006
Illinois	145	18[c]	358	44[c]	Kernel	11	Menzel et al. 2005
Missouri	667	994[b]	1,648	2,456[b]	MCP	9	Rommé et al. 2002
Indiana	335	66[c]	828	163[c]	Kernel	11	Sparks et al. 2005a
Vermont	83	82[b]	205	203[b]	Kernel	14	Watrous et al. 2006

[a] unknown
[b] standard deviation
[c] standard error

4.4.6 Fall Swarming and Roosting

Indiana bats start arriving at hibernacula during late August and fly around the entrances in an attempt to find mates, a phenomenon referred to as "swarming," typically a multi-species event (Cope and Humphrey 1977). Male Indiana bats typically remain active longer during autumn than do females. Once arriving at hibernacula, females may only remain active for a few days, whereas males remain active, seeking mates into late October and early November (with exact timing varying with latitude and annual weather conditions).

Fall roosting occurs in conjunction with swarming activities of the Indiana bat and usually occurs outside of the hibernaculum during this period (i.e., bats will day roost in trees and fly to their hibernaculum at night). However, clusters of active Indiana bats have been observed in caves at night roosting during swarming events (Gumbert et al. 2002). The maximum distance between identified roost trees and associated hibernacula varies among telemetry studies conducted during the fall roosting and swarming season. At 2 small P3 hibernacula in KY, Indiana bats roosted primarily in dead trees on solar exposed upper slopes and ridgetops within 2.4 km and 4.1 km (1.5 mi and 2.5 mi) of the cave entrances (Kiser and Elliott 1996, Gumbert 2001). In MI, Kurta (2000) tracked 2 male Indiana bats to roost trees located 2.2 km and 3.4 km (1.4 mi and 2.1 mi) from a P4 hibernaculum. In VA, all roost trees identified from 8 male and 3 female Indiana bats were within 1.4 km (0.6 mi) of a P3 hibernaculum, though the author noted that bats traveling outside of the study area (defined as the north side of a 3.2 km circle, centered on the hibernaculum) were not able to be located (Brack 2006). In PA, a male Indiana bat twice traveled 14 km (9 mi) from the hibernaculum where it was captured (USFWS 2007). In MO, radiotagged individuals traveled maximum distances of 6.4 km (4.0 mi) away from the nearby hibernaculum (Rommé et al. 2002). During telemetry studies outside Wyandotte Cave in IN, 2 females were relocated 30.7 km (19.1 mi) away from the cave (Hawkins et al. 2005, USFWS 2007).

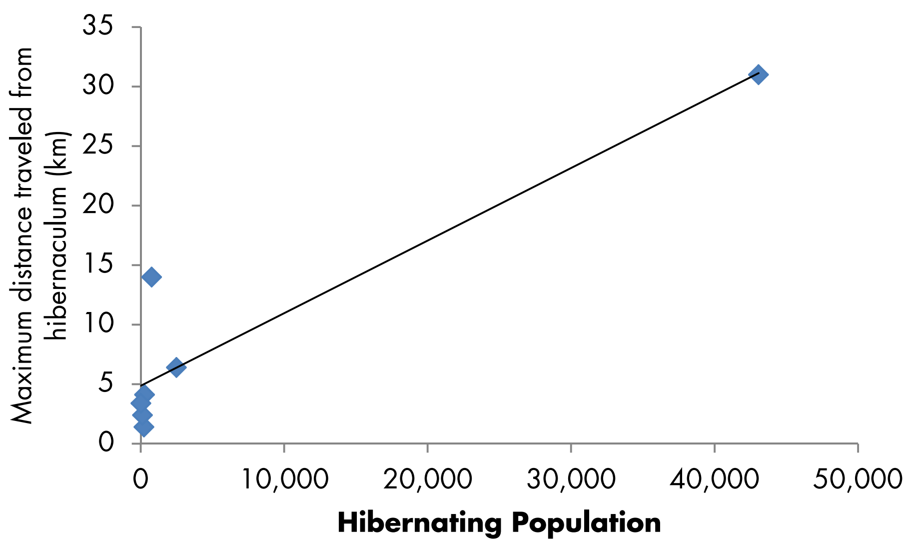

Figure 4-9. Population size of local hibernaculum and maximum distance traveled to roost trees from 7 fall swarming studies in VA, KY, IN, MI, MO, and PA (Brack 2006, Gumbert 2001, Hawkins et al. 2005, Kiser and Elliot 1996, Kurta 2000, Rommé et al. 2002, USFWS 2007).

Most telemetry studies conducted during fall swarming have occurred outside of hibernacula with small populations of Indiana bats. The long distances traveled by Indiana bats studied near Wyandotte Cave seem to suggest that use of habitat during fall swarming may change with hibernacula size (Hawkins et al. 2005). Thus, as the density of Indiana bats swarming outside of the hibernaculum increases, Indiana bats may need to move farther from the site to find available roost and prey resources. Despite the lack of data collected at moderately sized hibernacula (i.e., P2), a pattern of increased foraging distances with increased hibernating populations is apparent in the data collected for the aforementioned studies (Figure 4-9). This relationship is primarily being driven by the single study conducted outside of a P1 hibernaculum

(Hawkins et al. 2005, conducted near Wyandotte Cave, IN); additional swarming studies conducted at moderately sized hibernaculum would further elucidate this relationship. However, these data represent the best available information on foraging and travelling patterns of Indiana bats during fall swarming.

Kiser and Elliott (1996) found that during swarming, Indiana bats in KY used day roosts under the sloughing bark of trees near caves and traveled to the cave entrance each night. Few data are available on the roosts used by swarming Indiana bats, but roosts used by Indiana bats in KY tended to be smaller in size than roosts used in the summer reproductive period. Roost trees used during the fall in KY ranged from 11.9 cm to 67.1 cm (4.7 in to 26.4 in) dbh, primarily located on ridgetops and upper slopes (Kiser and Elliott 1996). Gumbert (2001) found a male Indiana bat roosting in a 6.4-cm (2.5-in) dbh flowering dogwood (*Cornus florida*), which is the smallest roost tree documented for the species. Species of roost trees used in KY were similar to those used for summer roosts, with the exception of the following species that were only documented in the fall: Virginia pine [*Pinus virginiana]*, shortleaf pine [*P. echinata]*, pitch pine [*P. rigida]*), flowering dogwood, and sourwood (*Oxydendrum arboreum*) (Kiser and Elliott 1996, Gumbert 2001).

Indiana bats tend to roost more often as individuals in fall than in summer (USFWS 2007). Roost switching occurs every 2 to 3 days and trees used by the same individual tend to be clustered in the environment. Similar to summer, fall roost trees most often are in sunny forest openings created by human or natural disturbance (USFWS 2007). Indiana bats show strong site fidelity (especially females) and typically return to the same hibernacula year after year (Hall 1962, LaVal and LaVal 1980, Gumbert et al. 2002), but switching between different hibernacula does occur. Hall (1962) reported Indiana bats apparently switching between hibernacula: 20 Indiana bats (n = 15 females, 5 males) banded in 1 hibernaculum were recovered in a different hibernaculum in subsequent winters, with distances between caves ranging from 2 mi to 320 mi. More recently, a female Indiana bat that was captured emerging from the South Penn Tunnel in Bedford County, PA, in the spring of 2007 was recaptured in winter 2009-2010 at Hellhole Cave in Pendleton County, WV, a distance of approximately 138 km (86 mi) (C. Butchkoski, PGC, personal communication and C. Stihler, WV Department of Natural Resources, personal communication). Similarly, an Indiana bat captured during swarming at the Hartman (or Canoe Creek) Mine in Blair County, PA, in fall 2007 was captured in a cave in Tucker County, WV, in winter 2009-2010, a distance of approximately 214 km (133 mi) (C. Butchkoski, PGC, and C. Stihler, WVDNR, personal communication).

4.5 Current Threats

As stated previously, the Indiana bat was listed as endangered in 1967 (32 Fed. Reg. 4001, 11 Mar 1967). Pursuant to Section 4 of the ESA a species may be listed as endangered or threatened because of any of the following 5 factors;

1) The present or threatened destruction, modification, or curtailment of its habitat or range;
2) Over utilization for commercial, recreational, scientific, or educational purposes;
3) Disease or predation;
4) Inadequacy of existing regulatory mechanisms; and
5) Other natural or man-made factors affecting its continued existence (16 U.S.C. § 1533 (a)(1).

Recovery of Indiana bats initially focused on minimizing disturbance at hibernacula, and efforts were made to protect all major hibernacula in the years following its listing. Despite this protection, the species continued to decline in number, suggesting that issues with its summer range or other factors were also contributing to its decline (USFWS 2007).

Current threats that influence recovery efforts for the Indiana bat include habitat destruction and degradation, disturbance at hibernacula, and disease. Threats to the Indiana bat vary during its annual life cycle. Factors that may influence the Indiana bat's vulnerability include energetic impacts caused by disturbance to roosting areas (both at hibernacula and maternity colonies), availability of hibernation and summer roosting habitat, and connectivity of suitable habitat. Life history characteristics such as obligate colonial roosting, early and rapid parturition of young, and necessary conservation of fat reserves during hibernation may intensify their susceptibility to these disturbances.

4.5.1 Loss or Degradation of Summer, Migration, and Swarming Habitat

Loss of forested habitats used by Indiana bats during the summer season for roosting, swarming, and feeding has been cited as a factor for endangerment (USFWS 1983). In some regions of the Indiana bat's summer range, up to 97% of forested habitat has been cleared (USFWS 2007). Historically, forest loss has been primarily due to land conversion to agriculture; but currently the greatest cause of forest loss is from urbanization and associated development (Wear and Greis 2002). Although Indiana bats will utilize forest-agricultural edges for foraging, they have been found to avoid high-density residential areas (Sparks et al. 2005b).

Forest harvest practices can impact the suitability of Indiana bat habitat. Removing or felling roost trees during the active period (1 Apr to 31 Oct) can cause direct injury or death to Indiana bats (Cope et al. 1974, Belwood 2002), and cutting (standing) dead trees for firewood is cited as threat to roost trees (USFWS 1983, Krusac and Mighton 2002). Impacts to forested habitats used for maternity colonies by Indiana bats can negatively impact reproduction. Because philopatry to maternity colonies is high (USFWS 2007), the loss of colonies due to forest destruction or degradation can have implications on reproductive success, as females must expend energy in search for new suitable colonies (Sparks et al. 2003, Barclay et al. 2004).

The alteration of riverine habitats can also negatively impact Indiana bat habitats (USFWS 2007). Specifically, channelization projects can destroy riparian vegetation, which, in turn impacts foraging and roosting habitat and insect food sources (Humphrey et al.1977, Humphrey 1992, Drobney and Clawson 1995). Migration pathways and swarming sites also may be affected by habitat loss and degradation.

Silvicultural practices such as selective harvesting and shelterwood cuts that result in the retention of dead and dying trees have been found to increase Indiana bat roosting potential (Gardner et al. 1991b, MacGregor et al. 1999, Ford et al. 2002). Managing forests to develop characteristics of old growth forests will help promote suitable roosting habitats for Indiana bats (Clawson 1986 as cited by USFWS 2007, Callahan 1993, Krusac and Mighton 2002).

4.5.2 Disturbance or Destruction of Hibernating Habitat

Indiana bat hibernacula have been degraded or destroyed for many reasons (USFWS 2007). Mining (saltpeter), cave recreation, and tourism have led to the alterations of caves that include barriers or modifications to cave entrances (e.g., doors, gates, buildings) and destruction of cave physical characteristics. These alterations can modify air flow patterns and temperatures, rendering caves unsuitable or marginal for hibernating Indiana bats. A specific example of this degradation is the construction of a building over the entrance of Coach Cave in KY, which resulted in cave temperatures increasing from 4°C to 6°C to 11°C (39°F to 43°F to 52°F) and a decline in the population of hibernating Indiana bats from approximately 100,000 Indiana bats to 4,500 Indiana bats (Currie 2002). Similar obstructions of airflow and subsequent increases in cave temperatures have been documented in Indiana bat hibernacula in KY (MacGregor 1993), IN (Johnson et al. 2002), and MO (Tuttle and Kennedy 2002).

In addition to altering cave microclimates through alteration of airflow, cave gates and doors have been reported to cause injury and mortality from collisions as bats exit and enter caves. Vandals have directly killed hibernating Indiana bats, and documented mortalities have numbered in the 10,000s (Carter County, Kentucky; Greenhall 1973, as cited by USFWS 2007). Campfires also have contributed to the direct killing of Indiana bats at hibernacula (MacGregor 1993 as cited by USFWS 2007).

Physical disturbance to hibernating bats from human activities such as mining (saltpeter), tourism and recreation, and research can negatively impact bats by causing them to arouse during hibernation. Because arousal is metabolically expensive, when bats are disturbed they use fat reserves that are critical for survival (Thomas et al. 1990, as cited by USFWS 2007). The impacts of disturbance can be manifested through lower survival and/or reproductive rates after bats leave their hibernacula. However, it is often difficult to document the impacts of disturbance because bats rarely experience immediate mortality from such events, and detection of a bat's response to disturbance is difficult to assess (Mohr 1972 and Humphrey 1978, as cited by USFWS 2007). Although disturbance at caves was a primary concern for Indiana bats when the species was first listed, through education and conservation activities human disturbance at caves largely has been addressed and is not affecting Indiana bats to the degree it once was (USFWS 2009a).

Other threats to Indiana bat hibernacula include flooding and ceiling collapse at caves, either due to mining or natural causes. Such catastrophes can have a significant effect on the Indiana bat population because of the concentration of individuals found in relatively few hibernacula.

4.5.3 Disease and Parasites

Disease and parasites in Indiana bats are poorly understood and had not been cited as major factors in population declines prior to the discovery of WNS in 2007 (USFWS 2007). Although rabies and parasites contribute to mortality, the 2007 Draft Recovery Plan did not associate these diseases with the decline of Indiana bats. WNS (discussed in Sections 4.1.1 – White-Nose Syndrome and 7.2.1 – Changed Circumstances) was not considered a threat to Indiana bats prior to its discovery in 2007, but is recognized in the 2009 Indiana Bat Five-Year Review (USFWS 2009a). The disease already has caused large scale mortality in the eastern United States and is anticipated to continue to spread to Indiana bat hibernacula in other eastern and midwestern states. It is possible that other previously undetected diseases could impact Indiana bats in the future, consistent with the emergence of diseases that have caused mass declines and extinctions in other species.

4.5.4 Climate Change

Although the manifestations of climate change are expected to be complex and widely varied, several potential negative impacts to Indiana bats may occur. Temperature increases associated with climate change may be influencing northward range shifts that have been documented for Indiana bats (Clawson 2002, USFWS 2007; although Meretsky noted that confounding factors are clearly involved [USFWS 2007]) and predicted for little brown bats (Humphries et al. 2002). A recent analysis of 866 studies on global warming's effects on wildlife found that nearly 60% of species considered were already showing shifts in the timing of specific seasonal events, such as migrations, at an average rate of 2.3 days per decade (Parmesan and Yohe 2003, as cited in Gomberg 2008). Similarly, mismatched phenology of insect availability relative to times of peak energy demand for Indiana bats could negatively affect reproductive success and survival (V. Meretsky, Indiana University, personal communication as cited by USFWS 2009a). Refer to Section 7.2.1 – Changed Circumstances for a more in-depth discussion of the potential impacts of climate change on the Indiana bat.

4.5.5 Collision Mortality at Wind Facilities

To date, 5 Indiana bat fatalities have been documented in post-construction monitoring studies at wind energy facilities. Two of the fatalities occurred at the Fowler Ridge wind facility in Benton County, IN, during the fall migration period; the first occurred in September 2009 and the second occurred in September 2010 (Good et al. 2011). The third Indiana bat fatality occurred at the North Allegheny Wind facility in Cambria and Blair counties in Pennsylvania[19]. This fatality also occurred during the fall migration period in September 2011. The fourth Indiana bat fatality occurred on July 26, 2012 at the Laurel Mountain Wind Power facility near Elkins, WV[20]. The fifth Indiana bat fatality occurred on the night of October 2-3, 2012 at the Blue Creek Wind Farm in Paulding County, OH[21] While it is assumed that other Indiana bat mortality at wind facilities have occurred, these fatalities represent the only documented taking of a federally threatened or endangered bat species at a wind facility to date. Because very low Indiana bat mortality has been documented at wind facilities, there is a lack of direct data specific to the Indiana bat. Therefore, the following section will discuss impacts that have been documented for bats in general and will make inferences to Indiana bats where appropriate.

4.5.5.1 Collision Rates

Concern regarding impacts to wildlife from wind facilities focused primarily on birds prior to 2003 (Johnson et al. 2003a). Bat fatalities were discovered in relatively small numbers beginning in the late 1990s in conjunction with avian fatality monitoring. However, several high profile bat mortality surveys at wind facilities on forested ridges of the Appalachian Mountains in 2003 and 2004 raised concerns about the impacts to bats (Kunz et al. 2007a). An estimated 2,092 bats were killed at the Mountaineer Wind Energy Center in WV between 4 April 2003 and 11 November 2003 (Kerns and Kerlinger 2004), although Arnett et al. (2008) estimated that the total number of bats killed during 2003 could have been as high as 4,000.

Similarly high rates were estimated for 2 6-week studies conducted in 2004 at Mountaineer (1,364 to 1,980 fatalities) and Meyersdale, PA (400 to 920 fatalities) (Kerns et al. 2005; Table 4-4). In 2005, the estimated bat mortality rate at the Buffalo Mountain, TN, wind facility (18 turbines) was the highest documented annual rate reported in the United States to date (63.9 bats per turbine and 39.7 bats per MW; Fiedler et al. 2007). This was an order of magnitude greater than the 2004 national average of 3.4 bats per turbine per year (Johnson 2004). Post-construction monitoring at wind facilities in the latter part of the decade have continued to report higher than expected levels of bat mortality at wind energy sites, though mortality rates varied by region (Johnson 2005, Arnett et al. 2008, Gruver et al. 2009).

Bat deaths and injuries were initially thought to primarily result from the impact of physically colliding with turbines (Johnson et al. 2004, Horn et al. 2008). However, the recent discovery that bats can be killed as a result of decompression sickness, or barotrauma, caused by low-pressure vortices formed in the wake of rotating turbine blades demonstrates that bats do not have to physically collide with turbines to be at risk (Baerwald et al. 2008b). Tissue damage is caused by this rapid or excessive pressure change; pulmonary barotrauma is lung damage due to expansion of air in the lungs that is not accommodated by exhalation. Baerwald et al. (2008b) reported that internal hemorrhaging consistent with barotrauma was found in 90% of bat carcasses examined, and that direct contact with turbine blades only accounted for about half of the fatalities observed at the wind facility studied.

Bat mortalities rates are typically calculated by using the number of observed carcasses and correcting for searcher efficiency, carcass persistence, and searchable area. Variation in bat mortality estimates among

[19] See <http://www.fws.gov/northeast/pafo/>. Accessed October 2011.

[20] See http://www.fws.gov/westvirginiafieldoffice/ibatfatality.html. Accessed November 15, 2012

[21] See http://www.fws.gov/midwest/News/release.cfm?rid=604&utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+FwsMidwestNewsroom+%28FWS+Midwest+News+and+Highlights%29

studies may be partially attributable to differences in monitoring methodology and correction factors among other variables

4.5.5.2 Geographic Variation

In a review of 21 studies from 19 different wind energy facilities in 5 regions of the United States and 1 province in Canada, Arnett et al. (2008) found that estimates of bat fatalities were highest at wind energy facilities located on forested ridges in the eastern United States and lowest in the Rocky Mountain and Pacific Northwest regions. Bat fatalities were lower and more variable among sites in the upper Midwest, with estimates ranging from 0.2 bat per MW to 8.7 bats per MW or 0.1 to 7.8 bats per turbine (Table 4.4). However, a 2009 post-construction study at Blue Sky Green Field in WI documented an unprecedented, high mortality rate for the Midwest, with total estimated mortality of 40.5 bat fatalities per turbine (35.6 bats per turbine when incidental finds were removed) or 24.6 bat fatalities per MW (21.6 bats per MW when incidental finds were removed) for the 88-turbine facility (Gruver et al. 2009); the species composition of these fatalities will be discussed below in Section 4.5.5.2.1 – Species Distribution. Likewise, the Cedar Ridge wind facility in WI also documented high bat mortality rates, estimated at 50.5 bats per turbine per study period (BHE 2010).

Although trends among sites within the same geographic areas have been relatively consistent, in some cases facilities in the same geographic region have had highly variable rates. For example, in southwestern Alberta, 3 facilities in the same geographic region had significantly different estimates of bat fatalities. Bat mortality at Summerview (2005) was on average 14.1 times greater than Castle River and McBride Lake (E. Baerwald and R. M. R. Barclay, University of Calgary, unpublished data as cited by Arnett et al. 2008).

Table 4-4. Estimated bat mortality rates reported at wind-energy facilities in the United States and Canada.

Project Location	Year	No. of turbines at site	Estimated no. bats per turbine/yr	95% confidence interval (per no. b/t/yr)	Study period	Source
U.S. - Midwest						
Blue Sky Green Field, WI	2008	88	35.6	30.98-51.16 [c f]	21 Jul-31Oct 2008, 15 Mar-31 May 2009	Gruver et al. 2009
Buffalo Ridge, MN (Phase I)	1999	73	0.26	0.06-0.46[c]	15 Mar-15 Nov 1999	Johnston et al. 2003a
Buffalo Ridge, MN (Phase II)	1998	143	1.62	1.21-2.03[c]	15 Mar-15 Nov 1998	Johnston et al. 2003a
Buffalo Ridge, MN (Phase II)	1999	143	1.94	1.53-2.35[c]	15 Mar-15 Nov 1999	Johnston et al. 2003a
Buffalo Ridge, MN (Phase III)	1999	138	2.04	1.46-2.62[c]	15 Mar-15 Nov 1999	Johnston et al. 2003a
Buffalo Ridge, MN (Phase II)	2001	143	3.26	2.25-4.48[c]	15 Jun-15 Sep 2001	Johnston et al. 2004
Buffalo Ridge, MN (Phase III)	2001	138	2.78	1.96-3.71[c]	15 Jun-15 Sep 2001	Johnston et al. 2004
Buffalo Ridge, MN (Phase II)	2002	143	1.36	0.82-2.00[c]	15 Jun-15 Sep 2002	Johnston et al. 2004
Buffalo Ridge, MN (Phase III)	2002	138	1.3	0.89-1.77[c]	15 Jun-15 Sep 2002	Johnston et al. 2004
Cedar Ridge, WI	2009	41	50.5 [d]	NR	Mar-May; July-Nov 2009	BHE 2010
Crescent Ridge, IL	2005/2006	33	0.18-2.67	4.36-5.46	Sep-Nov 2005;Mar-May 2006; Aug 2006	Kerlinger et al. 2007
Fowler Ridge, IN	2010	355	22.2	19.32-29.17[c]	13 Apr-5 May 2010; 1 Aug-15 Oct 15 2010;	Good et al. 2011
Forward Energy Center, WI	2008-2009	86	NR	NR	15 Jul 2008-15 Oct 2009	Drake et al. 2010
Kewaunee County, WI	1999-2001	31	4.26	NR	Jul 1999-Jul 2001	Howe et al. 2002
NPPD Ainsworth, NE	2006	36	1.91 [d]	0.91-3.37[c]	13 Mar-4 Nov, 2006	Derby et al. 2007
Top of Iowa, IA	2003	89	3.74-8.08[d]	NR	15 Apr-15 Dec 2003	Jain 2005
Top of Iowa, IA	2004	89	7.19-13.14[d]	NR	15 Apr-15 Dec 2004	Jain 2005
AVERAGE Midwest		112.2	9.7			

Project Location	Year	No. of turbines at site	Estimated no. bats per turbine/yr	95% confidence interval (per no. b/t/yr)	Study period	Source
U.S. - South-Central						
Buffalo Gap, TX	2007-2008	155	0.21	NR	Jul 2007-Dec 2009	Tierney 2009
Oklahoma Wind Energy Center, OK	2004-2005	68	1.19-1.71[i]	NR	May-Jul 2004/2005	Piorkowski and O'Connell 2010
AVERAGE South Central		111.5	0.83			
Eastern United States						
Buffalo Mountain, TN (Phase I)	2000-2003	3	20.8	19.5-22[c]	29 Sep 2000-30 Sep 2003	Fiedler 2004
Buffalo Mountain, TN (Phase II)	2005	18	63.9		Apr-Dec 2005	Fiedler et al. 2007
Casselman, PA	2008	23	32.2	20.8-51.4	26 Jul-10 Oct 2008	Arnett et al. 2009
Cohocton/Dutch Hill, NY	2009	50	13.8-40	804.13-3062.02	15 Apr-15 Nov 2009	Stantec 2010a
Cohocton/Dutch Hill, NY	2010	50	5.04-25.62[d]	65.63-963.89[d]	26 Apr-22 Oct 2010	Stantec 2011b
Lempster Ridge, NH	2009	12	6.21[d]	3.08-9.84[d]	15 Apr-31 Oct 2009	Tidhar et al. 2010
Maple Ridge, NY	2006	195	11.39-20.31	14.3-34.7	17 Jun-15 Nov 2006	Jain et al. 2007
Maple Ridge, NY	2007	195	15.5	14.1-17.0	30 Apr-14 Nov 2007	Jain et al. 2009a
Maple Ridge, NY	2008	195	8.2	7.4-9.0	5 Apr-9 Nov 2008	Jain et al. 2009b
Mars Hill, ME	2007	28	4.37	NR	23 Apr-23 Sep 2007	Stantec 2008c
Mars Hill, ME	2008	28	0.17	NR	19 Apr-8 Oct 2008	Stantec 2009b
Meyersdale, PA	2004	20	25.1	20.1-32.7[c]	2 Aug-13 Sep 2004	Arnett 2005
Mount Storm, WV (Phase I)	2008	82	24.2	17.1-33.1[cd]	18 Jul-17 Oct 2008	Young et al. 2009a
Mount Storm, WV (Phase I,II)	2009	132	28.6	18.7-40.5	23 Mar-14 Jun & 16 Jul-8 Oct 2009	Young et al. 2009b, 2010
Mount Storm, WV (Phase I,II)	2010	132	9.98[d]	8.2-14.06[cd]	16 Apr-14 Jul 2010	Young et al. 2011
Mountaineer, WV	2004	44	37.7	31.2-45.1[c]	2 Aug-13 Sep 2004	Arnett 2005
Mountaineer, WV	2003	44	47.5	31.8-91.6[c]	4 Apr-22 Nov 2003	Kerns and Kerlinger 2004
Munnsville, NY	2008	23	3.6[fg]	32.99-40.19[fg]	15 Apr-15 Nov 2008	Stantec 2009c
Noble Bliss, NY	2008	67	7.58-14.66[h]	NR	21 Apr-14 Nov 2008	Jain et al. 2009c

Project Location	Year	No. of turbines at site	Estimated no. bats per turbine/yr	95% confidence interval (per no. b/t/yr)	Study period	Source
Noble Clinton, NY	2008	67	3.76-5.45[dh]	NR	26 Apr-13 Oct 2008	Jain et al. 2009e
Noble Ellensburg, NY	2008	54	4.19-8.17[dh]	NR	28 Apr-13 Oct 2008	Jain et al. 2009d
Stetson Mountain I, ME (Year 1)	2009	38	2.11	NR	20 Apr-21 Oct 2009	Stantec 2010b
Stetson Mountain II, ME (Year 1)	2010	17	2.48	2.19-2.77	19 Apr-31 Oct 2010	Normandeau 2010
AVERAGE East		66.0	17.9			
U.S. - West						
Foote Creek Rim, WY Year 1	1998-1999	69	2.38[f]	0.68-4.71[f]	3 Nov 1998-31 Oct 1999	Young et al. 2003
Foote Creek Rim, WY Year 2	2000	69	0.63[f]	0.2-2.04[f]	1 Nov 1999-31 Dec 2000	Young et al. 2003
Foote Creek Rim, WY Year 3	2001-2002	69	0.94[f]	0.26-1.13[f]	1 Jun 2001-5 Jun 2002	Young et al. 2003
Judith Gap, MT	2006-2007	90	13.4 [d]	NR	Aug-Oct 2006, Feb-May, 2007	TRC Environmental 2008
AVERAGE West		74.3	4.3			
U.S. - Pacific NW and Coast						
Biglow Canyon, OR	2008	76	3.29	2.27-4.85 [c]	Jan-Dec 2008	Jeffrey et al. 2009
Biglow Canyon, OR	2009	76	0.96	0.57-1.49[c]	26 Jan-11 Dec 2009	Enk et al. 2010
Combine Hills, OR (Phase I)	2004-2005	41	1.88	1.15-2.8c	9 Feb 2004-8 Feb 2005	Young et al. 2006
High Winds, CA Year 1	2003-2004	90	2.72	NR	Aug 2004-Jul 2005	Kerlinger et al. 2006
High Winds, CA Year 2	2004-2005	90	3.63	NR	Aug 2003-Jul 2005	Kerlinger et al. 2006
Hopkins Ridge, WA	2006	83	1.13	0.69-1.71 [c]	Jan-Dec 2006	Young et al. 2007
Klondike, OR (Phase I) Year 1	2001-2002	16	1.16	0.41-2.12 [c]	2001-2002	Johnson et al. 2003b
Stateline, OR/WA	2002	399	0.954	0.646-1.312[c]	Jul 2001-Dec 2002	Erickson et al. 2003a
Stateline, OR/WA	2003	454	1.51	1.08-1.94[c]	Jan 2003-Dec 2003	Erickson et al. 2004
Vansycle, OR	1999	38	0.74	0.26-1.56	1999	Erickson et al. 2000
Wild Horse, WA	2007	127	0.7	NR	Jan-Dec 2007	Erickson et al. 2008
AVERAGE Pacific NW and Coast		135.5	1.7			

Project Location	Year	No. of turbines at site	Estimated no. bats per turbine/yr	95% confidence interval (per no. b/t/yr)	Study period	Source
Canada						
Castle River, AB	2001-2002	60	0.22-0.89[a]	NR	Apr 2001- Jan 2002	Brown and Hamilton 2006a
McBride Lake, AB	2003-2004	114	0.47[a]	NR	Jul 2003-Jun 2004	Brown and Hamilton 2004
Ripley, ON	2008	38	0.17-12.38[j]	NR	Apr-May, Jul-Oct 2008	Jacques Whitford Stantec Ltd. 2009
Summerview, AB	2005-2006	39	18.49	NR	Jan 2005-Jan 2006	Brown and Hamilton 2006b
Summerview, AB	2006-2007	39	26.32	NR	Jul-Sep, 2006 & 2007	Baerwald 2008a
Wolfe Island, ON	2009	86	14.77	NR	1 Jul-31 Dec 2009	Stantec 2010c
AVERAGE Canada		62.7	11.1			
AVERAGE U.S. and Canada		92.2	10.9			

[a] estimation unadjusted for searcher efficiency or scavenger rate

[b] where a range of estimated number of bats per turbine was given, the median was used to calculate average estimated number bats per turbine per year for each region

[c] reported as 90% confidence interval

[d] estimation based on study period, not per year

[e] reported as 99% confidence interval

[f] estimation includes incidental fatalities

[g] estimation is an average of standardized search estimate and dog search estimate

[h] range includes estimations of 1-day, 3-day, and 7-day standardized surveys

[i] author did not define if estimation is calculated for fatalities per turbine/year or per turbine/study period

[j] estimation is a range of spring and fall study periods

NR not reported by author

4.5.5.2.1 Species Distribution

At present, fatalities of 13 of the 45 bat species present in North America have been documented at wind energy facilities. These 11 species include: northern long-eared bat, little brown bat, Indiana bat, eastern small-footed bat, tri-colored bat, Seminole bat (*Lasiurus seminolus*), hoary bat, silver-haired bat, eastern red bat, western red bat (*Lasiurus blossevillii*), Brazilian free-tailed bat (*Tadarida brasiliensis*), evening bat (*Nycticeius humeralis*), and big brown bat (Arnett et al. 2008, USFWS 2010; Table 4-5).

Several consistent patterns have emerged with regard to the species distribution of bat fatalities at wind facilities in North America. Three species of long distance migratory bats have been killed in the largest proportions: the foliage-roosting hoary bat and eastern red bat and the cavity-roosting silver-haired bat (Kunz et al. 2007b, Arnett et al. 2008). Collectively, these species comprised approximately 75% of documented fatalities and hoary bats make up about half of all fatalities in 2008 (Arnett et al. 2008). Silver-haired bats have been recorded more frequently at sites in western Canada, IA, WI, and the Pacific

Northwest relative to the eastern United States (Arnett et al. 2008, Gruver et al. 2009). Eastern red bats have most commonly been found in eastern forested sites and in the Midwestern United States (Arnett et al. 2008). Eastern red bats comprised 61.3% and 60.9% of fatalities at Buffalo Mountain, TN from 2000 to 2003 and 2005, respectively (Fiedler 2004, Fiedler et al. 2007). The tri-colored bat also has experienced high mortality rates and has comprised up to 25% of North America fatalities (Arnett et al. 2008).

At the 19 facilities reviewed by Arnett et al. (2008), fatalities of summer resident species, including little brown, northern long-eared, and big brown bats, were relatively low (0% to 13.5%) with the exception of Castle River, Alberta, and Top of Iowa, IA, where little brown bats made up nearly 25% of fatalities (Brown and Hamilton 2002, Jain 2005). More recent post-construction studies also documented higher rates of *Myotis* mortalities than the majority of studies reviewed by Arnett et al. (2008). Gruver et al. (2009) reported a higher percentage (28.7%) of little brown bat fatalities at Blue Sky, WI, during fall 2008 and spring 2009. Similarly, post-construction mortality studies at 3 facilities in Clinton and Wyoming counties, NY, documented higher proportions of *Myotis* fatalities than those in the Arnett et al. (2008) review, ranging from 33.3% to 55.9% (Jain 2009c, 2009d, 2009e), as did studies at Cohocton/Dutch Hill and Munnsville wind facilities in central NY, 59.4% and 20.0%, respectively (Stantec 2009c, 2010a).

Looking at the species assemblages of bats reported in aircraft strike incidents may also be helpful in understanding use of airspace by different bat species and their relative risks of collision with objects in their flight path. Peurach et al. (2009) compiled data from 821 bat strikes that occurred between 1997 and 2007 in 40 states and from 20 countries as reported to the United States Air Force (USAF) Safety Center. A total of 402 bats were identified representing 25 species. Brazilian free-tailed bats comprised the majority of bat strikes (43%), followed by red bats (21%), hoary bats (8%), Seminole bats (6%), and silver-haired bats (4%). All of these species, with the exception of the Seminole bat (Wilkins 1987), are considered long-distance migrants (Villa and Cockrum 1962, Findley and Jones 1964, Timm 1989, Cryan 2003). Kuhl's pipistrelles (*Pipistrellus kuhlii)*; not native to North America) and tri-colored bats collectively comprised 8% of bat strikes. *Myotis* made up less than 0.5% of aircraft strikes. Although it has not been statistically demonstrated, aircraft strike data suggest a connection between long-distance migrants and risks at higher altitude.

Table 4-5. Observed species[a] composition of bat mortality reported at wind-energy facilities in the United States and Canada.

Project Location	Year	Number of fatalities (Percentage of total fatalities)											Total no. bat fatalities	Source
		EPFU	LABL	LABO	LACI	LANO	MYLU	MYSE	MYSO	PISU	TABR	Other		
U.S. - Midwest														
Blue Sky Green Field, WI	2008	33 (17.0)		11 (5.7)	29 (14.9)	51 (26.3)	60 (30.9)					10 (5.2)	194	Gruver et al. 2009
Buffalo Ridge, MN (Phase I,II,III)	1998-1999	1 (0.5)		37 (20.1)	108 (58.7)	6 (3.3)	5 (2.7)			6 (3.3)		21 (11.4)	184	Johnson et al. 2003a
Buffalo Ridge, MN (Phase II & III)	2001-2002	8 (5.3)		21 (13.9)	115 (76.2)	4 (2.6)	3 (2.0)						151	Johnson et al. 2004
Cedar Ridge, WI	2009	15 (17.9)		12 (14.3)	29 (34.5)	16 (19.0)	12 (14.3)						84	BHE 2010
Crescent Ridge, IL	2005-2006			6 (28.6)	6 (28.6)	8 (38.0)						1 (4.8)	21	Kerlinger et al. 2007
Fowler Ridge, IN	2010	17 (3.0)		368 (62.0)	86 (15.0)	116 (20.0)	2 (0.3)		1 (0.2)	2 (0.3)			592[b]	Good et al. 2011
Forward Energy Center, WI	2008-2009	12 (9.9)		14 (11.6)	34 (28.1)	36 (29.5)	12 (9.9)					13 (10.7)	121	Drake et al. 2010
Kewaunee County, WI	1999-2001	1 (1.4)		27 (37.5)	25 (34.7)	13 (18.1)						6 (8.3)	72	Howe et al. 2002
NPPD Ainswoth, NE	2006	1 (8.3)		1 (8.3)	12 (75.0)							2 (16.7)	16	Derby et al. 2007
Top of Iowa, IA	2003	3 (10.0)		6 (20.0)	11 (36.7)	2 (6.7)	9 (30.0)						31	Jain 2005
Top of Iowa, IA	2004	9 (11.8)		18 (23.7)	21 (27.6)	9 (11.8)	18 (23.7)			1 (1.3)			76	Jain 2005
AVERAGE Midwest		10.0 (9.8)		47.4 (22.3)	43.3 (39.1)	25.9 (17.5)	15.4 (14.2)		1 (0.2)	3.0 (1.6)		8.8 (9.5)	140.2	
U.S. - East														
Buffalo Mountain, TN (Phase II)	2005	1 (0.4)		145 (60.9)	31 (13)	18 (7.6)				41 (17.2)		2 (0.8)	238	Fiedler et al. 2007
Buffalo Mountain, TN (Phase I)	2000-2003	1 (0.9)		69 (60.5)	11 (9.6)	2 (1.8)				29 (25.4)		2 (1.8)	114	Fiedler 2004
Casselman, PA	2008	4 (2.7)		27 (18.2)	46 (31.1)	39 (26.4)	14 (9.5)			17 (11.5)		1 (0.01)	148	Arnett et al. 2009
Cohocton/Dutch Hill, NY	2009	2 (2.9)		2 (2.9)	12 (17.4)	11 (16.0)	41 (59.4)					1 (1.4)	69	Stantec 2010a
Cohocton/Dutch Hill, NY	2010	4 (6.3)		13 (20.6)	24 (38.1)	9 (14.3)	11 (17.5)	1 (1.6)				1 (1.6)	63	Stantec 2011b
Lempster Ridge, NH	2009	2 (2.0)			3 (30.0)	4 (40.0)	1 (1.0)						10	Tidhar et al. 2010
Maple Ridge, NY	2006	21 (5.4)		50 (13)	176 (45.9)	56 (14.6)	52 (13.5)					29 (7.6)	384[b]	Jain et al. 2007
Maple Ridge, NY	2007	17 (8.4)		20 (9.9)	100 (49.5)	32 (15.8)	31 (15.3)					2 (1.0)	202	Jain et al. 2009a
Maple Ridge, NY	2008	7 (5.0)		16 (11.4)	61 (43.6)	29 (20.7)	24 (17.1)					3 (2.1)	140	Jain et al. 2009b
Munnsville, NY	2008	1 (10.0)		1 (10.0)	6 (60.0)		2 (20.0)						10[b]	Stantec 2009c
Mars Hill, ME Year 1	2007			3 (13.0)	5 (21.0)	9 (38.0)	4 (17.0)						21	Stantec 2008c
Mars Hill, ME Year 2	2008			2 (40.0)	2 (40.0)	1 (20.0)							5	Stantec 2009b

Meyersdale, PA	2004	18 (6.9)		72 (27.5)	119 (45.4)	15 (5.7)	7 (2.7)	2 (0.7)		21 (8.0)		1 (0.5)	262	Kerns et al. 2005
Mountaineer, WV	2004	10 (2.5)		96 (24.1)	134 (33.7)	19 (4.8)	39 (9.8)			98 (24.6)		2 (0.5)	398	Arnett 2005
Mountaineer, WV	2003	2 (0.4)		200 (42.1)	88 (18.5)	28 (5.9)	60 (12.6)	6 (1.3)		87 (18.3)		4 (0.8)	475	Kerns and Kerlinger 2004
Mount Storm, WV (Phase I)	2008			35 (19.2)	57 (31.3)	30 (16.5)	18 (9.9)	1 (0.5)		29 (15.9)		3 (1.6)	182	Young et al. 2009a
Mount Storm, WV (Phase I & II)	2010	3 (4.6)		16 (24.6)	24 (36.9)	9 (13.8)	6 (9.2)			7 (10.8)			65	Young et al. 2011
Noble Bliss, NY	2008	1 (1.4)		6 (8.1)	24 (32.4)	13 (17.6)	29 (39.2)			1 (1.4)			74	Jain et al. 2009c
Noble Bliss, NY	2009			7 (19.4)	14 (38.9)	6 (16.7)	6 (16.7)					3 (8.3)	36[b]	Jain et al. 2010a
Noble Clinton, NY	2008			1 (2.6)	9 (23.1)	11 (28.2)	13 (33.3)			3 (7.7)		2 (5.1)	39	Jain et al. 2009e
Noble Clinton, NY	2009			1 (2.4)	19 (45.2)	11 (26.2)	11 (26.2)						42[b]	Jain et al. 2010b
Noble Ellensburg, NY	2008			1 (2.9)	6 (17.7)	7 (20.6)	19 (55.9)			1 (2.9)			34	Jain et al. 2009d
Noble Ellensburg, NY	2009	1 (3.6)		2 (7.1)	11 (39.3)	3 (10.7)	10 (35.7)			1 (3.6)			28[b]	Jain et al. 2010c
Stetson Mountain I, ME (Year 1)	2009				2 (40)	1 (20)	1 (20.0)						5	Stantec 2010b
Stetson Mountain II, ME (Year1)	2010	2 (14.3)			5 (35.7)	6 (42.9)	1 (7.1)						14	Normandeau 2010
AVERAGE East		5.7 (4.6)		35.7 (20.0)	39.6 (33.5)	15.4 (18.5)	18.2 (20.4)	2.5 (1.0)		27.9 (11.4)		4.0 (2.4)	122.3	
U.S. - South-Central														
Buffalo Gap 2, TX	2007-2008				5 (41.7)						4 (33.3)	3 (25.0)	12	Tierney 2009
Oklahoma Wind Energy Center, OK	2004-2005	1 (0.9)		3 (2.7)	10 (9)	1 (0.9)				1 (0.9)	94 (84.7)	1 (0.9)	111	Piorkowski and O'Connell 2010
AVERAGE South Central		1 (0.9)		3 (2.7)	7.5 (25.35)	1 (0.9)				1 (0.9)	49 (59)	2 (13)	61.5	
U.S. - West														
Foote Creek Rim, WY	1999	1 (2.4)			34 (82.9)	1 (2.4)	4 (9.8)					1 (2.4)	41	Young et al. 2003
Foote Creek Rim, WY	2000				10 (83.3)	1 (8.3)	1 (8.3)						12	Young et al. 2003
Foote Creek Rim, WY	2001-2002				12 (66.7)	3 (16.7)	1 (5.6)					1 (5.6)	18	Young et al. 2003
Judith Gap, MT	2006-2007				17 (49)	4 (11)						14 (40)	35	TRC Environmental 2008
AVERAGE West		1 (2.4)			18.3 (70.5)	2.3 (9.6)	2 (7.9)					5.3 (16)	26.5	
U.S. - Pacific NW and Coast														
Biglow Canyon, OR	2008				25 (50.0)	25 (50.0)							50	Jeffrey et al. 2009
Biglow Canyon, OR	2009				4 (23.5)	8 (47.1)						3 (17.6)	17	Enk et al. 2010
Combine Hills, OR (Phase I)	2004-2005				13 (62.0)	8 (38.0)							21	Young et al. 2006
High Winds, CA Year 1	2003-2004		3 (4.3)		45 (64.3)						22 (31.4)		70	Kerlinger et al. 2006
High Winds, CA Year 2	2004-2005		1 (2.2)		17 (37.0)	2 (4.3)					26 (56.5)		46	Kerlinger et al. 2006
Hopkins Ridge, WA	2006	1 (5.3)			4 (21.0)	12 (63.0)	1 (5.3)					1 (5.3)	19	Young et al. 2007
Klondike, OR Phase I	2001-2002				3 (50.0)	1 (16.7)						2 (33.3)	6[b]	Johnson et al. 2003b

Stateline, OR/WA Year 1	2002	2 (3.7)			25 (46.3)	25 (46.3)	1 (1.9)					1 (1.9)	54	Erickson et al. 2003a
Stateline, OR/WA Year 2	2003				34 (45.9)	39 (52.7)						1 (1.4)	74	Erickson et al. 2004
Vansycle, OR	1999				5 (50.0)	3 (30.0)	1 (10)					1 (10)	10	Erickson et al. 2000
Wild Horse, WA	2007				10 (58.8)	3 (17.6)	4 (23.5)						17	Erickson et al. 2008
AVERAGE Pacific NW and Coast		1.5 (4.5)	2 (3.3)		16.8 (46.3)	12.6 (36.6)	1.8 (10.2)				24 (44)	1.5 (11.6)	34.9	
Canada														
Wolfe Island, ON	2009	13 (7.2)		44 (24.4)	54 (30.0)	36 (20.0)	13 (7.2)					20 (11.0)	180	Stantec 2010c
Castle River, AB	2001-2002				30 (57.7)	7 (13.4)	12 (23.1)					3 (5.8)	52	Brown and Hamilton 2006a
McBride Lake, AB	2003-2004	1 (1.9)			47 (87.0)	1 (1.9)	5 (9.2)						54	Brown and Hamilton 2004
Ripley, ON	2008	5 (4.2)		7 (5.8)	38 (31.7)	17 (14.2)	22 (18.3)	2 (1.7)		10 (8.3)		19 (15.8)	120	Jacques Whitford Stantec Ltd. 2009
Summerview, AB	2005-2006	4 (0.8)		1 (0.2)	244 (45.9)	272 (51.1)	6 (1.1)					5 (0.9)	532	Brown and Hamilton 2006b
Summerview, AB Year 2, 3	2006-2007	18 (1.8)		6 (0.6)	608 (61.2)	337 (33.9)	6 (0.6)					18 (1.8)	993	Baerwald 2008a
AVERAGE Canada		8.2 (3.2)		14.5 (7.8)	170.2 (52.3)	111.7 (22.4)	10.7 (9.9)	2 (1.7)		10 (8.3)		13.0 (7.1)	321.8	
AVERAGE U.S. and Canada		6.8 (5.7)	2.0 (3.3)	36.0 (18.9)	46.8 (35.2)	26.1 (21.1)	14.0 (16.0)	2.4 (1.2)	1.0 (0.2)	20.9 (8.9)	36.5 (51.5)	5.6 (7.5)	121.1	

[a] EPFU = big brown bat; LABL = western red bat; LABO = eastern red bat; LACI = hoary bat; LANO = silver-haired bat; MYLU = little brown bat; MYSE = northern long-eared bat; MYSO = Indiana bat; PISU = eastern pipistrelle (now tri-colored bat); TABR = Brazilian (Mexican) free-tailed bat.

[b] Number bats found includes incidental fatalities.

Similarly, long-distance migrants comprised the majority of fatalities at the 21 post-construction mortality studies reported by Arnett et al. (2008). While Brazilian free-tailed bats are not represented in significant numbers in post-construction monitoring results from wind facilities to date, this is likely due to paucity of post-construction studies within the range of this bat. Post-construction mortality studies have not been conducted at the majority of wind energy facilities in TX or NM where large colonies of Brazilian free-tailed bats are known to reside (Kunz et al. 2007b). High proportions of Brazilian free-tailed bat fatalities (41.3% and 85.6% in CA and OK, respectively) were documented at the only 2 post-construction mortality studies conducted at wind facilities within their range (Arnett et al. 2008).

In summary, it is clear that bats are being killed by wind turbines throughout the United States and Canada, with higher mortality occurring in the eastern United States along forested ridges and some agricultural facilities in the Midwest. Out of the 45 bat species in the United States, 11 have been documented as fatalities at wind farm sites and studies have found that migratory bat species have constituted 75% of all bat fatalities. Data indicated that risk for *Myotis* species, such as the Indiana bat, is significantly less than other migratory bat species, although risk may vary by site, and may be influenced by geographic variation, the habitat in which the wind turbines are sited or other factors. Indiana bats are at risk, as evidenced by 3 confirmed fatalities and the likely occurrence of undocumented fatalities due to a lack of post-construction monitoring or difficulty of detecting the species. However, these 3 fatalities represent the only Indiana bat fatalities documented to date, and therefore the degree to which Indiana bats are at risk is highly uncertain.

4.5.5.2.2 Seasonal Timing

While not all post-construction mortality studies have monitored bat mortality over the entire period in which bats are active (generally Apr through Nov), bat fatalities consistently have been found to be episodic and concentrated in the late summer dispersal and fall migration periods. This has been the case, with few exceptions, across all geographic areas within which post-construction mortality monitoring has been conducted (Young et al. 2003, Kerns and Kerlinger 2004, Johnson 2005, Nicholson et al. 2005, Kunz et al. 2007b, Fiedler et al. 2007, Arnett et al. 2008, Gruver et al. 2009, Drake et al. 2010, Stantec 2010c).

A long-term study at Buffalo Mountain, TN, from 2000 to 2003 and 2005 documented 75% of bat fatalities between early August and mid-September, although peaks in mortality varied slightly across years. From 2000 to 2003, 82.4% of fatalities occurred from 16 July to 30 September, with the majority (53.8%) occurring from 16 August to 15 September (no fatalities were documented after 31 Oct; Fiedler 2004). The seasonality of fatalities in 2005 was similar, with 84.9% of fatalities occurring between 16 July and 30 September. The peak, however, was more concentrated in 2005, with the majority (55.9%) of fatalities occurring between 16 August and 31 August (no fatalities were documented after 15 Oct; Fiedler et al. 2007). Bat fatality patterns at the recent Blue Sky Green Field study also documented a peak in mortality during August and September (Gruver et al. 2009). Studies from Germany also supported this pattern of seasonal fatality during the fall migration period (Durr and Bach 2004, Brinkmann 2006).

Bat mortality during the spring migration period has consistently been lower than mortality documented during the fall. One noted species-specific exception to this has been documented for silver-haired bats. At Buffalo Mountain, TN, 15 of 18 silver-haired bats (83%) were found between mid-April and early-June 2005 (Fiedler et al. 2007), although this pattern was not observed in studies conducted from 2000 to 2003 at the same site. Spring mortality of silver-haired bats was also documented, though in lesser numbers, at Summerview, Alberta; 16 of 272 (6%) silver-haired bat fatalities were found in May and June. These studies suggest that spring migration may be a period of risk particularly for silver-haired bats (and not the other species of long-distance migrants [i.e., hoary bats, eastern red bats, and western red bats]) at some wind facilities.

Data from post-construction studies compiled by the USFWS suggest that *Myotis* mortality patterns are consistent with that observed for long-distance migrants, with the majority occurring in the late summer/fall period (Jennifer Szymanski, USFWS, and Megan Seymour, USFWS, personal communication). Of the total 3,433 bat fatalities documented in 26 mortality monitoring studies conducted within the range of the Indiana bat, there were a total of 225 little brown bat fatalities (0.07%). Using 7 studies that conducted monitoring for the spring through fall period, 8%, 34%, and 58% of *Myotis* fatalities occurred in the spring, summer, and fall, respectively, with seasons defined as spring: 1 April to 30 May; summer: 1 June to 31 July; fall: 1 August to 30 November. This is similar to the proportions observed for all bat fatalities: 3%, 11%, and 86% (does not add to 100% because of rounding effects) in that most of the mortality occurred in the fall.

While a correlation between bat mortality and pre-construction acoustic studies has not been established, acoustic results are consistent with general bat mortality trends. Bat activity as measured by acoustic detectors during 2002 and 2003 in TN support some seasonal pattern of bat fatalities. Bat activity levels increased in mid-July to early August, quadrupled by mid-August, and then decreased to previous levels by early to mid-September (Fiedler 2004). At the Maple Ridge facility in NY, Jain et al. (2007) found that bat fatalities were low in mid-June, peaked from mid-July to mid-August, and then declined precipitously through mid-November. Acoustic calls identified to the genus *Myotis* during 2008 acoustic surveys conducted for the Project were consistent with these patterns. As shown in Figure 4-10, the majority of *Myotis* activity in the initial study area was recorded during the late summer and early fall period. Average *Myotis* bat activity across all detectors was 26%, 28%, and 47% in the spring, summer, and fall respectively[22]. However, 72% of summer calls occurred during the late summer dispersal period (15 July to 31 July), which is the period of overlap when both summer foraging and migration may be occurring. These acoustic activity patterns indicate that the majority of *Myotis* activity in the Action Area would occur in the late summer and early fall period consistent with bat mortality data from other projects. This pattern may have been more pronounced if acoustic surveys were continued beyond 3 September 2008, as other studies have shown fall bat activity to remain high throughout the month of September (see above discussion).

[22] Note that due to detector malfunction, some detectors had incomplete recordings for each season. Detectors with less than an 80% success rate were not included in the summary of activity per season.

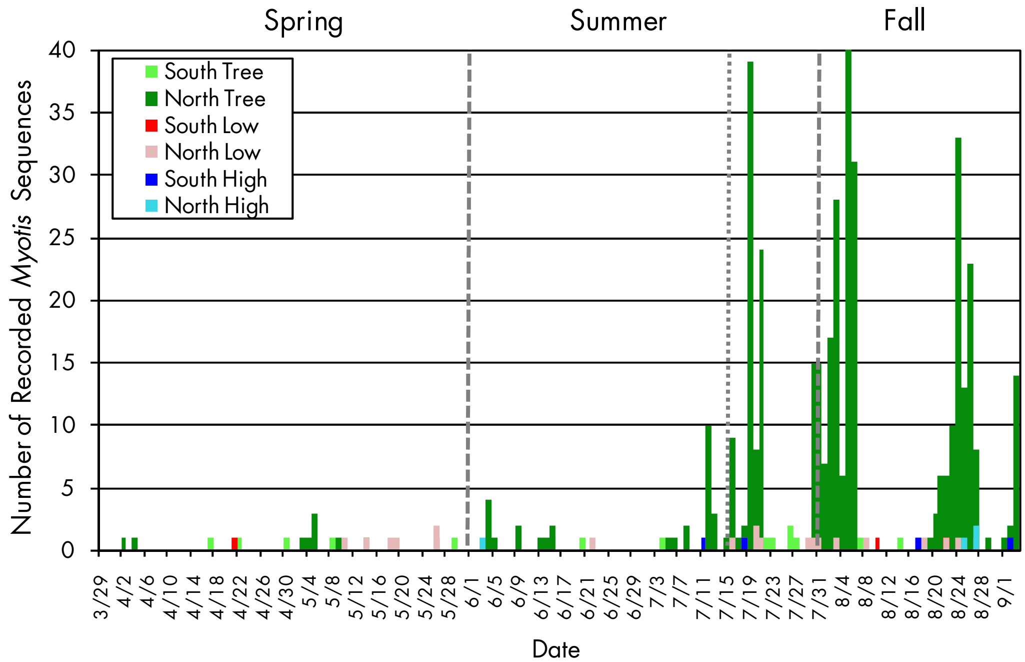

Figure 4-10. Number of *Myotis* call sequences per night recorded at 6 Anabat detectors deployed at 2 m (7 ft), 20 m (66 ft), and 40 m (131 ft) from 29 April to 3 September 2008 at 2 60-m (197-ft) MET towers in the Buckeye Wind initial study area (includes Action Area as well as area to the north), Champaign County, OH. (Note: data for the North tree detector is included in this figure; however, the detector success rate was less than 70% with detector malfunction from 5/27 to 6/1, 7/22 to 7/29 and 8/7 to 8/17. The proportion of late summer/fall detection rates therefore could be more pronounced.)

A further indication that the fall period represents the season with highest mortality risk is data from the USAF compiled by the National Museum of Natural History, Smithsonian Institution. These data lend support for the seasonal nature of bat mortality from collision with human structures. Of the 821 bat collisions reported to the USAF aircraft from 1997 through 2007, mortality peaked during the spring and fall, with more than 57% occurring from August through October (Peurach et al. 2009).

4.5.5.2.3 Nightly Timing

There may also be differences in the timing of mortality at finer temporal scales. It has been suggested that nightly foraging activity of all insectivorous bats studied to date can be characterized as bimodal (Erkert 1982), the result of 2 foraging periods interrupted by night roosting (Anthony et al. 1981). This bimodal pattern has been described as being especially apparent in lactating female bats because they must return to maternity roosts to feed young (Swift 1980, Maier 1992). Fluctuation in insect abundance also has been shown to follow bimodal patterns (Swift 1980), which may drive patterns of nightly activity observed for bats (Racey and Swift 1985, de Jong and Ahlén 1991).

Bat activity monitored in acoustic studies conducted at Buffalo Mountain, TN, documented a bimodal pattern of nightly activity during some years of study, but not in others (Fiedler 2004). Erkert (1982) postulated that insectivorous bats would be unlikely to follow the usual bimodal pattern under conditions of low prey density which would cause bats to forage more continuously throughout the night. Thus, Fiedler (2004) speculated the wet and cool weather conditions in 2003 may have explained why bimodal activity was not observed during this year of study, compared with the bimodal pattern observed in 2002.

Another possible explanation for deviations from Erkert's (1982) bimodal foraging activity theory could be related to species-specific patterns. Nightly activity of Myotis as determined from 34,030 Myotis call sequences recorded during acoustic surveys conducted by Stantec (described in detail in Section 4.4.4.2 – Foraging and Traveling Behavior) showed more of a unimodal pattern of activity. Hours after sunset were calculated as the difference between the timestamp on each acoustic file and the sunset time for that unique date and location with seasons defined as spring 1 April to 31 May; summer 1 June to 31 July; and fall 1 August to 31 October. Figure 4-11 (Stantec unpublished data 2010) showed Myotis activity peaking during the period from the first 1 hr to 6 hr after sunset and declining steadily thereafter. The observed pattern was apparent during all seasons but most pronounced during fall.

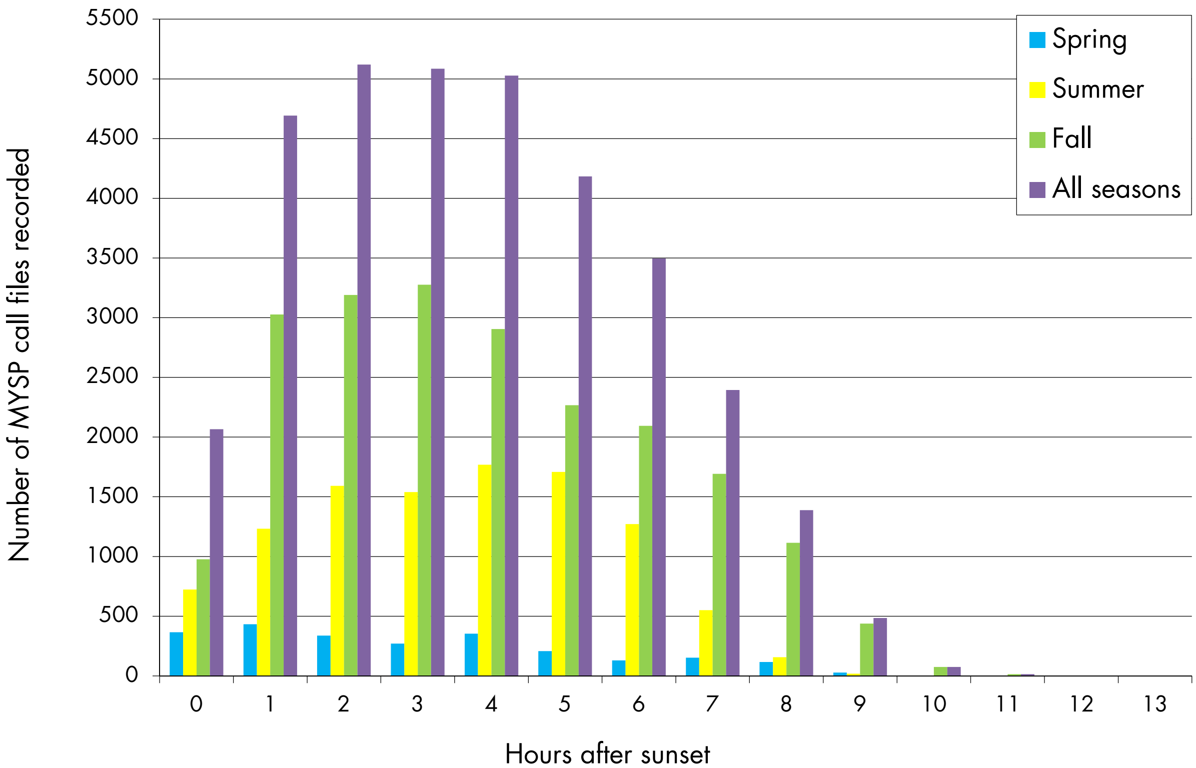

Figure 4-11. Number of Myotis call sequences recorded using 96 Anabat detectors during acoustic surveys from 2005 to 2009 at 19 proposed wind power facilities in ME, NH, NY, OH, VT, and WV.

Few studies have attempted to determine the timing of fatalities within a given night due to the difficulty of determining exact time of death. Fiedler et al. (2007) assessed hourly timing of fatalities for all species during searches on a few nights within a peak mortality window. There was no apparent hourly periodicity of bat mortality. However, small sample size and number of nights monitored may have obscured any existing hourly patterns.

Data from bat strikes with USAF aircraft may provide useful information in the absence of timing information associated with post-construction mortality monitoring. Of 174 bat strikes with USAF aircraft in the United States from 1997 to 2007 for which time and place of impact were known, more than 84% occurred between 1901 and 0200 (Peurach et al. 2009). As previously discussed, the majority of these bat strikes occurred during the spring and fall migratory periods and are, therefore, presumably related to patterns of activity during migration rather than during summer foraging.

4.5.5.3 Behavioral Risk Factors

It is not well understood why long distance migratory species appear to be most at risk from wind turbines (Howe et al. 2002, Cryan and Brown 2007, Kunz et al. 2007a) or why there are higher levels of mortality in the fall migration period compared to the spring. There are several hypotheses that suggest certain migratory and/or mating behaviors unique to migrant species make them more susceptible to collision with wind turbines, especially during the fall migration period (Cryan and Brown 2007). Long distance movements may result in greater exposure to wind facilities over a larger area. Hoary bats do not hibernate in caves but instead perform cross-continental migration movements to winter in warm climates (Cryan 2003, Cryan et al. 2004, Cryan and Brown 2007). Silver-haired bats have also shown movement at the continental scale, although migration patterns may differ between western and eastern groups (Cryan 2003).

Collision risk may also be elevated in migrating bats because they may travel without or with reduced use of echolocation (Van Gelder 1956, Griffin 1970, Crawford and Baker 1981, Timm 1989, as cited by Johnson and Strickland 2003, Johnson et al. 2003a, 2003c). There is evidence that bats use vision rather than echolocation to navigate during long-distance flights (Mueller 1968, Williams and Williams 1970, Fenton 2001 as cited by Johnson and Strickland 2003) which may make it more difficult to maneuver effectively around turbines. Cryan and Brown (2007) suggested mating behavior may play a role in elevated risk to hoary bats. Migrating hoary bats, and perhaps other species of Lasiurines, may orient toward and congregate around the tallest, most highly-visible landscape structures during the fall to locate potential mates.

Bats may follow different migration routes or patterns during the spring versus fall, similar to avian migration patterns (e.g., Cooke 1915; Lincoln 1950; Richardson 1974, 1976 as cited by Johnson and Strickland 2003). Hoary bats have been observed flying in clusters during the fall, compared to more scattered formations during the spring (Zinn and Baker 1979 as cited by Johnson and Strickland 2003). It also has been suggested that late-summer and early-fall peaks in mortality could be associated with increased numbers of volant juveniles who suffer higher mortality due to lack of experience, yet results of monitoring studies generally do not support this hypothesis (Arnett et al. 2008).

4.5.5.3.1 Flight Behavior

Morphological differences that affect flight characteristics, foraging habitat selection, and flight height (Aldridge and Rautenback 1987) have been suggested to influence collision risk. Bat species assemblages and activity levels have been found to vary by vertical strata and habitat types because wing morphology affects maneuverability within structural clutter (Norberg and Rayner 1987, Crome and Richards 1988, Bradshaw 1996, Lance et al. 1996, Kalcounis et al. 1999, Hayes and Gruver 2000, Menzel et al. 2000).

Species within the genus Myotis have average to low wing loading and a low aspect ratio, which allows for slow but agile flight (Norberg and Rayner 1987). This agility allows Myotis to forage in more cluttered environments. In a study conducted by LaVal et al. (1977) in MO, gray, little brown, northern long-eared, and Indiana bats all foraged in relatively cluttered environments to varying degrees. Gray bats foraged in riparian areas and over water, while little brown bats foraged along forest edges and within the forest. Both northern long-eared and Indiana bats were clutter foragers and foraged in forested areas, but Indiana bats foraged primarily in the canopy, while northern long-eared bats foraged below the canopy but above the understory shrub layer, suggesting vertical stratification of resource use.

In contrast, hoary and red bats have relatively high wing loading and aspect ratios and are thus adapted for fast, relatively unmaneuverable flight, which necessitates foraging in open areas with limited vegetative clutter (Farney and Fleharty1969, Barclay 1985, Norberg and Rayner 1987). Barclay (1985) described hoary bats as using long-range prey detection and pursuit foraging strategies, flying rapidly along straight line paths in open areas and using echolocation calls designed to detect insects at a distance. Similarly, LaVal et al. (1977) found that hoary and red bats tended to forage in open areas away from forest clutter, including high over the forest canopy and open fields.

While the lack of maneuverability may be an explanation for the disproportionate mortality rates for these species at wind facilities, it is unlikely that it is the only reason. These morphological differences primarily influence foraging behavior and their influence on migratory behavior is unknown. Species with similar morphological characteristics and flight behaviors as hoary and red bats, such as big brown bats (Barclay 1985, Menzel et al. 2005), have not experienced similar mortality rates at wind facilities (Arnett et al. 2008). Menzel et al. (2005) reported significantly greater big brown bat activity levels above the forest canopy than within or below it. Conversely, silver-haired bats have experienced relatively high rates of mortality at wind facilities, yet they fly slowly, are highly maneuverable, use echolocation calls that support a short-range foraging strategy, and are more commonly detected at ground level than hoary bats (Barclay 1985).

4.5.5.3.2 Flight Height

Although relatively little is known about the foraging behavior of bats during migration, flight altitude is likely an important factor contributing to collision risk for different species. Eastern red bats were visually observed flying during the day from 46 m to 140 m (151 ft to 459 ft) agl over Washington, D.C. (Allen 1939 as cited by Johnson and Strickland 2003). High altitude flights of Brazilian free-tailed bats have been documented in several publications (Williams and Williams 1967, Williams et al. 1973). Brazilian free-tailed bats have been recorded as high as 1,500 m (4,921 ft) while foraging on migrating insects (McCracken et al. 1996, 1997 as cited by Fiedler 2004).

Increased efforts to track bat collisions with aircraft have improved our knowledge of bat flight altitudes. Williams and Williams (1967) and Linnell et al. (1999) suggested most bat strikes with aircraft occurred at heights less than 300 m agl during take-off and landing. Records compiled from 1997 to 2007 for bat collisions with USAF aircraft documented bat strikes occurring as high as 2,500 m agl and showed that bat strikes often occur at altitudes higher than previously thought (Peurach et al. 2009). Of the 147 records of bat strikes that occurred in the United States in which the pilot recorded the altitude, 36% occurred between 300 m and 3,000 m (984 ft and 9843 ft) agl, with the average altitude reported as 345 m (Peurach et al. 2009). Peurach (2003) reported a hoary bat from a USAF strike at 2,500 m agl, which is the highest flight altitude known for this species. Given their high flight altitudes, it is not unexpected that Brazilian free-tailed bats comprised 43% of strikes with USAF aircraft (Peurach et al. 2009).

Myotis flight heights generally are thought to be low relative to long-distance migrant species. Bat strike data with USAF aircraft for *Myotis* support this assumption, as only 1% of USAF bat aircraft strikes were reported for *Myotis* from 1997 to 2007. Similarly, Williams and Williams (1967) did not report any *Myotis* in aircraft strikes at a study at Randolph Air Force Base, TX, despite observations of *Myotis* flying around buildings and light sources. Based on the 10-year USAF bat-strike database, Peurach et al. (2009) posited that it is likely that the bats struck by aircraft are flying in more open space and at greater heights while migrating or feeding, and locally common, resident bats infrequently encounter flying aircraft.

This is consistent with observations of *Myotis* flight altitudes in other studies. A PA study examined the influence of canopy height and structure on flight behavior (among other things) of a maternity colony that was largely composed of little brown bats, but also included Indiana bats (Russell et al. 2008). There were a total of 26,442 observations over 9.2 hr of bats crossing a heavily trafficked highway en route to foraging areas. Bats used canopy cover when approaching the highway from roosts, fewer bats crossed in areas lacking canopy cover, and bats crossed lower and closer to traffic where adjacent canopy was low (≤6 m; 20 ft). During the same study, more than 1,700 observations of bats crossing a mowed field (55 m [180 ft] wide) revealed that the vast majority of commuting individuals flew less than 2 m (7 ft) agl. Other studies have also documented Indiana bats flying relatively low to the ground while foraging (i.e., between 2 m and 30 m [6 ft to 100 ft.] agl, Humphrey et al. 1977, Brack 1983, Gardner et al. 1989).

Data regarding the height Indiana bats fly during migration are severely lacking, but there are 2 emerging viewpoints based on anecdotal and empirical data compiled by the USFWS (USFWS 2011a): Indiana bats fly at or below tree canopy height, and they fly considerably higher than tree canopy height. L. Robbins (Missouri State University, personal communication as cited in USFWS 2011a) argues that detection of Indiana bats above 10 m (33 ft) is rare during any part of their active season. Turner (2006) suggested that migrating Indiana bats may be flying low to the ground based on radio telemetry data from over 20 Indiana bats emerging from PA hibernacula, 1 of which was documented flying under Interstate 80 (I-80). Similarly, based on observations of over 100 Indiana bats tracked during spring and fall migrations, J. Chenger (BCM, personal communication) suspected migrating Indiana bats were flying low to the ground based on aircraft and ground telemetry data. This is also consistent with acoustic data collected by Stantec, presented in Section 4.4.4.2 – Foraging and Traveling Behavior, which found *Myotis* activity at 50 m (164 ft) was about 3% of activity at ground level.

However, the reliability of these data is uncertain because acoustic studies may not detect higher flying bats and while radio telemetry can detect higher flying bats, it cannot distinguish flight height. Additionally, radio telemetry studies to date have largely been conducted in the east and Indiana bat flight behaviors observed in these studies may not hold true for Indiana bats in other regions that likely migrate across large expanses of open terrain. Although it is not known if migrating Indiana bats follow certain landscape features, given the long migratory distances documented for Indiana bats in the Midwest RU, it is likely that Indiana bats have to fly over areas devoid of tree canopy during some portions of their journeys which may necessitate different flying behaviors. Further, Indiana bat researchers, V. Brack and D. Sparks (as per M. Seymour, USFWS, personal communication), have observed Indiana bats above tree canopy, approximately 60 m to 90 m (200 ft to 300 ft) agl.

Despite these uncertainties, several lines of evidence together point towards *Myotis* flying at relatively low heights, compared with species of long distance migrants. Observations from radio telemetry migration studies (J. Chenger, BCM, personal communication, Turner 2006), summer foraging observations (LaVal and LaVal 1980, Russell et al. 2008, others), aircraft bat strike data (Peurach et al. 2009), acoustic studies associated with pre- and post- construction studies at wind facilities (Stantec unpublished data, Reynolds 2006, Fiedler 2004), morphological characteristics (i.e., low aspect ratio and high wing loading), and echolocation call signatures adapted to cluttered environments (Saunders and Barclay 1992) all point towards *Myotis* flights predominately occurring below the rotor swept zone during migration and summer foraging and traveling activities. These low flight heights may help explain why *Myotis* are reported less frequently colliding with wind turbines (Arnett et al. 2008), aircraft (Williams and Williams 1967, Peurach et al. 2009), and other tall anthropogenic structures (discussed in detail in Section 4.5.5.6 – Bat Collision with Other Structures) than other groups of bats, particularly long-distance migrants.

Bat Attraction to Wind Facilities

Bats may be killed in higher than expected numbers at wind facilities because they are attracted to turbines or some other feature, or combination of features. Horn et al. (2008) observed the flight altitude, direction, and types of flight maneuvers of bats, birds, and insects at night during nightly 9-hr sessions of thermal infrared (TIR) video. Bats were observed actively foraging near operating turbines, approaching both rotating and non-rotating blades and monopoles, following or becoming trapped in blade-tip vortices, investigating various parts of the turbine with repeated fly-bys, and being struck directly by rotating blades. According to Horn et al. (2008), bats observed in the study may have been investigating the turbines as roosting, foraging or mating sites. Thus, risk of collision or barotrauma could disproportionately affect bats that may be flocking to turbines in association with mating behavior (Cryan and Brown 2007, Horn et al. 2008) or for foraging or roosting purposes (Horn et al. 2008).

Other theories as to why bats may be attracted to wind facilities exist; however, to date there are few empirical data to enable further understanding of these assumptions. Kunz et al. (2007b) proposed 11 hypotheses to explain where, when, how, and why insectivorous bats are killed at wind energy facilities. Several of these included ideas about possible attraction.

- Linear corridor hypothesis– wind energy facilities constructed along forested ridgetops create clearings with linear landscapes that are attractive to bats;
- Roost attraction hypothesis– wind turbines attract bats because they are perceived as potential roosts;
- Landscape attraction hypothesis– bats feed on insects that are attracted to the altered landscapes that commonly surround wind turbines;
- Heat attraction hypothesis– flying insects upon which bats feed are attracted to the heat produced by nacelles of wind turbines;
- Visual attraction hypothesis– nocturnal insects are visually attracted to wind turbines; and
- Thermal inversion hypothesis– thermal inversions create dense fog in cool valleys, concentrating both bats and insects on ridgetops.

Few data are currently available to either support or refute the hypotheses put forward by Kunz et al (2007b). However, in their study of ultrasound emissions from a variety of wind turbines as a potential attractant to bats, Szewczak and Arnett (2006) found evidence to suggest that the "acoustic attraction hypothesis" is not playing a significant role in attracting bats toward wind turbines with consequential fatalities from rotor strikes (see additional discussion of the effects of sound produced by turbines in Section 5.1.2.1 – Sound from Operating Turbines).

4.5.5.4 Influence of Weather

Bats are known to suppress their activity during periods of rain, low temperatures, or strong winds (Erkert 1982, Adam et al. 1994, Erickson et al. 2002, Russo and Jones 2003). Weather variables such as wind speed, temperature, and barometric pressure have been found to influence bat activity and mortality rates at some wind facilities. Of the 21 post-construction monitoring studies reviewed by Arnett et al. (2008), studies that addressed relationships between bat fatalities and weather patterns found disproportionate number of bats were killed on nights with low wind speed (<6 m/s) and fatalities increased immediately before and after passage of storm fronts. Horn et al. (2008) also reported blade rotational speed was a significant negative predictor of observed collisions with turbine blades, suggesting that bats may be at higher risk of fatality on nights with low wind speeds. The association of bat activity with wind speed is expected because bat flight ability is limited by wind strength, as is the flight ability of their insect prey (Fiedler 2004). Pre- and post-construction acoustic monitoring has also documented a negative relationship with average nightly wind speed (Fiedler 2004, Reynolds 2006). Reynolds (2006) found bat activity to be highest on nights with wind speeds less than 5.4 m/s during the spring migratory period at the Maple Ridge, NY, wind facility. Bat activity levels at Buffalo Mountain, TN also showed a negative association with average nightly wind speeds (Fiedler 2004).

Positive correlations between bat activity and temperature have been documented, both on a nightly basis (Lacki 1984, Negraeff and Brigham 1995, Hayes 1997, Vaughan et al. 1997, Gaisler et al. 1998, Shiel and Fairley 1998) and annual basis (O'Farrell and Bradley 1970, Avery 1985, Rydell 1991). Associations between temperature and bat fatalities in post-construction monitoring studies have been less consistent than for wind speed. While a correlation between temperature and bat fatalities was not documented at Mountaineer, a positive association between temperature and fatalities was documented at Meyersdale (Kerns et al. 2005). Pre- and post-construction acoustic surveys at wind facilities have found bat activity to be negatively correlated with low nightly mean temperatures (Fiedler 2004, Reynolds 2006). For example, Reynolds (2006) found no detectable spring migratory activity on nights when daily mean temperature was below 10.5°C (50.9°F). Bat activity at Buffalo Mountain, TN, from 2000 to 2003 was most closely correlated with average nightly temperatures among the variables considered (Fiedler 2004). This is consistent with observations of J. Kiser (Stantec, personal communication) during 19 years of summer mist-netting surveys in the midwestern and eastern United States. According to Kiser, bat activity predictably declined once nighttime temperatures dropped below approximately 12°C (54.5°F). The data presented in the studies above, and other experiences, have led to the general conclusion among experts that,"…among all bat species…activity declines in heavy rain, high wind, and cold (some specifically mentioned temperatures below 50°F – 55°F) – conditions that impair flight or ability to thermoregulate, or reduce insect activity" (USFWS 2011a).

Unlike avian turbine collision, inclement weather (e.g., low fog or cloud ceilings or stormy conditions) does not appear to be strongly correlated with bat mortalities. At sites in MN, WY, and TN, bat collisions with wind turbines occurred during clear weather approximately one-third to one-half of the time (Johnson et al. 2000; Young et al. 2003; Nicholson 2001, 2003 as cited by Johnson and Strickland 2003; Fiedler et al. 2007). Consistent with this, Kerns et al. (2005) reported few bat fatalities were discovered during storms, contrasted by high bat fatalities before and after the passage of frontal systems, especially on low wind nights at Mountaineer and Meyersdale.

Barometric pressure, temperature, and relative humidity are all interrelated and are associated with passing storm fronts. There is some evidence that higher barometric pressure is associated with higher mortality. Good et al. (2011) found that mortality increased with increasing barometric pressure; and barometric pressure was higher than normal on the night when Indiana bat mortality occurred. However, barometric pressure was lower than normal on the night with the most overall mortality (Good et al. 2011). Barometric pressure was positively associated with mortality at Mountaineer and Meyersdale (Arnett et al. 2008).

Fiedler (2004) found that mortality was positively associated with average nightly wind direction. One explanation may be that mortalities increased as wind direction deviated from the predominant, southwestern, wind direction. Further, increased mortalities on nights with more northerly winds may be a result of more bats moving during weather conditions conducive to migration.

The correlations between wind speed and mortality are reinforced by operational curtailment and feathering experiments that demonstrated reductions in bat mortality by increasing the speed at which turbines become operational, or the cut-in speed. At the Casselman wind facility in PA over 2 years of experimental study during the peak fall migration period, total fatalities at turbines operating at the manufacturer's specified cut-in speeds were estimated to be 5.4 (2008) and 3.6 (2009) times greater on average than at turbines feathered at wind speeds of 5.0 and 6.5 m/s[23]. Overall, 83% (95% confidence interval [CI] = 52% to 93%) of fatalities in 2008 and 72% (95% CI = 44% to 86%) of fatalities in 2009 at experimental turbines likely occurred when the turbines were operating at the manufacturer's specified cut-in speeds. A similar feathering study in southwest Alberta, Canada (Baerwald et al. 2008a), documented a 60% reduction in fatality at turbines with cut in speeds of 5.5 m/s. A recent study in IN found that bat fatalities were reduced by a mean of 50% (90% CI = 38% - 60%) at 5.0 m/s and 79% (90% CI = 71% - 85%) at 6.5 m/s (Good et al. 2011)[24] when curtailment was employed. During a subsequent study at the same facility in 2011, use of feathering and cut-in speeds of 3.5 m/s, 4.5 m/s and 5.5 m/s resulted in mean bat fatality reductions of 36.3%, 56.7% and 73.3%, respectively (Good et al. 2012)[25]. According to Arnett et al. (2010), similar reductions in mortality were reported in Germany by O. Behr (University of Erlangen), but no further information on this study is available. Thus, this study will not be discussed further in this HCP.

4.5.5.5 Turbine Dimensions and Lighting

Limited data suggest that turbine height may influence the risk of bat collision with wind turbines. Barclay et al. (2007) found that turbine height potentially influenced the number of bat fatalities in their review of post-construction mortality studies at 6 wind facilities in 7 states. While avian mortality remained constant with turbine height, the number of bat fatalities increased with increasing turbine height; turbines with more than 65 m (213 ft) nacelle height had the highest mortality rates among bats. The authors suggest the discrepancy between avian and bat mortality relative to turbine height could be related to differing migratory flights heights. Somewhat consistent with this, at Buffalo Mountain mortality rates were almost 2 times as numerous at larger turbines (78 m [256 ft] nacelle height; 69.6 bats per turbine per year) compared with that at smaller turbines (65 m [213 ft] nacelle height; 35.2 bats per turbine per year). However, sample sizes were highly unequal (i.e., 3 smaller [0.66 MW] turbines compared with 15 [1.8 MW] larger turbines) and on a per MW basis there were fewer fatalities at larger turbines (i.e., there were 53.3 bats per MW killed at 0.66 MW turbines compared with 38.7 bats per MW killed at 1.8 MW turbines, Fiedler et al. 2007). At the Buffalo Ridge facility, MN, taller turbines with greater rotor-swept areas caused higher numbers of bat fatalities per turbine and per MW compared with smaller turbines (Johnson et al. 2003a, 2004).

Limited data also suggest that rotor swept area may influence the risk of bat collision with wind turbines. Three turbine models are operating at the Fowler Ridge Wind Facility; all 3 have the same turbine height but each has a different rotor diameter (Good et al. 2011). Bat mortality increased with increasing rotor diameter, and the effect was significant even after adjusting for all other coefficients tested (Good et al. 2011).

Although bats are known to aggregate near lights (e.g., street lights) to forage on insects (Furlonger et al. 1987, Fenton 1997), studies conducted to date do not indicate increased collision risk for turbines lit with FAA-regulation red strobe lights on nacelles. While some birds were attracted to certain types of steady burning, non FAA-regulation lights at Mountaineer (i.e., sodium vapor lighting, Kerns and Kerlinger 2004

[23] There was no statistical difference in fatality reductions at the 2 cut-in speeds. However, Arnett noted that "we found little differentiation in the amount of time different cut-in speed treatments were in effect…which may explain in part why we found no difference in bat fatalities between the two treatments" (Arnett et al. 2011).

[24] There was a statistical difference in reductions between these 2 treatments (Good et al. 2011).

[25] This data was not used to calculate estimated take in Section 5.1.2.6 – Collision/Barotrauma Mortality because it was not available at the time the Draft HCP was completed and because it includes a range of cut-in speeds that are not included in the Proposed Action.

as cited by Kerns et al. 2005), data from post-construction mortality studies at Mountaineer and Meyersdale did not indicate a difference in bat fatalities at lit and unlit turbines (Kerns et al. 2005). This is supported by other post-construction mortality studies (Erickson et al. 2003a, as cited by Johnson and Strickland 2003, Johnson et al. 2003a, Fiedler et al. 2007), as well as the Horn et al. (2008) TIR camera study that found no significant difference in bat activity at lit and unlit turbines. While no studies to date indicate increased collision risk at lit turbines, controlled studies comparing fatalities at red and white FAA lights have not been conducted and response to white lights is unknown (Arnett et al. 2008).

4.5.5.6 Bat Collision with Other Structures

Bat collisions with aircraft have been reported since 1967 (Williams and Williams 1967, Martin et al. 2005, Peurach et al. 2009) and bat collisions with tall anthropogenic structures including buildings, television and communication towers, lighthouses, fences, and power lines have been reported since 1930 (Saunders 1930, Van Gelder 1956, Zinn and Baker 1979, Avery and Clement 1972, Ganier 1962, Gollop 1965, Timm 1989, Terres 1956, Dedon et al. 1989 as cited by Johnson and Strickland 2003, Crawford and Baker 1981). Similar to mortality patterns at wind facilities and for bat-aircraft strikes (with the exception of Brazilian free-tailed and Seminole bats), the majority of recorded bat collisions with other structures has involved red, hoary, and silver-haired bats. The frequency and magnitude of fatalities resulting from collision with tall anthropogenic structures has been lower than those observed at wind turbines (Arnett 2005, Cryan and Veilleux 2007) and have been lower than reported bird fatalities (Anonymous 1961, Avery and Clement 1972, Elder and Hansen 1967, Ganier 1962, Overing 1936, Saunders 1930, Terres 1956, Timm 1989, Van Gelder 1956, Zinn and Baker 1979 as cited by Johnson and Strickland 2003, Crawford and Baker 1981).

Studies conducted to date suggest that bats are more at risk from rotating turbines than stationary structures. Of the 64 turbines studied at Mountaineer and Meyersdale in 2004, the only turbine with no observed fatalities was nonoperational throughout the study period (Kerns et al. 2005). The experts agree that there is no evidence that bats routinely collide with nonmoving blades or towers. Several cited data from specific wind facilities noted that while dead bats are routinely found at operational turbines, they are not found at non-operational turbines or MET towers (USFWS 2011a). MET towers searched at wind turbine sites in WY, TN, MN, and OR resulted in no bat collision mortalities (Nicholson 2003, Johnson et al. 2003b, Johnson et al. 2003c as cited by Johnson and Strickland 2003). Conversely, avian mortality at MET towers was 6 times higher than at wind turbines at a site in WY (Johnson et al. 2000).

5.0 IMPACT ASSESSMENT

According to the Section 7 implementing regulations (50 CFR Part 402.02), "effects" refer to the direct and indirect effects of an action on the covered species or its critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline. Direct effects are those that have an immediate effect on the species or its habitat. Indirect effects are those that are caused by the proposed action at a later time, but still are reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. Cumulative effects are those from future state or private activities (i.e., non-federal) that are reasonably certain to occur within an action area.

The following sections describe direct, indirect, and cumulative effects to Indiana bats that are expected to result from the 100-turbine Project, which are summarized in Table 5-1. Impacts to other bats and birds are addressed the EIS Section 5.6 and Chapter 4 of the ABPP (Stantec 2011a). Indiana bats are known to use the Action Area during the summer maternity period and are expected to travel through the Action Area during spring and fall migration (see Section 4.2.4 – Distribution in the Action Area). Based on genetic data and data from banding/telemetry studies (refer to Section 4.4.3 – Migration), it is highly likely that Indiana bats migrating through the Action Area are from the Midwest RU; therefore, all effects can be evaluated as they pertain to the Midwest RU or local populations.

A conditional CECPN has been issued for 52 turbines associated with the Project. A separate OPSB application for a CECPN (see Section 1.4.4 – Major Utility Facility Review) has been submitted for the Buckeye II Wind Project (see Section 2.1 – Applicant Background and Project History). This application has been submitted by Champaign Wind LLC, a seperate EverPower subsidiary. Construction of any of the additional turbines will not commence until the CECPN for Buckeye II Wind Project is issued. Due to the timelines for developing the OPSB application and HCP and uncertainty of the outcome of the CECPN process, the level of detail provided in the OPSB application and HCP are not identical. However, ample information has been included in this HCP to adequately assess the potential impacts to the Indiana bat (see Chapter 5.0 – Impact Assessment) from the full 100-turbine Project. The assessment in the HCP includes a reasonable worse case estimate of possible impacts for the 100-turbine Project and all 100 turbines will be constructed within the Action Area described in the HCP. The additional turbines, as described in the Buckeye II Wind Project OPSB application, will not result in a greater impact to the Indiana bat than what is described and analyzed in this HCP.

5.1 Direct Effects

5.1.1 Direct Effects – Construction and Decommissioning

5.1.1.1 Noise, Vibration, and Disturbance

Temporary increases in disturbance, such as noise, human activity, and vibrations from equipment are expected to result from construction and decommissioning activities. Noises associated with these activities will include sounds associated with diesel-powered earthmoving equipment such as irregular engine revs, back up alarms, gravel dumping, and the clanking of metal tracks (Hessler 2009). Construction activities are expected to occur during daylight hours throughout the year, although timing will favor non-inclement weather and activity is therefore likely to be heaviest during the spring, summer, and fall, with the tree clearing to be conducted between 1 Nov and 31 Mar. Construction activities will regularly move from place to place within the Action Area. The Project, including all 100 turbines, will be constructed within 1 to 2 construction phases; each phase is expected to continue for 12 to 18 months, with potential of overlap of the phases. The maximum potential construction disturbance at any particular location would occur over a few days to up to a few weeks. Similarly, decommissioning activities are estimated to take place over a limited time period, not to exceed approximately 1 year.

The distribution of construction/decommissioning activity is expected to result in limited disturbance to Indiana bats. While none of the 100 turbines will be closer than 2.9 km (1.8 mi) to any maternity roost tree identified in 2009, Indiana bats in the Action Area could be exposed to noise levels and vibrations that they may not have experienced in the past if unidentified maternity roosts are located in close proximity to construction or decommissioning activities. Some studies indicate that Indiana bats are sensitive to certain types of disturbance. Callahan 1993 and Sparks 2003 found that Indiana bats abandoned their primary roost trees near bulldozing activity, resulting in decreased Indiana bat abundance. Female bats in Illinois used roosts at least 500 m (1,640 ft) from paved roadways (Garner and Gardner 1992).

Table 5-1. Summary of direct and indirect effects to Indiana bats from the 100-turbine Buckeye Wind Power Project, Champaign County, OH.

Impact Description	Effect Type		Insignificant/ discountable	Likely to result in take
	Direct	Indirect		
Construction				
Noise, vibration, disturbance	X		X	
Vehicular collision	X		X	
Removal of wooded habitat				
Loss of roosting habitat		X	X	
Loss of foraging habitat		X	X	
Habitat fragmentation		X	X	
Increased energy expenditure		X	X	
Impacts to aquatic habitat				
Reduction of aquatic insect prey		X	X	
Reduced water availability and/or quality		X	X	
Increased energy expenditure		X	X	
Operation/Maintenance				
Sound from Operating Turbines	X		X	
Lighting	X		X	
Vegetative Control	X	X	X	
Collision with Vehicles	X		X	
Collision/barotrauma Mortality	X			X
Decommissioning				
Noise, vibration, disturbance	X		X	
Collision with Vehicles	X		X	
Impacts to aquatic habitat				
Reduction of aquatic insect prey		X	X	
Reduced water availability and/or quality		X	X	
Increased energy expenditure		X	X	
Mitigation				
Tree Planting	X		X	
Noise, human activity, disturbance	X		X	
Collision with Vehicles	X			
Invasive Species Control		X	X	
Tree Girdling		X	X	

Construction-related activities may disturb Indiana bats that roost or forage in habitat ranked as Category 1, 2, or 3 located near turbines, roads, transmission lines, or lay-down areas. However, construction and decommissioning activities are not expected to be concentrated near high quality Indiana bat roosting and foraging habitat, as they will take place within a very small proportion of this habitat available to Indiana bats in the Action Area.

Some studies suggest that Indiana bats may be able to tolerate loud noises and seemingly disturbing activities; Indiana bats used roosts near Interstate 70 (I-70) and in close proximity to the Indianapolis Airport, including a primary maternity roost tree that was located 600 m (1,970 ft) south of I-70. The colony occupied this maternity roost tree despite constant high levels of noise from I-70 and airport runways. However, their use of this seemingly suboptimal area could have been due to lack of a more suitable roosting area away from noise and disturbance, as the surrounding area was highly fragmented with limited forested habitat remaining (USFWS 2007).

Additionally, some studies suggest that Indiana bats shift their centers of activity to avoid disturbance. As discussed in Section 5.2.1.1 – Wooded Habitat Removal, Indiana bats frequently shift roosts (Kurta et al. 2002, Kurta 2005) and have been known to shift their centers of activity in response to changing resources (Kurta and Murray 2002, Kurta et al. 2002, Carter 2003). Indiana bats have been documented shifting their centers of activity by up to 4.8 km (3.0 mi) (T. Carter, Ball State University, personal communication) and have been documented traveling up to 6.0 km (3.7 mi) between roosts (Carter 2003). These findings provide support that Indiana bats can shift their summer activity centers relatively large distances when needed.

Construction/decommissioning activities will occur largely in agricultural areas where the sounds of tractors, trucks, and other agricultural machinery are commonplace. While Project construction activities may be longer in duration and are not exactly the same as agricultural activities, Indiana bats in the Action Area may already be used to roosting in proximity to loud, temporary noises and human activity associated with agricultural activities.

If construction-related activities cause injury to individuals that significantly alters their behavior patterns, this constitutes "harassment" under Section 9 of the ESA. However, as previously described, noise, vibration, or disturbance associated with construction and decommissioning activities is expected to occur in a very small portion of the Indiana bat suitable habitat available in the Action Area (0.8% of areas designated as Categories 1 – 3). Any shifts in activity that may occur are expected to be temporary, since construction activity is not likely to exceed a few weeks at any one location, and Indiana bats should be able to resume normal activities in vacated areas after construction has subsided. Thus, negative physiological effects such as increased energy expenditure and lost reproductive fitness are expected to be insignificant or discountable (i.e., too small to be detectable or measurable).

5.1.1.2 Collision with Vehicles

Although bats are very agile flyers, there is evidence that bats (including Indiana bats) can be killed by collision with vehicles. A single Indiana bat fatality along with multiple little brown bat fatalities were documented over a 36-day study resulting from presumed collision with vehicles on U.S. Route 22 in PA (Russell et al. 2008). These mortalities were associated with a highway located along a narrow road corridor (20 m [66 ft]) surrounded by forested habitat, between an active little brown bat maternity colony and a core foraging area. However, the highway traffic that was the subject of the Russell et al. (2008) study is very different from the traffic that will result from construction activities for the Project.

Vehicle activity associated with the Project will include large, slow moving construction vehicles that will make trips in and out of the Action Area along local and state roads that already support significant traffic. Major Project components, including sections of the turbines and construction materials (such as concrete), would be delivered to active construction areas via truck. These components would arrive via I-70, and/or US Route 33 and deliveries to the Action Area would be via US Route 36 and State Route (SR) 56, with other state and local roads used to access specific turbine sites or other Project facilities. Similar roads would be used to take Project components out of the Action Area during decommissioning.

Unlike the Russell et al. (2008) study, construction vehicles will not make frequent trips within road corridors that are likely to function as Indiana bat foraging or traveling corridors. Rather, vehicular activity will be spread throughout the Action Area (see access road layout in Figure 1-1), with temporary concentrations of activity near turbines being constructed. Additionally, the small amount of increased vehicular traffic associated with Project construction of the 100-turbine Project will occur over a limited time period, estimated to be between a total of 1 to 3 years between 1 or 2 construction phases, which would only partially include the Indiana bat active period and would occur mostly during day-light hours when Indiana bats are not flying. Similarly, decommissioning activities are estimated to take place over a limited time period, not to exceed approximately 1 year.

As a result of the factors discussed above, mortality of Indiana bats caused by vehicle strikes with construction or decommissioning vehicles is not likely. Thus, it is anticipated that vehicular traffic associated with the Project will result in direct effects that are insignificant and discountable and not expected to rise to the level of take.

5.1.2 Direct Effects – Operation and Maintenance

5.1.2.1 Sound from Operating Turbines

There is a potential for increased ambient sound generated by wind turbines to impact wildlife that reside within or near wind facilities. Operating wind energy facilities raise background sound levels, although the sound footprint of a given facility will vary based on turbine design (i.e., size and operating specifications) and existing ambient sound levels. The influence of turbine-generated sound on wildlife also varies with the auditory perception of the species exposed to the increased sound and the extent to which their life history strategies depend on sound.

Several studies investigating the effects of activities associated with high levels of anthropogenic noise (e.g., roads, oil and gas infrastructure, aircraft overflights) have documented effects to animal behavior, population demographics, and community composition in the vicinity (Barber et al. 2010). However, these noise sources generally produce a much higher sound level than would be expected to be produced by wind turbines. Also, because few of these studies isolated noise from other possible causes (e.g., road mortality, visual disturbance, chemical pollution, habitat fragmentation, increased predation, and invasive species along edges), the independent contribution of anthropogenic noise is uncertain (Barber et al. 2010). Despite the difficulties of isolating the effects of noise from other causal factors, recent studies provide support that increased ambient noise levels from human activities can interfere with animal perception of sounds and can impede acoustical communication, predator-prey interactions, reproductive success, and time-energy allocation (Barber et al. 2010).

Little is known about the effects to Indiana bats, or bats in general, from increases in ambient sound generated by wind turbines. Studies have shown that gleaning bats, or those that rely on prey-generated sounds to capture prey on the ground or foliage surfaces (Neuweiler 1989), are susceptible to the masking effects of sound emissions. A radio-tag study showed that a gleaning bat, Bechstein's bat (*Myotis* *bechsteinii*), was less likely to cross a roadway than was a sympatric open-space foraging bat, Barbastrelle bat (*Barbastella barbastellus*) (Kerth and Melber 2009, as cited in Barber et al. 2010). A laboratory study demonstrated that gleaning bats avoided hunting in the presence of played back road noise that contained energy between 3 kHz and 8 kHz (Schaub et al. 2008, as cited in Barber et al. 2010). Noise may therefore act as a fragmenting agent, similar to other forms of habitat fragmentation such as forest removal or alteration, for gleaning bat species (Barber et al. 2010).

Indiana bats hunt their prey in the air while flying, also known as hawking, using echolocation (an auditory behavior that uses ultrasonic signals to detect prey and maneuver through the environment). Thus, similar impacts from road-generated noise as those seen in gleaning bats are not expected in Indiana bats. Although Gardner et al. (1991a) found that Indiana bat roosts were further from paved roads than non-paved roads, the potential contributing effects of noise were not isolated from other potential causal factors in this study, such as the configuration and quality of the surrounding habitat, and it is unknown what effect noise of paved roads may have contributed to this observed difference.

Kunz et al. (2007b) suggested that bats may become acoustically disoriented upon encountering turbines during migration or feeding. However, observations of bat flight activity using TIR cameras at wind energy facilities suggest that bats are able to normally fly and forage in close proximity to wind turbines (Ahlén 2003 as cited in Kunz et al. 2007b, Horn et al. 2008). There is some thought that turbine-generated sound could attract bats to turbines and increase collision risk, because some bat species are known to orient toward distant audible sounds (Buchler and Childs 1981, as cited in Kunz et al. 2007b). However, Szewczak and Arnett (2006) studied ultrasound emissions from a variety of wind turbines as a potential attractant to bats and concluded that ultrasound emissions, as measured from the ground-level, do not likely play a significant role in attracting bats toward wind turbines with consequential fatalities from rotor strikes[26]. While the studies referenced above indicate that bats may not be affected by sound from operating turbines, there are no data that specifically addresses the impacts of sound from wind turbine operation on migrating or foraging Indiana bats.

None of the 100 turbines will be closer than 2.9 km (1.8 mi) to maternity roost trees documented in 2009 (see Section 6.1 – Avoidance Measures and 6.1.1 – Project Planning and Siting). Of the known turbine locations, 33 (63%) will be sited in Category 4 habitat, the lowest quality habitat for Indiana bats, where Indiana bats are least likely to forage so that exposure to sound from operation of these turbines is unlikely. Of the 52 known turbine locations, 3 turbines (6%) are in Category 1 habitat (highest quality habitat), 10 (19%) will be sited in Category 2 habitat, and 6 (12%) will be sited in Category 3 habitat. While the locations of the additional 48 turbines are not yet known, the majority of the Action Area (about 70%) is comprised of Category 4 habitat and open areas are generally preferable for siting of turbines over wooded areas. The distribution of the remaining 48 turbines among habitat categories will be similar to the distribution for the known 52 turbine locations (see Table 6-2, Section 6.1 – Avoidance Measures, and Section 6.1.1 – Project Planning and Siting).

Operational turbines that occur within proximity to undocumented roost trees or foraging areas may create sound that is detectable to Indiana bats that occur in these areas. No literature exists that describes how Indiana bats respond to operating turbines. Contributions from turbine sound are likely to be negligible in the context of overall ambient sound levels. Sound from wind turbines is very low, estimated to be quieter

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[26] The authors cautioned that ultrasound could be emitted from turbine models not tested during their investigation or from turbine nacelles.

than 50 db(A) (equivalent to a field with insects) approximately 200 feet from a turbine (Hessler 2009). Additionally, feathering of turbines at low wind speeds at night, which will be used as a tool to minimize impacts to Indiana bats, will also help reduce turbine-generated increases to ambient sound levels during times of increased bat foraging activity. During the summer months, when foraging success is critical for successful pup rearing, more restrictive nightly cut-in speeds would be applied to Project turbines located in the higher Habitat Categories roosting and foraging habitat. Thus, feathering would simultaneously reduce bat strike fatalities and keep ambient sound levels low during biologically critical periods and within ecologically important areas. Therefore, effects from sound at operating turbines are considered insignificant or discountable and take due to sound is not likely to occur.

5.1.2.2 Lighting

FAA lights that will be installed on some of the turbines are not expected to increase collision/barotrauma mortality or have any direct or indirect effects on Indiana bats. Arnett et al. (2008) synthesized available information on bat fatalities from 21 studies conducted at 19 wind energy facilities in 5 regions of the United States and 1 province in Canada. None of the studies reviewed demonstrated statistically significant differences in fatality between turbines equipped with FAA lights and those that were unlit. Further, Arnett (2005) studied bat activity and fatalities at the Mountaineer facility in WV and at the Meyersdale facility in PA and found that turbines with FAA lights did not appear to affect the incidence of foraging bats around turbines and there was no difference between numbers of bat passes recorded with acoustic detectors at lit and unlit turbines. Additionally, bat fatalities documented at the Mountaineer and Meyersdale facilities were not different between turbines equipped with FAA lights and those that were unlit. Finally, Horn et al. (2008) used TIR cameras to study behavioral responses of bats to operating wind turbines and concluded that aviation lighting did not appear to affect the incidence of foraging bats around turbines. However, controlled studies comparing fatalities at red and white FAA lights have not been conducted and response to white lights is unknown (Arnett 2008).

Regardless, Buckeye Wind will minimize turbine lighting per specifications of the FAA. Attached to the top of the some of the nacelles will be a single, medium intensity aviation warning light. The minimum amount of obstruction avoidance lighting specified by the FAA will be used (FAA 2007); approximately 1 in every 5 turbines will be lit, and all lights within the Project will illuminate synchronously. FAA lights are anticipated to be flashing red strobes (L-864) that operate only at night. Buckeye Wind will use the lowest intensity lighting as allowed by FAA. To the extent possible, USFWS-recommended lighting schemes will be used on the nacelles, including reduced intensity lighting and lights with short flash durations that emit no light during the "off phase". Further, MET towers will also utilize the minimum lighting as required by the FAA.

In addition to FAA lights, there may be a limited number of security lights that may be required at the substation and O&M facilities. However, operational lighting will be minimized to the maximum extent practicable and Project design will incorporate minimum intensity lighting on all Project structures, where feasible. Unnecessary lighting on the O&M building and substation will be eliminated to reduce attraction of bats at night (though no attraction of bats to building and substation lights has been documented, taking this step will reduce impacts to birds). No steady burning lights will be left on at Project buildings. Where lights are necessary for safety or security, motion detector lighting or infrared light sensors will be used to avoid continuous lighting. Any lights controlled by motion detector or infrared light sensors will be shielded downward to minimize skyward illumination, and high intensity, steady burning, bright lights such as sodium vapor or spotlights will not be used. Motion detector lights will be used above tower doors and at the substation for nighttime maintenance visits and for security. Thus, it is not anticipated that FAA or operations lighting will result in harm or mortality of Indiana bats; therefore, effects are insignificant or discountable and not likely to rise to the level of take.

See additional information on avoidance and minimization of impacts to bats and birds from lighting in the Buckeye Wind ABPP (Stantec 2011a) and in the EIS Section 5.6 and Section 5.1 of the ABPP.

5.1.2.3 Vegetative Control

To control the spread of invasive species, herbicides may be used around Project facilities, where needed. The vast majority of Project facilities will be located in areas that are currently used for agricultural purposes. Any areas of herbicide use will not extend outside of disturbed areas. Herbicides are commonly used in agricultural activities; therefore, the use of herbicides associated with the Project will not be significant as compared to current land use practices. As part of the monitoring outlined in Section 6.5.2.5 - Vegetation Management and Mapping, Buckeye Wind will mow the search areas of at least 25% of the turbines to increase searcher efficiency rates, unless other acceptable methods of searching become available (see Section 7.2.1.9 – Uses of New Methods, Information, or Technological Advances). Because the majority of turbines will be placed in agricultural areas and mowing will occur in areas that have been previously cleared of trees for agricultural purposes, mowing will not result in removal of Indiana bat habitat. No additional wooded areas beyond that which was removed during Project construction (see Section 5.2.1.1 – Wooded Habitat Removal) would be cleared in the Indiana bat active period during operation and maintenance. Human presence or noise from mowing equipment is expected to be similar to active agricultural operations that are ongoing in the Action Area and are not likely to result in disturbance to Indiana bats.

For the reasons stated above, ongoing vegetative controls associated with Project operation are insignificant and discountable and not likely to result in take of Indiana bats.

5.1.2.4 Collision with Vehicle

Although bats are very agile flyers, there is evidence that bats (including Indiana bats) can be killed by collision with vehicles (see Section 5.1.1.2 – Collision with Vehicles).

During Project operation and maintenance, vehicle activity associated with the Project will include maintenance vehicles traveling to various turbines daily. These vehicles will make trips in and out of the Action Area along local and state roads that already support significant traffic. Replacements for major Project components, including blades, generators and other components in the nacelle, would be delivered to active Project areas via truck. These components would arrive via I-70, and/or US Route 33 and deliveries to the Action Area would be via US Route 36 and SR 56, with other state and local roads used to access specific turbine sites or other Project facilities.

Vehicular activity will be spread throughout the Action Area (see access road layout in Figure 1-1), with temporary concentrations of activity near turbines during major maintenance activities. Additionally, the small amount of increased vehicular traffic associated with Project operation and maintenance of the 100-turbine Project will be insignificant compared to regular traffic in the Action Area and would occur mostly during day-light hours when Indiana bats are not active.

As a result of the factors discussed above, mortality of Indiana bats caused by vehicle strikes with operation and maintenance vehicles is not likely. Thus, it is anticipated that vehicular traffic associated with the Project will result in direct effects that are insignificant and discountable and not expected to rise to the level of take.

5.1.2.5 Collision/Barotrauma Mortality

As described in Section 4.5.5 – Collision Mortality at Wind Facilities, impacts to bats from wind facilities are well documented (Johnson et al. 2003a, Kunz et al. 2007a, Arnett et al. 2008), with long-distance migratory bats being the most affected, particularly during the late-summer through fall migratory period. Prior to fall 2009, no Indiana bats were known to have been killed at a wind facility. The 2 documented Indiana bat fatalities at the Fowler Ridge wind facility in Benton County, IN, the 1 documented Indiana bat at the North Allegheny wind facility in Cambria and Blair Counties, PA, and the 1 documented Indiana bat at the Blue Creek Wind Farm in Paulding County, OH, during the fall migratory periods of 2009, 2010, 2011, and 2012 confirm that Indiana bats are at risk of collision with wind facilities during the fall migratory period as reported by Good et al., 2011; risks to Indiana bats during spring and summer from operation of wind facilities within the homerange of maternity colonies remains unknown. While the male Indiana bat mortality documented at the Laurel Mountain Wind Farm occurred on July 9, risk is still considered low during spring and summer as compared to risk to fall migratory Indiana bats. These Indiana bat fatalities were likely not the first Indiana bats to have been killed at a wind facility; other Indiana bat mortalities probably have not been detected due to lack of post-construction monitoring at many wind projects, inaccurate identifications, lack of detection due to small size, decomposition of carcasses, or removal by scavengers. So while it is assumed that additional mortality has occurred, these fatalities represent the only documented taking of Indiana bats at wind facilities to date. Therefore, Indiana bats compose an extremely low proportion of total documented bat mortality at wind facilities. Because very low Indiana bat mortality has been documented, there is a lack of data on collision and barotrauma risk specific to the Indiana bat.

5.1.2.5.1 Collision Risk Model

The risk of Indiana bat collision with wind turbines in the Action Area is unknown and relatively few empirical data exist to inform assumptions about risk. The following section summarizes the results of a collision risk model (presented in full in Appendix A) that was used to estimate mortality of Indiana bats as a result of Project operation. The collision risk model was based on best available scientific information and included site-specific empirical data, as well as expert opinion and historical and current literature on Indiana bats. The collision risk model incorporated information on Indiana bat use of the Action Area, site characteristics, and a 100-turbine Project layout[27].

Mortality of Indiana bats was estimated during 3 periods in which Indiana bats display distinct behavioral characteristics that could differentially affect their exposure to wind turbines: spring emergence and migration, or "spring" (1 Apr to 31 May); summer habitat use, or "summer" (1 Jun to 31 Jul); and fall migration, or "fall" (1 Aug to 31 Oct). Although these seasons are presented as being discrete, it is expected that there is overlap in seasonal behaviors (i.e., migration and summer habitat use) between these defined periods. Variation in weather conditions and other stochastic factors could also affect the exact timing of this annual chronology. However, these periods are expected to adequately encapsulate seasonal behaviors that could differentially affect collision risk.

[27] For the CRM (see Appendix A), the 100 turbine locations were derived using the known 52 turbine locations and a random placement of the additional 48 turbines within suitable areas (excluding wooded areas, accounting for OPSB regulated setbacks to residences, roads, property lines, etc., and other restrictions). If the CRM estimates a higher take estimate with the final placement of the additional 48 turbines, adaptive management will maintain actual take numbers at the level requested in this HCP. No amendment to the take limit will be sought as a result of the final location of the additional 48 turbines.

Under conditions of high uncertainty, simple models with minimal inputs are generally preferred in the risk assessment literature to more complex models with large numbers of inputs (Warren-Hicks and Moore 1998). In cases where many key elements that affect risk are not well documented or understood, the use of simple models that incorporate uncertainty analysis focused on the model equations and inputs can provide decision-makers with a framework for understanding the degree of confidence that can be assigned to model outputs (Warren-Hicks 1999, Canham et al. 2003, Warren-Hicks and Hart 2010). The Bolker et al. (2006) model is an example of this simplistic type of model that requires minimal inputs and employs simple geometry and basic probability theory. Given the uncertainty in modeling Indiana bat collision in the Action Area, the Bolker et al. (2006) model was used but expanded upon by incorporating empirical data and expert opinion on Indiana bat behaviors and conditions leading to risk into the published mathematical framework. Additionally, the Bolker et al. (2006) model framework was modified by formally incorporating a risk-based approach to decision-making based on the model outputs, including the use of a formal uncertainty analysis.

The uncertainty analysis used a probabilistic approach that relied on either a range of values, or a formal distribution for each model input, rather than a deterministic approach based on single-point estimates. A Beta distribution was used when input values varied between 2 limits, but there was reason to believe that a subset of values within those limits was more likely to occur, as with proportions or probabilities. A uniform distribution was used when there was limited information about whether 1 value was more likely to occur than another. In some cases, random samples were drawn from an actual distribution based on empirical data, rather than a theoretical distribution. For model inputs whose distributions were based only partially or not at all on empirical data, a sensitivity analysis was conducted to investigate the degree to which changes in the input distributions affected model results. Season-specific estimates of collision/barotrauma were influenced by 5 primary components: seasonal population size, flight height, weather conditions that influence the number of bats that are active on a nightly basis, movement bouts within the turbine array, and mortality probability.

Seasonal Population

To estimate the summer population of Indiana bats in the Action Area, a conservative approach was taken. Indiana bats were assumed to have the potential to occur in suitable habitat throughout the Action Area during the summer, even though mist-netting in 2008 did not document Indiana bats in the Action Area, and mist-netting in 2009 resulted in 3 Indiana bat captures whose home ranges collectively occupied 3% of the Action Area and 1 Indiana bat in the center of the Action Area who was only tracked for 1 night, and whose roost tree was located 2.3 km (1.5 mi) east (outside) of the Action Area. Using a combination of these site-specific, empirical data, models predicting and quantifying suitable habitat within the Action Area, and conservative assumptions based on relevant literature and professional judgment, the summer Indiana bat population was estimated to be between 10.1 and 2,271.4 Indiana bats (see Appendix A for details on methods). Based on simultaneous emergence counts conducted at known Indiana bat roost trees within or near the Action Area, a minimum Indiana bat population size of 99 was estimated in Summer 2009 (K. Lott, ODNR, personal communication).

The size of migratory populations of Indiana bats moving through the Action Area during the spring and fall migration periods was extrapolated from USFWS Indiana bat population estimates from winter 2008-2009 hibernacula surveys in the migratory range of the Action Area (A. King, USFWS, personal communication). Assumptions about the distances and directions of travel during migration were derived from literature, expert opinion, and band returns from Indiana bats captured in the Action Area. These data were used to estimate the numbers of Indiana bats likely to pass through the Action Area during migration which ranged from approximately 2,900 Indiana bats to 5,800 Indiana bats (see Section 4.2.4 – Distribution in the Action Area and Appendix A for more information).

Flight Height

Assumptions about flight height, an input variable that strongly influenced the potential for collision, were informed by the height distribution of *Myotis* call sequences recorded with acoustic detectors (previously described in Section 4.4.4.2 – Foraging and Traveling Behavior), as well as observations of Indiana bat and *Myotis* flight height reported in literature and expert opinion. To account for uncertainty of Indiana bat flight height relative to the rotor swept zone, probability distributions were created for high, moderate, and low flight height scenarios and run as separate models (Table 5-2).

Table 5-2. Proportion of Indiana bats assumed to be flying within the rotor swept zone under high, moderate, and low height scenarios of the collision risk model.

Flight height scenario	Season		
	Spring	Summer	Fall
Low	5%	1%	10%
Moderate	15%	10%	20%
High	25%	20%	30%

Weather Conditions

Probability distributions for wind speed and temperature were developed from approximately 3 years of data collected at 2 MET towers in the Action Area (see Appendix A). The probability distribution for the distances and frequency with which Indiana bats are likely to travel within the turbine array during the summer was based on professional judgment as well as empirical data from 11 radio-tagged female Indiana bats[28] and the distances traveled between 23 roost locations[29] and 1,124 telemetry locations. The probability distribution for Indiana bat movements within the turbine array during migration was based on literature and professional judgment. Given the uncertainty in migration flight paths through the turbine array, a uniform probability distribution was used to reflect the number of potential crossings between 0 and 1, with each possible distance traveled through the turbine area having an equal chance of occurrence.

Movements within the Turbine Array

The number of movements across the turbine area is a function of the total distance traveled within the turbine array, comprised of the number of times that a given distance will be traveled and the probability that a given distance will be traveled. Movements across the turbine array were estimated separately for summer and during migration. In summer, large-scale movement bouts between roost trees and foraging locations were derived from the available telemetry data. The maximum distance across the turbine array was divided into 10% distance bins, and each distance bin was given a probability of occurrence based on the distances recorded between Indiana bat roost and telemetry locations for 10 female radio tagged

[28] Although 19 Indiana bats (17 females and 2 males) were radio tagged in the tri-county area in 2008 and 2009, only 11 female bats were successfully tracked during nightly foraging and traveling activities.

[29] Although 43 roost trees (38 female maternity roosts and 5 male roosts) were identified in the tri-county area in 2008 and 2009, only 23 maternity roosts had bats using them that had associated radio telemetry locations for distance calculation.

bats captured in the tri-county area in 2008 and 2009. It was assumed that summer activity could be summarized by 4 large-scale movement bouts during a night (leaving a roost tree at dusk; arriving at a night roost, or returning to a roost; leaving a roost for a second time; and returning to a roost at dawn), with the distance traveled during each bout based on the average distanced documented during Indiana bat telemetry. Along with these large-scale movements, a bat could make an unspecified number of small-scale movements that did not affect its risk of collision, because these movements occurred at or below tree canopy height (see Appendix A for details on methods).

Mortality Probability
Mortality probability was estimated based on the average number of turbine encounters, adjusted by the probability that a bat would survive the encounter. In the Bolker et al. (2006) model framework, a turbine encounter will occur if a bat's flight height is within the rotor swept zone and its flight path intersects a turbine location; effectively, if it is within collision or barotrauma distance of a rotor blade. The factors affecting the number of predicted turbine encounters are turbine location, height of turbine center (i.e., nacelle height), rotor length, angle of approach, probability of safe passage (i.e., survival as a result of avoidance or other factors), and flight height.

The turbine blade was conservatively extended for the purposes of the model to account for the potential for Indiana bats to be trapped in low-pressure vortices at the tips of rotor blades (i.e., barotrauma). The distance from the blade tip within which barotrauma can occur is still unknown. Researcher E. Baerwald, University of Calgary, who first described barotrauma from wind turbines in bats, described the diameter of this "small zone of [dropping] pressure" as "a meter or so" (Handwerk 2008). To conservatively account for the uncertainty in defining the zone of barotrauma, and to ensure that barotrauma impacts to Indiana bats would not be underestimated in the model, the length of the turbine blade was extended by 3 m (9.8 ft). The estimated length of the barotrauma zone was increased from Baerwald's estimate to account for changes in the length of the zone of compression due to changes in the rotational speed of the turbines. This increase serves to effectively enlarge the size of the rotor swept zone, which results in a higher number of possible turbine encounters, which correspondingly increases mortality probability.

These factors were incorporated into a geometric model developed by Bolker et al. (2006) using a probabilistic approach. The actual chance of survival is unknown and may be affected by avoidance, attraction, random chance, or other unknown factors. To account for this uncertainty and to test the sensitivity of the model outcome to this parameter, Beta probability distributions were developed for 3 potential survival scenarios. Survival scenarios were based on professional judgment related to Indiana bat morphology, mortality patterns of *Myotis* bats at wind facilities, and survival rates used in available collision risk models.

To test the uncertainty of collision risk estimates to parameter assumptions, a Monte Carlo analysis (Manly 2007) was used that entailed repeated random sampling of model input distributions (or measured data) based on 100,000 iterations. This approach is most defensible, given the high degree of uncertainty in the underlying model inputs, and it lends itself well to the development of adaptive management strategies, described in Section 6.5 – Monitoring and Adaptive Management. The Monte Carlo analysis generated a distribution of model predictions that were used to inform the final estimations of mortality resulting from collision or barotrauma.

5.1.2.5.2 Collision Risk Model Results

As described in Appendix A, the predicted amount of incidental take is based on the mean values predicted by model simulations using various model inputs (i.e., population size, flight height, and survival probability). The requested amount of incidental take was then calculated by reducing the amount of modeled take due to reductions from implementation of a feathering program to minimize take (see Section 5.1.2.5.3 – Estimated Take with Feathering; Table 5-5). Given the conservative approach that was taken to develop highly influential model inputs (i.e., population size, flight height, and survival probability) and because many of the model input distributions were derived from empirical data on *Myotis* species or Indiana bats specifically, the take estimate for this HCP is considered a conservative estimate of actual collision/barotrauma. Because survival probability is unknown for Indiana bats, the mean of the median values for 3 potential survival scenarios is used to represent expected mortality. Annual Indiana bat mortality for the low, moderate, and high flight height scenarios ranged from 6.9 Indiana bats per year to 25.4 Indiana bats per year, which includes adult female, adult male, and unborn and non-volant juveniles in the spring and summer (Table 5-3). Approximately 51% to 57% of the annual mortality is estimated to occur during the fall migration period.

Table 5-3. Collision risk model-predicted seasonal and annual Indiana bat fatalities (median values) under high, moderate, and low flight height scenarios within the rotor swept zone for 100-turbine Buckeye Wind Project.

Flight height scenarios	Mean fatalities of 3 survival scenarios			
	Spring	Summer	Fall	Annual
Low	2.4	0.1	4.4	6.9
Moderate	6.9	0.7	8.7	16.3
High	10.9	1.5	13.0	25.4

Collision risk model results indicate that predicted mortality of Indiana bats is highest during the migratory periods and lowest during summer residency in maternity colonies. This is a result of the assumptions made about Indiana bat exposure to the rotor swept zone during migration; assumptions that were made based on biology and not on observed post-construction mortality. Data on observed Indiana bat mortality at wind facilities do not provide sufficient information to accurately predict risks to Indiana bats since only 3 fatalities have been documented. While all 3 fatalities were observed in the fall, this does not preclude risk during the spring, since fewer post-construction mortality studies have been conducted in the spring. Buckeye Wind is situated in an area with documented summer habitat use and therefore it is a spring migration endpoint for some individuals. It is unknown if or how spring migration behavior may influence risk, and thus assumptions about spring and fall migratory behavior were kept similar.

5.1.2.5.3 Estimated Take with Feathering

The results of the collision risk model represent mortality probabilities under operating conditions that do not include feathering of turbines at low wind speeds. However, feathering will be applied to turbine operations with varying operational constraints as a condition of the HCP and associated ITP to minimize take of Indiana bats (see Table 5-4a and Section 6.2 – Minimization Measures for specifics of feathering plan). Three[30] operational effectiveness studies have documented substantial, but variable, rates of bat fatality reduction using cut-in speeds ranging from 5.0 m/s to 6.5 m/s (11.1 mph to 14.5 mph; Table 5-4b). The median minimum, maximum, and average reductions in bat fatalities in these 3 studies were 44.0%, 86.0%, and 68.3% respectively. It is important to note that different turbine models were used in each study, and as such, turbine blade rotation below the cut-in speed may be variable among studies.

[30] One study (Casselman) included 2 years of treatments.

Table 5-4a. Summary of nighttime operational feathering that will be applied to turbines during Evaluation Phase Year-1. Feathering will be applied to all turbines, using cut-in speeds that correspond to the habitat risk category assigned to each turbine location. Any turbines installed after the first year of operation will be feathered using the respective cut-in speeds of existing turbines in the same habitat risk category as adjusted through adaptive management, if those cut-in speeds differ from those in this table.

Habitat risk category	Estimate for 52-Turbine Layout	Estimate for 100-Turbine Layout*	Cut-in speed - m/s		
			Spring (1 Apr - 31 May)	Summer (1 Jun - 31 Jul)	Fall (1 Aug - 31 Oct)
Category 1 - Highest Risk	4	10	5.0	6.0	6.0
Category 2 - Moderate Risk	9	15	5.0	5.75	5.75
Category 3 - Low Risk	6	15	5.0	5.5	5.75
Category 4 - Lowest Risk	33	85	None**	5.25	5.75
Totals	52	125			

* The breakdown for the known 52 turbine locations is given for reference. Siting for the additional 48 turbines will seek to avoid the higher risk category sites to the extent practicable. The table shows a reasonable estimate for maximum number of turbines in each category, resulting in a sum >100. No more than 100 turbines will be built.

** Turbines will be cut-in at the manufacturer's specified cut-in speed. The turbines will be feathered below the cut-in speed.

The 3 studies provide evidence that feathering is an effective way to reduce bat mortality and the general magnitude of that reduction. To estimate the take that would result from the Project, Buckeye Wind has applied the median reduction in fatality among all 3 studies (68.3%) to the median results from the collision risk model (refer to Appendix A), resulting in a take estimate for the Project of 5.2 Indiana bats per year. This provides a reasonable estimate of expected take of Indiana bats since the feathering plan for the Project employs cut-in speeds that are variable but within the parameters used for those 3 studies. However, assumptions made in the collision risk model, along with the use of distributions for model inputs (rather than static values), resulted in a range of possible mortality estimates. Under the most conservative assumptions (i.e., high flight height and with the median minimum reduction in fatality from the 3 operational effectiveness studies [44.0%]), the maximum annual mortality is estimated to be 14.2 Indiana bats per year. Likewise, under the least conservative assumptions (i.e., low flight height and with the median maximum reduction in fatality from the 3 operational effectiveness studies [86.0%]), the maximum annual mortality is estimated to be 1.0 Indiana bat per year (Table 5-5). Turbines at Buckeye Wind will not rotate (i.e., will be feathered) below the cut-in speed set during adaptive management (see Section 6.5.1 – Monitoring for Minimization). Increased reductions in mortality from feathering may be observed at Buckeye Wind compared to reductions observed at studies in Table 5-4b if turbines in those studies were curtailed (i.e., may still have rotated below the cut-in speed) instead of feathered.

Table 5-4b. Observed range in reductions in bat fatalities and median values for 4 operational effectiveness studies in the range of the Indiana bat. Turbines were feathered at Casselman and in Southwest Alberta, and curtailed at Fowler Ridge.

Study	Observed fatality reduction[a]			Source
	Min	Max	Average	
Casselman 2008[b]	52.0%	93.0%	82.0%	Arnett et al. 2010
Casselman 2009[b]	44.0%	86.0%	72.0%	Arnett et al. 2010
Fowler Ridge 2010[c,d]	38.0%	85.0%	64.5%[e]	Good et al. 2011
Southwest Alberta[f]	NA	NA	60.0%	Baerwald et al. 2009
Median fatality reduction	44.0%	86.0%	68.3%	

[a] All studies used a combination of cut-in speeds of 5.0 m/s to 6.5 m/s except Baerwald et al. 2009, which used 5.5 m/s

[b] Based on a 95% confidence interval

[c] Based on a 90% confidence interval

[d] Good et al 2012, published after completion of the Draft HCP, considered fatality reductions at cut-in speeds of 3.5 m/s, 4.5 m/s and 5.5 m/s at Fowler Ridge in 2011 with a mean reduction of 36.3%, 56.7% and 73.3%, respectively. While these data were not included in calculation of the the estimated reduction, it is noted that the reductions in mortality by 73.3% at cut-in speeds of 5.5 m/s (the only tested cut-in speed included in this HCP) is similar to the median fatality reduction (68.3%) presented in this Table. Further a reduction in mortality of 73.3% at a cut-in speed of 5.5 m/s is within the range of reductions seen at cut-in speeds between 5.0 m/s-6.5 m/s at the facilities presented in this Table.

[e] Based on the median of the reported average reductions from each treatment (5.0 m/s = 50%; 6.5 m/s = 79%)

[f] Study did not provide confidence intervals for appropriate min and max comparison to other studies

Fluctuations in annual mortality can be expected as a result of natural stochasticity in variables that lead to mortality over time. To account for this uncertainty and natural variability, this HCP proposes that single and multi-year levels of take be authorized. Accordingly, the average annual mortality estimated by the collision risk model was used to develop 5-year and 25-year take limits (Table 5-6). Measures described in Section 6.5.3 – Adaptive Management for Minimization will allow Buckeye to manage any year-to-year fluctuations in the take number and maintain the 5-year and 25-year take limits. It is expected that any significant fluctuation from the expected annual take level of 5.2 Indiana bats per year will not occur after the first couple years of monitoring, as the operational parameters (e.g., cut-in speeds) will be adjusted to account for actual take levels, if necessary. Note that requested take will be reduced based on future population reductions from WNS in the Midwest RU as described in Section 5.1.2.6.4 – Take Reductions as a Result of WNS.

While the ITP Term is for 30 years, which includes construction, operation and decommissioning periods, no Indiana bat take is expected during construction, decommissioning, and mitigation activities (refer to previous and following subsections in Section 5.0 – Impact Assessment for more detail on expected effects from these activities). Although no take is expected during these phases, the ITP authorization would apply during these phases in the unlikely event that take did occur. Proposed take limits are for total mortality during the 25-year period during which turbines are operational and include both observed mortality (i.e., carcasses found during post-construction monitoring) and unobserved mortality that may occur but is not documented for various reasons, including ineffective searching or removal by scavengers. As detailed in Section 6.5 – Monitoring and Adaptive Management, monitoring throughout the life of the Project will be used to ensure compliance with the 5-year and 25-year take limits.

Table 5-5. Collision risk model-predicted annual Indiana bat mortality for the 100-turbine Buckeye Wind Project with expected reductions from feathering.

Flight height scenario	Unadjusted average annual mortality	Estimated annual mortality with expected reductions from feathering		
		86.0%	68.3%	44.0%
Low	6.9	1.0	2.2	3.8
Moderate	16.3	2.3	5.2	9.1
High	25.4	3.6	8.1	14.2

Table 5-6. Requested Indiana bat take ITP limits for the 100-turbine Buckeye Wind Project in Champaign County, OH.

ITP intervals	Take request[31]	Timing/calculation considerations
5-Year	26.0	Calculation of the 5-year take period will begin in any year in which the estimated take exceeds 5.2 Indiana bats; estimated take over any consecutive 5-year period beginning with any year when take exceeds the expected average (5.2 Indiana bats) will not exceed 26.0 Indiana bats.
ITP Term	130.0	Calculated based on the cumulative expected annual take over the 25-year operational life of the Project (as defined in Section 2.5 – ITP Duration): Expected Average Mortality per year is 5.2 Indiana bats and will not exceed 130.0 Indiana bats for 25 years of operation.

As stated above, the 5-year limit is based on the moderate flight scenario with the mean expected reductions in Indiana bat mortality (i.e., 5.2 Indiana bats x 5 years = 26.0 Indiana bats). Although it is not possible to have mortality of a partial bat, it is possible to estimate mortality of a partial bat; since annual Indiana bat mortality will be calculated using bias correction factors for searcher efficiency and carcass persistence, mortality estimates will be expressed in terms of partial bat fatalities (see Section 6.5.2 – Methods for Minimization Monitoring for details on these calculations). Based on these assumptions, a maximum take of 26.0 individuals over a 5–year period, for a total requested take authorization of 130.0 individuals over the ITP Term, is requested to be authorized under the ITP. While annual take levels provide a benchmark for monitoring take and will enable adaptive management actions to be tailored to respond to observable results from each monitoring year (see Section 6.2.2 – Project Operation and Maintenance), the 5-year limit is expected to more closely reflect the average expected annual mortalities that will result from the Project.

Because take could be higher in some years due to unusual weather event effects - -or other factors - -that are not currently understood, annual take estimates will indicate appropriate adaptive management. As more information is collected, it is expected those factors will become better understood and the adaptive

[31] Please see *Phase Considerations for Take Allowance* below for discussion on how these take numbers would change depending on the number of turbines erected and timing of the erection.

management measures will reduce the possibility that higher than average expected take will occur (see Section 6.5.3 – Adaptive Management for Minimization).

Since the collision risk model explicitly accounted for sex- and age-specific mortality (see Appendix A Section 3.3), take estimates include mortality of adult female, adult male, and unborn and non-volant juveniles. Adjustments to mortality documented during monitoring will also take into account mortality of unborn or non-volant juveniles. Since most adult female Indiana bats give birth to 1 pup per year, adult female Indiana bats found between 1 April and 15 July will be multiplied by 2. This multiplier is based on data from Kurta and Rice (2002) and Humphrey et al. (1977) which suggest that approximately 90% of captured females are in reproductive condition (i.e., pregnant, lactating, or post-lactating) during the summer reproductive period (see Section 4.3 – Demographics for further detail).

In addition to the 5-year and 25-year take limits proposed, this HCP defines annual mortality thresholds that will be used for the purposes of adaptive management and to facilitate responsiveness in management actions to ensure ITP compliance. At the conclusion of each monitoring year, annual Indiana bat mortality will be placed into 1 of the 3 categories described in Table 5-7.

Greater than Expected annual mortality measured over any 1-year term will be used as an early warning that adjustments to minimization efforts are necessary. Under these circumstances, Buckeye Wind will implement adaptive management strategies, as outlined in Section 6.5 – Monitoring and Adaptive Management.

Table 5-7. Annual Indiana bat mortality estimated from observed and unobserved mortality based on the 100-turbine Buckeye Wind Project collision risk model and expected reductions in mortality from feathering.

Average Mortality category	**Estimated annual mortality**	**Reasoning**
Less than Expected	5.2 or fewer Indiana bats per year	Mortality expected with greater than the median maximum reduction from feathering – 86.0%
Expected	5.2 Indiana bats per year	Mortality expected with the median reduction from feathering – 68.3%
Greater than Expected	Greater than 5.2 Indiana bats per year (not expected to exceed 14.2)	Mortality expected with less than the median minimum reduction from feathering – 44.0%

<u>Phasing Considerations for Take Allowance</u>

Since the collision risk model generated expected mortality for a 100-turbine Project, but construction could occur in a phased manner with only some of these turbines in operation in the beginning stages of the Project, the take allowances presented in Table 5-6 will be pro-rated according to the number of turbines that are in commercial operation in a given year. For example, if 52 turbines are built and put into commercial operation, the 5-year limit would be 52/100 = 52% of 26, or 13.5 Indiana bats. If additional turbines are commissioned within the 5-year period, the 5-year take limit would also be pro-rated. For example, if 52 turbines are commissioned in the first 2 years and the remaining 48 turbines are commissioned in Year-3, the 5-year take limit would include 2 years at 52% of the expected annual take limit (i.e., 2.7 Indiana bats), and 3 years at 100% of the expected annual take limit. Thus, the total 5-year take limit would be calculated as follows: (2.7 + 2.7) + (5.2 + 5.2 + 5.2) = 21.0 Indiana bats. As part of the reporting requirements for the HCP, Buckeye Wind will provide 30-day advance notice to the USFWS and ODNR DOW in writing for each turbine or group of turbines that is placed into commercial operation, providing the date and location of each turbine and a recalculation of the take limits.

If turbines are commissioned during the Indiana bat active period (1 Apr to 31 Oct), the take allowance would be similarly pro-rated. For example, if the first 52 turbines are commissioned on 1 June, 29% of the active period would have passed. The turbines would then be operating during 71% of the active period and the expected take for that year would be 52% x 71% x 5.2 = 1.9 Indiana bats. Using the above example (with the remaining 48 turbines being commissioned before the beginning of the Year 3 active period), the 5-year take limit then would be (1.9 + 2.7) + (5.2 + 5.2 + 5.2) = 15.6.

The 25-year operational life of the Project would commence upon commercial operation of the first turbine. Since this may include a partial year of operation, the expected take level for the 25-year period may be less than 130.0 Indiana bats. In the case that the full authorized take is not reached by the end of the ITP Term, Buckeye Wind may seek to extend the ITP Term through an amendment (see Section 7.3 – HCP Amendments).

5.1.2.6 Biological Significance of Incidental Take (Collision Mortality)

It is important to understand the long-term biological significance of sustained annual incidental take of Indiana bats from Project operation. Under the Proposed Action, total annual Indiana bat mortality, including adult females, adult males, and juveniles, is estimated to range from approximately 1.0 Indiana bat per year to 14.2 Indiana bats per year, assuming mortality is reduced by 44% to 86% as a result of feathering turbines (Tables 5-4b and 5-5). Based on the 5-year take limit, the total number of Indiana bats authorized to be taken over the ITP Term is 130.0 Indiana bats. Putting this level of mortality into context requires knowledge of Indiana bat life-history characteristics and baseline information on population trends.

When evaluating the biological significance of Indiana bat mortality from the Project, it is important to consider their unique life-history strategies (Barclay and Harder 2003). Life-history characteristics of a given population determine the degree to which its viability is affected by increased mortality. Organisms whose populations are characterized by low birth rate, long life span, naturally low mortality rates (i.e., K-selected species, Pianka 1970), high trophic level, and small geographic ranges are likely to be most susceptible to cumulative, long-term impacts on population size, genetic diversity, and ultimately, population viability (McKinney 1997, Purvis et al. 2000, as cited in National Research Council [NRC] 2007).

Bat species demonstrate considerable variation in traits such as fecundity, age of maturity, and longevity. As a group, bats have relatively long life spans and produce relatively few offspring compared with other small mammals, which may be due to low extrinsic mortality (e.g., low predation), reproductive constraints, or other characteristics (Barclay and Harder 2003 as cited in NRC 2007, Charnov 1993, Kozlowski and Wiegert 1986). Bats are atypical among mammals with respect to their life-histories because they have small body sizes but are long-lived (Barclay and Harder 2003 as cited in NRC 2007). The probability of extinction in bats has been linked to several of these characteristics (Jones et al. 2003 as cited in NRC 2007).

The Indiana bat population in the Midwest RU has experienced overall increases over the past 10 years (see Section 4.1—Species Status). Initial analysis of the biological significance of incidental take focuses on take in the context of this scenario. However, in winter 2010-2011, WNS was documented in the Midwest RU for the first time. While it is currently unknown what the impact of WNS is on the Midwest RU population, WNS in the Northeast RU has resulted in substantial Indiana bat population declines (e.g., 61.2% decline in NY's Indiana bat population based on hibernacula counts between 2007 and 2010 [A. King, USFWS, personal communication]) and may have similar results in the Midwest RU over time. Therefore, a second analysis of the biological significance of incidental take was completed using a WNS population effect scenario based on NY data. The biological significance of take based on both analyses is discussed in the following sections.

5.1.2.6.1 Impacts to Local Maternity Colonies Pre-WNS

Given the long lifespan of Indiana bats and their relatively low reproductive rates, loss of reproductive females can have significant impacts on the viability of the population. A proportion of spring, summer, and fall take may be to adult females who belong to a maternity colony located in the Action Area. To evaluate the impacts of the taking on the viability of a single local maternity colony within the Action Area, it was important to isolate expected adult female mortality from the total expected annual mortality. To do this, expected mortality during the spring, summer, and fall was calculated, and then the proportion of this mortality expected to be attributed to local adult females was estimated using a number of different assumptions as described in the following paragraphs. Impacts to the entire population of females, males, and juveniles from Project-related take are analyzed in Section 5.1.2.6.2 – Impacts to the Midwest RU Population Pre-WNS.

Because they are of the same guild, *Myotis,* as Indiana bats, observed mortality of little brown bats at wind facilities in the range of the Indiana bat was used as a surrogate to calculate the proportion of annual Indiana bat take expected to occur in the spring, summer, and fall seasons (little brown bat mortality patterns were not directly used to estimate Project-related take; see Appendix A). Of the total 3,433 bat fatalities documented in 26 post-construction mortality monitoring studies conducted within the range of the Indiana bat, there were a total of 225 little brown bat fatalities (0.07%; Jennifer Szymanski and Megan Seymour, USFWS, personal communication). Little brown bats comprised 8%, 34%[32], and 58% of fatalities in the spring, summer, and fall, respectively, with seasons defined as spring: 1 March to 31 May; summer: 1 June to 31 July; and fall: 1 August to 30 November. These proportions were used to estimate seasonal mortality expected to occur as a result of the Project, as shown in Table 5-8.

To estimate the amount of seasonal mortality expected to be attributed to adult females, the proportion of females expected to be in the population in each season was estimated. In the summer, females were estimated to comprise 92% of mortality based on the ratio of females to males observed during mist-netting studies in and near the Action Area (Table 5-9a, 5-9b; refer to Appendix A for more detail). During the spring and fall migratory period, females were estimated to comprise 73% of mortality, based on a 50:50 ratio of females to males at hibernacula and a ratio of 89 females to 11 males at the furthest migratory distances, resulting in an estimated average of 73% female Indiana bat composition within the Action Area (Table 5-9a, 5-9b; see Appendix A). Since the estimated number of females in the population was multiplied by 2 in the spring and summer prior to 15 July to account for loss of unborn juveniles in estimating mortality, and emergence counts conducted between 15 July and 15 August were assumed to include females and volant juveniles at a 1:1 ratio, to get the proportion of the population represented by adult females alone, the estimated spring and summer mortality estimates were divided by 2 (Table 5-9a, 5-9b; see Appendix A for derivation of these ratios and multipliers).

[32] The majority of summer mortality occurred in late July during late-summer dispersal, with the highest daily mortality of the entire monitoring period on 29 July.

Table 5-8. Estimates of seasonal Indiana bat mortality for the 100-turbine Buckeye Wind Project based on 1-year take estimate and 5-year take limit.

Season	Seasonal proportion of annual fatality[a]	Estimated seasonal mortality	
		Maximum 1-year take estimate[b]	5-year avg. annual take limit
Spring	8%	1.1	0.4
Summer	34%	4.8	1.8
Fall	58%	8.2	3.0
Annual	–	14.2	5.2

[a]Based on documented seasonal little brown bat mortality in 26 monitoring studies within the range of the Indiana bat.
[b]The CRM provides a range of potential annual take. Because it is expected that there will be year-to-year variation in incidental take, Buckeye Wind proposes a take limit based on the 5-year average, rather than a year-to-year limit. The maximum 1- year take estimate is based on the CRM's high flight scenario with minimum (44.2%) observed reductions from feathering.

Table 5-9a. Factors used to estimate the proportion of seasonal mortality that would be attributed to females from local maternity colonies under the 1-year take estimate for the 100-turbine Buckeye Wind Project.

Season	Estimated seasonal mortality	Proportion of mortality that is local	Annual local mortality for 1-year take estimate	Percentage of females in local population	Divisor for unborn or non-volant juveniles lost[a]	Annual local female mortality for 1-year take estimate
Spring	1.1	14%	0.2	73%	2	0.1
Summer	4.8	100%	4.8	92%	2	2.2
Fall	8.2	14%	1.1	73%	–	0.8
Annual	14.2	–	6.1	–	–	3.1

[a]The estimated number of females in the population was multiplied by 2 in the spring and summer to account for loss of unborn juveniles in estimating mortality. Thus, to get the proportion of the population represented by just adult females, estimated spring and summer mortality was divided by 2.

Table 5-9b. Factors used to estimate the proportion of seasonal mortality that would be attributed to females from local maternity colonies under the 5-year take estimate for the 100-turbine Buckeye Wind Project.

Season	Estimated seasonal mortality	Proportion of mortality that is local	Annual local mortality for 5-year take estimate	Percentage of females in local population	Divisor for unborn or non-volant juveniles lost[a]	Annual local female mortality for 5-year take estimate
Spring	0.40	14%	0.1	73%	2	0
Summer	1.80	100%	1.8	92%	2	0.8
Fall	3.00	14%	0.4	73%	–	0.3
Annual	5.20	–	2.3	–	–	1.1

[a]The estimated number of females in the population was multiplied by 2 in the spring and summer to account for loss of unborn juveniles in estimating mortality. Thus, to get the proportion of the population represented by just adult females, estimated spring and summer mortality was divided by 2.

The final step in estimating impacts to local populations was to estimate the proportion of the spring and fall migratory populations that was expected to be adult females belonging to maternity colonies in the Action Area. Given that up to 5,800 Indiana bats are estimated to travel through the Action Area during migration from up to 575 km (357 mi) away, there is a high probability that female Indiana bats killed during migration would be from multiple maternity colonies in different geographic areas. However, it's possible that some summer resident Indiana bats migrating between the Action Area and their hibernacula would be killed en route. Estimated population sizes in the Action Area in the spring/fall migratory periods and summer periods (Appendix A) were used to estimate the proportion of the migratory population that is likely to belong to the local population.

The mean local population size in the Action Area was between 10.1 and 2,271.4 Indiana bats (see Appendix A Section 2.1.1 – Summer Population). The estimated population size expected to migrate over the Action Area during spring and fall migration was approximately 5,800 Indiana bats assuming a 180-degree migration pattern from hibernacula, or 2,900 Indiana bats assuming a 360-degree migration pattern (see Appendix A Section 2.1.2 – Migratory Population).

The USFWS provided the following Leslie matrix model (Leslie 1945), a type of geometric population model, for use in assessing the viability of local maternity colonies with expected Project-related mortality over the ITP Term (USFWS comments on Buckeye Wind Draft HCP, March 10, 2011). This model provides a simplistic way of comparing population size with and without Project-associated take. This model represents a "best case" population scenario, as it does not address stochasticity or other perturbations that may be occurring in the environment that may impact the population. However, the model does provide insights on how Project-related take may influence population dynamics:

$$\text{Population size}_{(\text{year } t+1)} = (\text{Population size}_{[\text{year } t]} * \lambda) - \text{additive mortality} - \text{nonrecruitment}$$

Under recent conditions in the Midwest RU, and prior to WNS being discovered in the Midwest RU the USFWS recommended a population growth rate (λ, or "lambda") for local maternity colonies equal to 1.03, and a 100% recruitment (i.e., 0% non-recruitment) rate. Population growth rate of Indiana bats within the Action Area is unknown and likely varies from year to year depending on weather and other stochastic factors. Survival rates for adult females have been documented to range from 75.9% to 66.0% during a 10-

year period after banding (Humphrey and Cope, 1977, Boyles et al. 2007; see Section 4.3 – Demographics). However, results are generated from banding studies using unknown-aged individuals, and the authors caution that their results, while useful, cannot be taken as true survival rates for Indiana bats because of limitations in the data. Studies within the Midwest RU have indicated that reproductive rate of adult females can range from 82% to 93% (Kurta and Rice 2002, Humphrey et al. 1977; see Section 4.3 – Demographics). Juvenile Indiana bat survival rates are also uncertain, though a study of 1 maternity colony for 1 season estimated neonatal mortality to be 8% (i.e., 92% survival; Humphrey et al. 1977; see Section 4.3 – Demographics). Juvenile sex ratios are assumed to be generally equal (50:50), based on work by Hall (1962), Myers (1964), LaVal and LaVal (1980) and Humphrey et al. (1977).

The assumption of 100% recruitment (i.e., a closed population with no immigration or emigration and all juvenile females that survive return to the population in the following year as adults) is supported by evidence demonstrating strong philopatry (i.e., returning to the same place each year) in Indiana bats at maternity colonies, roost trees, foraging locations, and hibernacula (Garner and Gardner 1992, Kurta et al. 2002, Winhold et al. 2005).

The Leslie matrix model was run using a starting population of 70 Indiana bats, based on the average of 2 cumulative emergence counts in the tri-county area in 2008 and 2009 (43 Indiana bats and 99 Indiana bats, respectively).

Using the above information, we assumed a starting maternity colony size of 70 adult female Indiana bats, an annual adult survival rate of 66%, a reproductive rate of 82%, a juvenile sex ratio of 50 males to 50 females, a juvenile survival rate of 92%, and 100% recruitment of surviving juvenile females and adult females the following year. The annual population the following year would be calculated as follows:

Population in Year 2 = number of adult females in Year 1 that survive and return + their female offspring that survive and return; or

Population in Year 2 = (70*0.66) + (70*0.82*0.5*0.92) = 72.6

The population growth rate (λ, or "lambda") in this instance would be calculated by dividing the change in population size between Year 1 and Year 2 by the starting population size:

$$\lambda = 2.6/70 = 0.03 \text{ or } 3\%$$

A growth rate of 3% is equal to a lambda value of 1.03.

A Leslie matrix growth model was used because simple models are generally preferred to more complex models when there is little information on which to base model assumptions. This model was chosen to demonstrate how the Indiana bat population within the Action Area would be impacted by Project-related take, compared to the population without Project-related take. The Action Area is dominated by agriculture and landcover has remained largely unchanged (see Section 3.1.6 – Landcover); therefore, it is likely that within the Action Area, Indiana bat habitat suitability, quantity, and quality are likely stable. As a result, it is reasonable to assume high survivorship, reproductive, and recruitment rates for maternity colonies in the Action Area.

Impacts to local maternity colonies assuming losses to the population under the 1-year take estimate and 5-year take limits projected over the operational life of the Project (i.e., 25 years) were modeled using expected and worst-case scenarios (Table 5-10). Under the expected scenario, the survival of the local population was evaluated under the assumption that the average annual mortality of 5.2 individuals would occur each year. In the second, worst-case scenario, it was assumed that reproductive and energetic losses to local maternity colonies would be greater as larger numbers of Indiana bats are lost in a single, or successive, reproductive seasons. Thus, the maximum estimated 1-year take (i.e., 14.2) was assumed to occur in the first year of Project operation. Since take of no more than 26 Indiana bats would be authorized over any 5-year period, the cumulative mortality over the next 4 years would have to equal 26 – 14.2, or 11.8 Indiana bats. It was then assumed that the maximum take also occurred in Year-2 (i.e., 11.8 Indiana bats), and 0 mortality occurred in Year-3, Year-4, and Year-5. After applying the assumptions described in Tables 5-8, 5-9a, and 5-9b, the proportion of annual mortality that would be attributed to adult females was calculated (Table 5-10). This 5-year pattern was then repeated for 25 years for the purpose of running the Leslie matrix model.

To run the model, it was necessary to estimate the size of the population from which reproductive females would be lost. Individuals from 2 separate maternity colonies were documented in the Action Area during summer mist netting (see Section 4.2.4 – Distribution in the Action Area); therefore, Project-related impacts have the potential to affect at least 2 maternity colonies. Additional maternity colonies may be affected if suitable habitat exists adjacent to the Action Area and colony foraging activity overlaps with the Action Area.

Table 5-10. Expected and worst-case scenarios of total and adult female local Indiana bat mortality modeled over a 5-year period for the 100-turbine Buckeye Wind Power Project.

	Expected Scenario		Worst-case Scenario	
Year	**Total Local Mortality**	**Local Female Mortality**	**Total Local Mortality**	**Local Female Mortality**
1	2.3	1.1	6.2	3.1
2	2.3	1.1	5.3	2.4
3	2.3	1.1	0	0
4	2.3	1.1	0	0
5	2.3	1.1	0	0
Total	11.5	5.5	11.5	5.5

Since maternity colonies are the reproductive unit, loss of a single maternity colony would mean loss of the individuals in that colony, as well as their reproductive potential in future years. To assess the impacts in the theoretical worst case scenario, Buckeye Wind has considered the unlikely scenario in which all Project-related mortality affects 1 maternity colony. The projected population change of a single maternity colony resulting from Project-related take over the 25-year operational life of the Project was plotted against projected population change for this colony without take from the Project.

Given previously described assumptions about the starting population size, proportion of annual take attributed to local adult females each season, and the Leslie matrix model and parameters provided by the USFWS, estimated Project-related mortality of local adult females did not reduce the long-term viability of a single local maternity colony (Figure 5-1). Under both the expected and worst-case scenarios, the local population increased during the operational life of the Project by 36 Indiana bats and 33 Indiana bats, respectively. In the absence of Project-related take, the population is estimated to increase by 77 Indiana bats over the same term, which is a difference of 41 Indiana bats and 44 Indiana bats for the expected and worst-case scenarios, respectively. Based on collision risk modeling and expected reductions from feathering, it was estimated that up to 27.5 adult female Indiana bats from the local population would be taken over the 25-year operational life of the Project (see Table 5-10, 1.1 local female Indiana bats per year over 25 years).

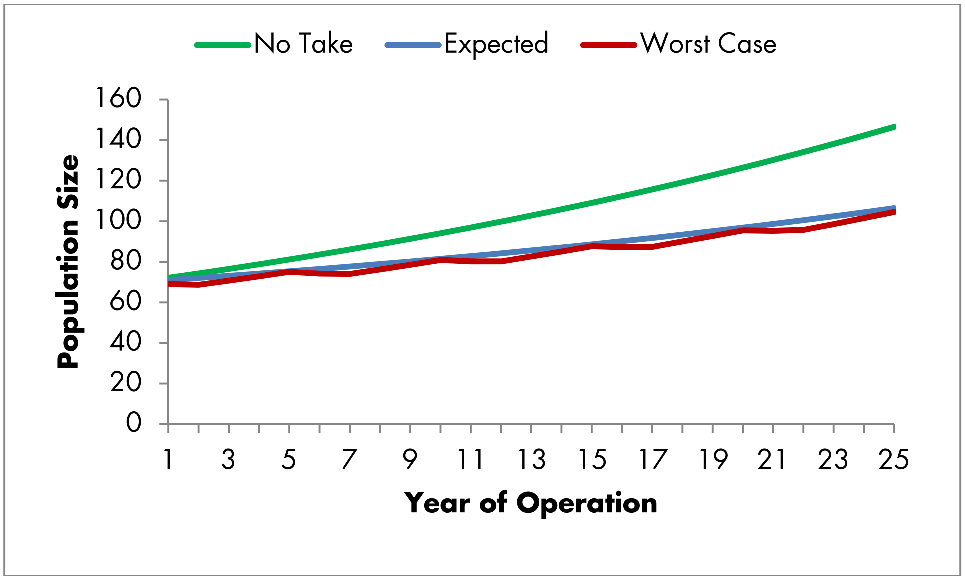

Figure 5-1. Impacts to a local maternity colony population due to the 100-turbine Buckeye Wind Project, pre-WNS. Leslie matrix model results given starting population size of 70 Indiana bats in a single, local maternity colony; λ = 1.03, and 0% nonrecruitment for expected scenario of annual adult female mortality = 1.1 Indiana bats each year in a 5-year cycle, and worst-case scenario of annual adult female mortality = 3.1 Indiana bats in Year-1, 2.4 Indiana bats in Year-2, and 0 Indiana bats in Year-3, Year-4 and Year-5.

Note that this modeling scenario is conservative because the level of mortality estimated by the collision risk model was strongly influenced by population size. Because the collision risk model was based on a population range of 10.1 to 2,271.4 Indiana bats, if the model were instead run assuming a local population of 70 Indiana bats, the expected mortality would be a small percentage of the mortality assumed in the Leslie matrix model analysis. Based on the results of the Leslie matrix model analysis and the assumptions used in that analysis, it is highly unlikely that the impacts of Project-related mortality would reduce the long-term viability of the local population.

5.1.2.6.2 Impacts to the Midwest RU Population Pre-WNS

Due to the location of the Action Area, Indiana bats that migrate through it are assumed to come from the Midwest RU (USFWS 2007) (refer to Section 4.4.3 – Migration for more detail). Therefore, this HCP is also evaluating the impact of Project-related take on the viability of the Midwest RU. Because of their long-standing endangered status and the ability to monitor Indiana bat populations via hibernacula counts, there are fairly robust data on current and historical population trends for Indiana bats. The 2011 rangewide population of Indiana bats was estimated to be 424,708 (Table 4-1), and the 2011 population estimate for the Midwest RU was 305,297 (Table 5-11, USFWS 2012c).

Table 5-11. U.S. Fish and Wildlife Service Indiana bat (*Myotis sodalis*) population estimates from 2003, 2005, 2007, 2009, and 2011 by state within the Midwest Indiana bat RU (USFWS 2012c).

State	2003	2005	2007	2009	2011
Alabama	265	296	258	253	261
Indiana	183,337	206,610	238,068	213,170	222,820
Kentucky	49,544	65,611	71,250	57,325	70,329
Michigan	20	20	20	20	20
Ohio	9,831	9,769	7,629	9,261	9,870
Tennessee	3,246	3,221	2,929	1,663	1,690
SW Virginia	430	202	188	217	307
Midwest RU	246,673	285,729	320,342	281,909	305,297

The loss of up to 130 Indiana bats over the ITP Term represents 0.05% or 0.04% of the Midwest RU population in 2009 and 2011, respectively. Affects to the long-term viability of the Midwest RU were analyzed using the Leslie matrix model and parameters provided by the USFWS (USFWS comments on Buckeye Wind Draft HCP, March 10, 2011). The USFWS recommended using a growth rate (λ) equal to 1.00 and 100% recruitment for the Midwest RU population pre-WNS. While the Midwest RU population size has fluctuated over the past 10 years, it has been on a stable or increasing trajectory (prior to WNS), with small population size fluctuations likely due to a lack of standardization in measuring and observer error (see Section 4.1 – Species Status). Further, OH hibernacula data show the same trend, with fluctuating but generally stable population sizes. Therefore, an estimate of λ = 1.00 (indicating a stable population) seems conservative and supported for a pre-WNS population. Similar to the maternity colony analysis, assuming 100% recruitment is supported by evidence of philopatry toward hibernacula (see Section 5.1.2.6.1 – Impacts to Local Maternity Colonies Pre-WNS) and because there is genetic evidence that the Midwest RU is a distinct reproductive unit (USFWS 2007; see Section 4.1 – Species Status).

The same expected and worst-case mortality scenarios were used for the Midwest RU analysis as were used to analyze impacts to a single maternity colony. However, impacts to the entire Midwest RU were calculated based on total annual mortality. Therefore, an annual mortality of 5.2 individuals (females, males, and juveniles) every year for 5 years was assumed under the expected scenario. For the worst-case scenario, annual mortality of Indiana bats was assumed to be 14.2 in Year 1, 11.8 in Year 2, and 0 in Year 3, Year 4 and Year 5 of a 5-year cycle. A starting population size of 305,297 Indiana bats (Time 0) was used in the Leslie matrix model, which is the 2011 estimated population size.

With a λ of 1.0 and no non-recruitment (i.e., 100% recruitment), the effect of estimated annual Project-related mortality on the Midwest RU is to reduce the Midwest RU population by 26 Indiana bats every 5 years in either the expected-case or the worst-case scenario (Figure 5-2). Over the ITP Term, this would equate to 130 Indiana bats, or 0.04% of the total RU population. Unlike the effects of Project-related mortality on a single maternity colony, there would not be additional loss of individuals due to lost reproductive capacity at the Midwest RU level. Unlike maternity colonies, the Midwest RU is not the reproductive unit. Because the Project will result in loss of a proportionately small number of individuals including males, females, and juveniles, with females most likely belonging to multiple maternity colonies among hundreds of colonies that will be unaffected by the Project, the Project is expected to have an insignificant effect on the reproductive capacity of the Midwest RU as a whole. Therefore, at current population levels, it is highly unlikely that the impacts of the Project-related taking would reduce the long-term viability of Indiana bats within the Midwest RU.

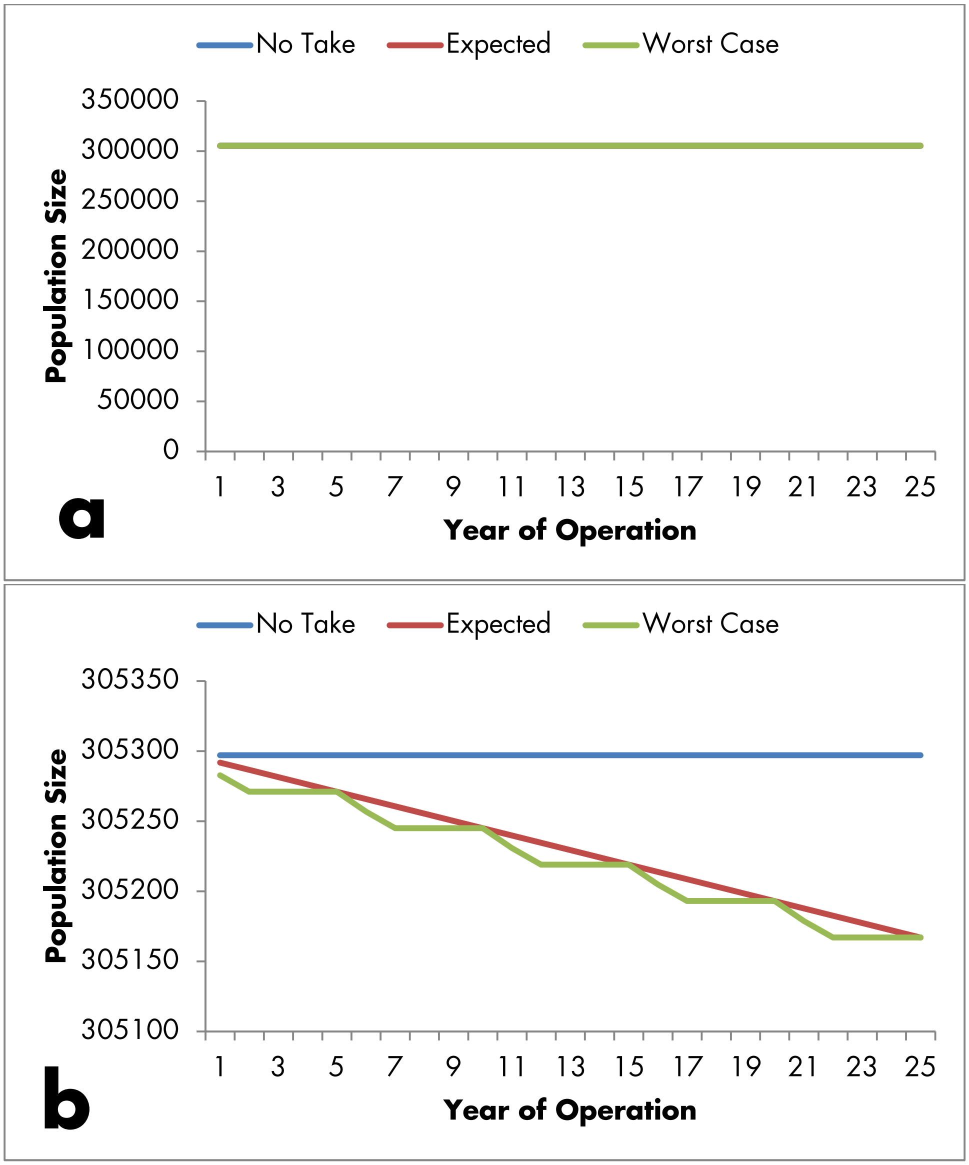

Figure 5-2. Impacts to the Midwest RU population due to the 100-turbine Buckeye Wind Project, pre-WNS. (a) Leslie matrix model results given starting Midwest RU population size of 305,297 Indiana bats, $\lambda = 1.00$, and 0% nonrecruitment for expected scenario of annual adult female mortality = 5.2 Indiana bats each year in a 5-year cycle, and worst-case scenario of annual adult female mortality = 14.2 Indiana bats in Year-1, 11.31 Indiana bats in Year-2, and 0 Indiana bats in Year-3, Year-4 and Year-5. Total impact of take is equal to 0.04% of the total RU population. (b) The same analysis, with the Y-axis scale bar truncated to show slight differences between the no take, expected, and worst-case scenarios.

5.1.2.6.3 Population Declines from White-Nose Syndrome

Although impact of the taking likely to result from the Project is highly unlikely to reduce the viability of a single local maternity colony or the Midwest RU at their current population levels, the impact of Project-related taking must be considered in light of anticipated population declines from WNS, which was first documented in the Midwest RU including OH in winter 2010-2011. Though documented during the winter of 2010-2011, declines in the Midwest RU population size attributable to WNS were not documented during this survey period. It is not unusual for population declines due to WNS to not become apparent until one or more survey periods after WNS symptoms are first observed (Turner et al. 2011). As summarized in Section 4.1 – Species Status, the most significant threat to both local and migratory Indiana bats in the Action Area is WNS. As previously discussed, WNS has the potential to undermine the basic survival strategy of more than half the bat species in the United States and almost all species of bats that occur at higher latitudes in North America by "causing premature arousals, aberrant behavior, and premature loss of critical fat reserves" in hibernating bats (Frick et al. 2010).

This HCP assesses the impact of Project-related take assuming WNS causes declines in the Midwest RU population and in local populations in the Action Area, as has been seen in the Northeast RU. Frick et al. (2010) reported that populations of all bats at hibernacula in eastern North America infected by WNS have decreased 73% on average from 2006 to 2010 (range from 30% to 99%). Winter Indiana bat census data from 2009-2010 in CT, MA, NY, and VT indicate that Indiana bat populations have experienced less severe declines as a result of WNS (i.e., 42% reduction), compared with declines in little brown bat and tri-colored bat populations (both estimated at 93% reduction), and northern long-eared bat populations (i.e., 99% reduction) (Langwig et al. 2010). The reductions reported by Frick et al (2010) and Langwig et al (2010) look at the impacts of WNS at the hibernacula level, whereas impacts across the entire RU could be different if individual hibernaculum are affected differently. The USFWS has estimated a 36.5% reduction in Indiana bat populations due to WNS across the Northeast RU from 2007 to 2009 (A. King, USFWS, personal communication).

Recently summarized data from NY, the state where WNS was first documented at a hibernaculum in 2007, provide the best available information on long-term population declines from WNS that might occur in the Midwest RU. In NY, Indiana bat survival rates were 65%, 98%, 61%, and 78% year-to-year during the first 4 winters WNS affected hibernating Indiana bats (A. King, USFWS, personal communication). Figure 5-3 and 5-4 represent population change at the individual maternity colony level and in the Midwest RU, with and without Project-related take, assuming Indiana bat populations were to experience similar declines as Indiana bats did in NY in the first 4 years of Project operation, and survival rates of 78% in each subsequent year over the 25-year operational life of the Project. A survival rate of 78% is maintained for Year 5 through Year 25 because it is the last known survival rate from the 4-year NY data set, it is similar to the 4-year average survival rate of 76% observed in NY, and there is no other information on the long-term results of WNS on Indiana bat populations. The scenario presented in Figure 5-3 assumes that declines of a single maternity colony in the Action Area track the same declines assumed for hibernacula in the Midwest RU; assumptions that are based on NY data.

Assuming similar annual population reductions at the single maternity colony level as those observed at the hibernacula level in NY, the single maternity colony was reduced to a population of 0 in Year 8 without the impacts of the Project-related take, while the single maternity colony was reduced to a population of 0 in Year 7 under both expected and worst case scenarios (Figure 5-3). Since only annual data were available from NY from which to base potential population reductions in the Midwest RU, it is not possible to know the exact time scale within which the population could be eliminated. In other words, it is possible that the difference in time between the population reaching 0 with and without impacts of Project-related take may be less than a full year, but it is not possible to determine based on best available information.

A similar modeling exercise was performed at the Midwest RU population level. Assuming similar annual population reductions in the Midwest RU as those in NY, the Midwest RU population affected with WNS at the end of 25 years is estimated to be 643 with no impacts from Project-related take, compared with a population of 620 or 628 under expected and worst-case take scenarios of impacts from the Project at the end of a 25-year operational life of the Project, which is a difference of 23 and 15 Indiana bats, respectively (Figure 5-4).

ITP issuance criteria state that, "the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild" [16 USC Section 10(a)(2)(B)(ii))]. Based on the Leslie matrix model, the single maternity colony would not be reduced to a non-viable population level appreciably sooner as a result of the Project than it would as a result of WNS in the absence of Project-related take. Similarly, the Midwest RU would not be reduced to low or non-viable population levels appreciably sooner as a result of the Project than it would as a result of WNS in the absence of impacts from Project-related take. Given what experts know about research on and management of WNS (i.e., there has been about 4 years of research on WNS to date, with no effective actions or solutions to slow or halt population declines), it is not reasonable to anticipate that impacts from Project-related take would preclude actions to reverse the effects of WNS on the species from taking effect. Therefore, impacts from the Project take are highly unlikely to appreciably reduce the likelihood of survival and recovery of the species.

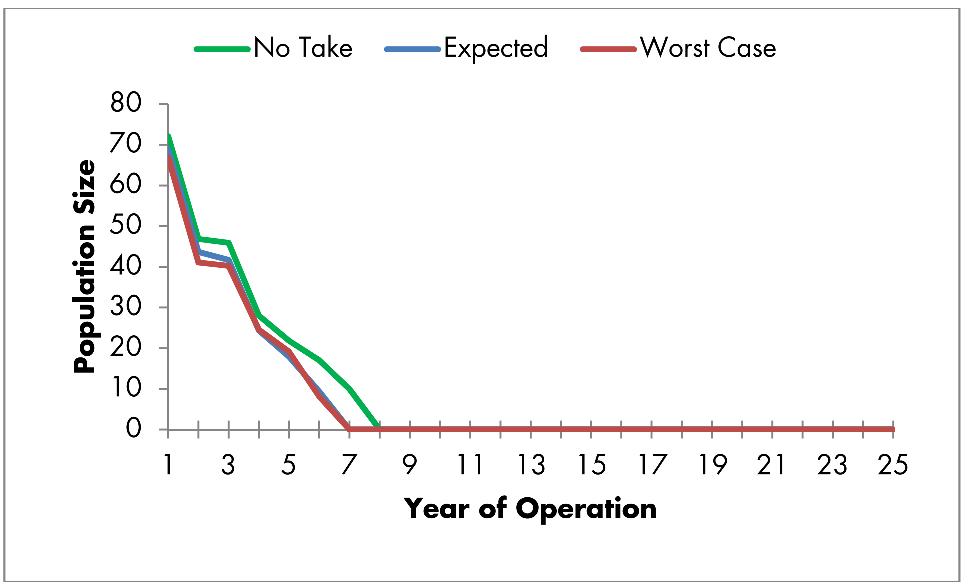

Figure 5-3. Impacts to a local maternity colony due to the 100-turbine Buckeye Wind Project, with WNS effects. Leslie matrix model results given starting population size of 70 adult female Indiana bats in the local maternity colony, expected and worst-case scenarios of Project-related mortality, and estimated population reductions from WNS based on NY data from 2007 to 2011.

Figure 5-4. Impacts to the Midwest RU population due to the 100-turbine Buckeye Wind Project, with WNS effects. Leslie matrix model results given starting Midwest RU population size of 305,297 Indiana bats, expected and worst-case scenarios of Project-related mortality, and estimated population reductions from WNS based on NY data from 2007 to 2011. Note that although there are slight differences between no take, expected, and worst-case scenarios, they appear identical at this scale.

5.1.2.6.4 Take Reductions as a Result of WNS

As a result of past and anticipated future declines due to WNS, the recovery of the Indiana bat is dependent upon reversing the current rate of decline. Therefore, Buckeye Wind, in coordination with the USFWS, will review the biennial winter census results compiled by the USFWS Indiana Bat Recovery Team and if the population of Indiana bats in the Midwest RU is reduced by 50% or more from 2011 pre-WNS mortality levels, Buckeye Wind will commit to reducing requested 5-year take limits by 50%. In this event, the 5-year take limit would be 13.0 Indiana bats (or average of 2.6 Indiana bats per year). These reductions in take will result from fewer Indiana bats exposed because of overall population declines, having an effective adaptive management plan in place, and voluntary reductions in take because as the population declines, each individual becomes more valuable to the population as a whole. While project-related take is not likely to result in appreciable reductions in the likelihood of survival or recovery of the species with WNS-induced population declines (see Section 5.1.2.6 – Biological Significance of Incidental Take [Collision Mortality]), Buckeye Wind will implement these reduced take limits as an added conservation program.

To estimate the effect of take limits reduced by 50% on the long-term viability of Midwest RU and maternity colony populations that have been reduced from current levels by WNS assuming similar reductions as those documented in NY data from 2007 to 2011, the Leslie matrix model was used to develop expected and worst-case scenarios (refer to Section 5.1.2.6 – Biological Significance of Incidental Take [Collision Mortality]). Figures 5-5 and 5-6 represent population change at the individual maternity colony and Midwest RU levels based on estimated population reductions from WNS and with Project-related mortality reduced by 50% after the Midwest RU population is reduced by 50% from estimated 2011 pre-WNS mortality levels (i.e., 70 adult female Indiana bats in the local maternity colony and 305,297 in the Midwest RU).

When Project-related mortality is reduced by 50%, the single maternity colony was reduced to a population of 0 in Year 8 with no Project-related mortality, and under the expected scenario. The single maternity colony was reduced to a population of 0 in Year 7 under the worst-case scenario. In Section 5.1.2.6.3 – Population Declines from WNS, the single maternity colony was reduced to a population of 0 in Year 7 under both the expected and worst-case scenarios; therefore, reducing take by 50% resulted in 1 extra year before the population was eliminated under the expected scenario, and no extra time under the worst-case scenario. However, since only annual data were available from NY from which to base potential population reductions, it is not possible to know the exact time scale within which the population could be eliminated. In other words, it is possible that the difference in time between the population reaching 0 with and without a 50% reduction in take may be less than a full year, but it is not possible to determine based on best available information.

In terms of the Midwest RU, the difference in population declines with and without Project-related take were less than the scenario in which take was not reduced by 50%. Specifically, the Midwest RU population affected with WNS at year 25 is estimated to be 643 with no Project-related take, compared with a population of 632 or 636 under expected or worst-case take scenarios at the end of the ITP Term, which is a difference of 11 and 7 Indiana bats respectively (Figure 5-6). In Section 5.1.2.6.3 – Population Declines from WNS, the Midwest RU population was reduced by 23 and 15 Indiana bats, respectively, under the expected and worst-case scenarios, when Project-related take was not reduced by 50%.

ITP issuance criteria state that, "the taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild" [16 USC Section 10(a)(2)(B)(iv)]. Based on these modeling results, Indiana bat populations at both the maternity colony and Midwest RU levels will not be reduced to low or non-viable levels appreciably sooner with impacts from Project-related take than without it, either with or without reducing impacts of Project-related take by 50%. Therefore, Project take is highly unlikely to appreciably reduce the likelihood of survival and recovery of the species. However, to minimize take to the maximum extent practicable, Buckeye Wind will commit to reducing authorized take by 50% when biennial winter census results compiled by the USFWS Indiana Bat Recovery Team indicate that the Indiana bat population in Midwest RU has been reduced by 50% of pre-WNS levels, defined as the 2009 population levels of281,909, used in the effects analysis in Section 5.1.2.6.2 – Impacts to the Midwest RU Population Pre-WNS and in this Section 5.1.2.6.3 – Population Declines from WNS. These reductions are appropriate because fewer Indiana bats will be exposed to potential collision/barotrauma and because each individual Indiana bat becomes more valuable as the population declines.

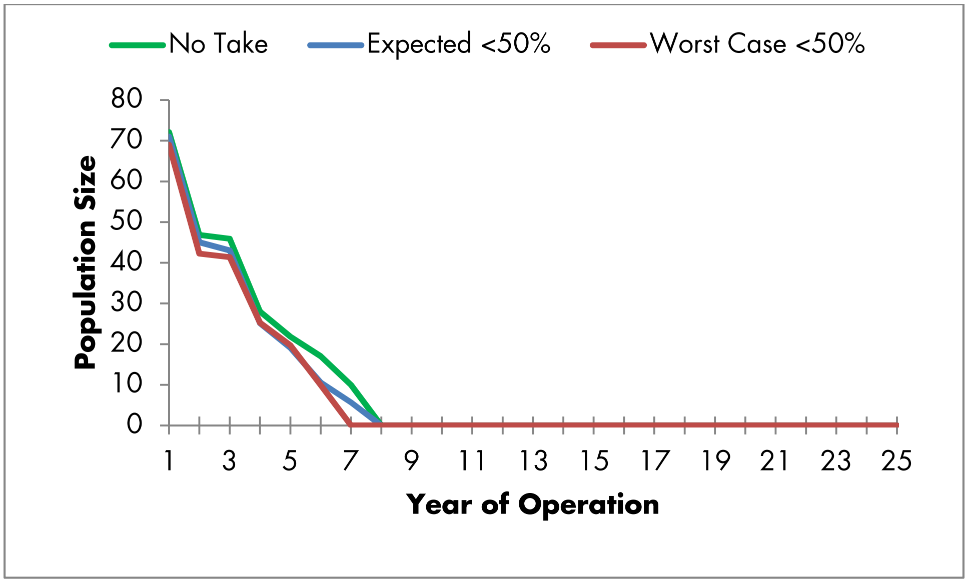

Figure 5-5. Impacts to a local maternity colony due to the 100-turbine Buckeye Wind Project, with WNS effects and 50% reduction in take. Leslie matrix model results given starting population size of 70 adult female Indiana bats in the local maternity colony, expected and worst case scenarios of Project-related mortality reduced by 50% after the Midwest RU population is reduced by 50%, and estimated population reductions from WNS based on NY data from 2007 to 2011.

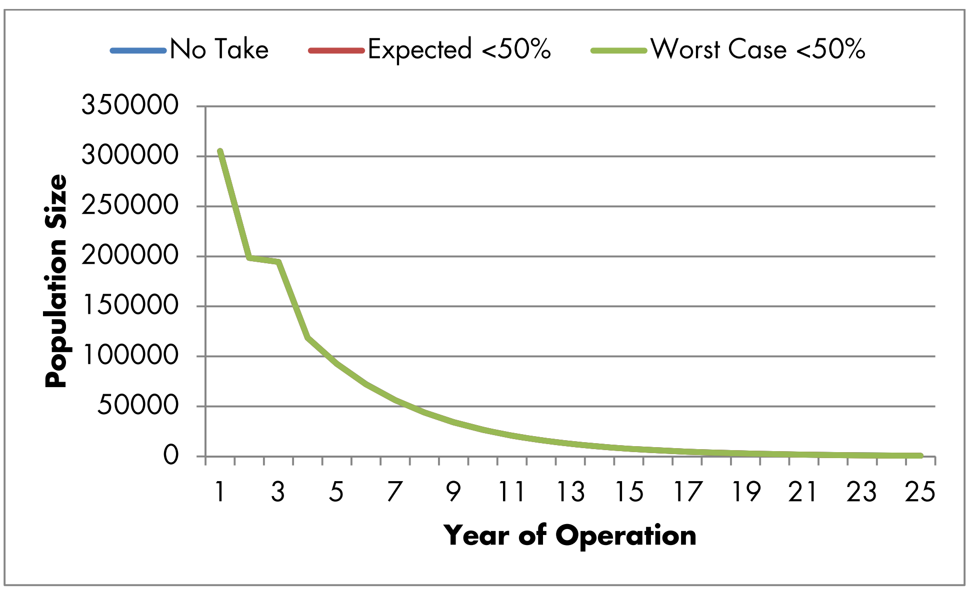

Figure 5-6. Impacts to the Midwest RU population due to the 100-turbine Buckeye Wind Project, with WNS effects and 50% reduction in take. Leslie matrix model results given the 2011 starting Midwest RU population size of 305,297 Indiana bats, expected and worst-case scenarios of Project-related mortality reduced by 50% after the Midwest RU population is reduced by 50%, and estimated population reductions from WNS based on NY data from 2007 to 2011. Note that although there are slight differences between no take, expected, and worst-case scenarios, they appear identical at this scale.

5.1.2.6.5 Summary of Leslie Matrix Model Results

The Leslie matrix model was applied to the population of a single maternity colony in the Action Area and to the entire Midwest RU Indiana bat population under 3 take scenarios: (1) no Project-related take, (2) expected impacts from Project-related take, and (3) worst-case impacts from Project-related take. For each of the 3 scenarios, the population trajectory was analyzed with 3 options: (1) no effect of WNS, (2) effect of WNS on population decline, and (3) effect of WNS on population decline with an associated 50% reduction in Project-related take once WNS reduced the Midwest RU Indiana bat population by 50%. Therefore, a total of 9 models were analyzed for a single maternity colony and a total of 9 models were analyzed for the Midwest RU (Table 5-12, Table 5-13). It is highly unlikely that the impacts of Project-related take would reduce the long-term viability of the maternity colony or Midwest RU population when no effect of WNS is included in the analysis. Further, impacts of Project-related take are highly unlikely to appreciably reduce the likelihood of survival and recovery of the maternity colony or Midwest RU population under predicted WNS scenarios.

Table 5-12. Results of 9 Leslie matrix growth models on a single maternity colony in the Action Area with a starting population size of 70 Indiana bats. Models compare population sizes with and without impacts of Project-related take from the 100-turbine Buckeye Wind Power Project over 25 years.

Scenario	Estimated year in which population is reduced to 0			Population size at year 25 (starting population = 70)		
	No Project-related Take	Expected Project-related Take	Worst-case Project-related Take	No Project-related Take	Expected Project-related Take	Worst-case Project-related Take
No effect of WNS (Figure 5-1)	n/a	n/a	n/a	147	106	103
Effect of WNS (Figure 5-3)	8	7	7	0	0	0
Effect of WNS with 50% take reduction (Figure 5-5)	8	8	7	0	0	0

Table 5-13. Results of 9 Leslie matrix growth models on the 2011 Midwest RU with a starting population size of 305,297 Indiana bats. Models compare population sizes with and without impacts of Project-related take for the 100-turbine Buckeye Wind Power Project over 25 years.

Scenario	Population size at year 25 (starting population = 305,297)		
	No Project-related Take	**Expected Project-related Take**	**Worst-case Project-related Take**
No effect of WNS (Figure 5-2)	305,297	305,167	305,167
Effect of WNS (Figure 5-4)	643	620	628
Effect of WNS with 50% take reduction (Figure 5-6)	643	632	636

5.1.3 Direct Effects – Mitigation

Mitigation activities will be composed of permanent preservation and enhancement in areas that support Indiana bat swarming habitat. Section 6.3 – Mitigation Measures includes a detailed description of mitigation actions, which include permanent preservation and enhancement of 87.8 ha (217.0 ac) of land within 11.2 km (7 mi) of a P2 hibernaculum in OH. Over the ITP Term, mitigation actions are expected to have a net beneficial effect on Indiana bats that will fully offset the impact of the taking. The beneficial effects of mitigation are fully discussed in Section 6.3 – Mitigation Measures. Other potential direct effects to Indiana bats from mitigation activities include disturbance from noise, human activity, tree planting and vehicular traffic associated with habitat restoration and enhancement activities.

5.1.3.1 Tree Planting

Some amount of mitigation land may require enhancement due to inadequate tree density. If a mitigation area has less than 300 trees per acre, on average, then tree planting will occur. Tree planting on mitigation lands will help to achieve a density of 300 stems per acre, on average, per Planting Area (stems/ac/PA), and will use at least 6 different tree species found in Appendix L of the PEP Guidelines (USFWS 2009b; see Section 6.3.4 – Restoration and Enhancement). A Planting Area is defined as any contiguous area where Buckeye Wind has protected lands in accordance with the Mitigation Measures (see Section 6.3 – Mitigation Measures) and is conducting restoration and enhancement activities (see Section 6.3.4 – Restoration and Enhancement). Travel corridors linking roosting and foraging habitats are an important feature of Indiana bat habitat; therefore, Buckeye Wind may choose to plant trees to establish a minimum travel corridor of 4 rows of trees covering an area of at least 15 m (50 ft) wide (USFWS 2009b) to connect woodlots or along unforested stream corridors.

Tree planting will necessitate minor soil and vegetation disturbance due to digging holes for tree planting and vehicular traffic for site preparation and maintenance. Because the rate of survival of planted trees can increase if completed during the growing season and because tree planting is expected to take place largely in currently non- or thinly-forested areas that are less likely to be occupied by Indiana bats, tree planting may be done in the Indiana bat active period, including the swarming period (15 Mar to 15

Nov[33]). Soil disturbance from planting activity (e.g., digging holes for tree planting) is expected to be minor and erosion and sediment control measures would not be necessary. It is not anticipated that tree planting associated with mitigation will result in take of Indiana bats and effects are anticipated to be insignificant or discountable.

5.1.3.2 Collision with Vehicles

Although bats are very agile flyers, there is evidence that bats (including Indiana bats) can be killed by collision with vehicles (see Section 5.1.1.2 – Collision with Vehicles).

During Project mitigation, vehicle activity associated with the Project will include contractor vehicles traveling to various portions of the mitigation area. These vehicles will make trips in and out of the mitigation area along local and state roads that already support significant traffic. Direct impacts may occur during tree planting activities when trucks delivering trees (for planting) will be traveling to and from the site. Understory thinning and other mitigation activities will occur during the non-active periods and will not have potential for direct or indirect effects.

Vehicular activity will be spread throughout the mitigation area, with temporary concentrations of activity in areas that require tree planting activities. Additionally, the small amount of increased vehicular traffic associated with Project mitigation will be insignificant compared to regular traffic in and around the mitigation area and would occur mostly during day-light hours when Indiana bats are not active.

As a result of the factors discussed above, mortality of Indiana bats caused by vehicle strikes with mitigation vehicles is not likely. Thus, it is anticipated that vehicular traffic associated with the Project will result in direct effects that are insignificant and discountable and not expected to result in take of the species.

5.1.3.3 Noise, Human Activity, and Disturbance

Temporary increases in noise, human activity, and disturbance may result from mitigation activities and monitoring for mitigation (see Section 6.5.4 – Monitoring for Mitigation):

- Temporary increase in noise associated with activities for ground preparation and vehicular traffic used to transport materials; and,
- Temporary increase in human activity for monitoring or tree planting.

Mitigation activities are expected to require a small team of workers. A small team of about 5 surveyors is expected to be required to conduct habitat assessments over a duration that is not likely to exceed 2 weeks during each survey year.

See Section 5.1.1.1 – Noise, Vibration, and Disturbance for a discussion of the potential impacts of anthropogenic disturbance on Indiana bats. Mitigation activities will be temporary in nature, require minimal noise-producing equipment (such as small power tools) and vehicular use, and involve day-time human activity (when Indiana bats are generally not active). Some activities (monitoring, tree planting) may occur in areas potentially used by Indiana bats for roosting. While this has the potential to result in arousal of roosting Indiana bats, disturbance will temporary and minor. Tree planting, which may result in minor

[33] The active period for the Action Area has been defined as 1 Apr to 31 Oct. Because mitigation activities will occur in areas where swarming will occur, the applicable period is extended.

disturbance due to activities associated with ground preparation and vehicular traffic to transport materials, is expected to occur most often at restoration parcels, which will be located largely in areas less likely to be occupied by Indiana bats. It is not anticipated that noise, human activity, or disturbance associated with mitigation activities will result in take of Indiana bats. Therefore, potential direct effects from mitigation activities are expected to be insignificant and discountable.

5.2 Indirect Effects

5.2.1 Indirect Effects – Construction and Decommissioning

5.2.1.1 Wooded Habitat Removal

Removal of wooded habitat that includes potential Indiana bat maternity roosting and foraging habitat during the non-active period for Indiana bats has the potential to negatively impact adult female and juvenile Indiana bats during the summer reproductive period. Because Indiana bats show site fidelity and return to the same foraging and roosting areas every year, adult females could suffer energetic losses if they had to find new roosting and/or foraging areas upon their return to their summer maternity colonies in early summer. Because adult female Indiana bats are already energetically stressed from hibernation and due to the energetic demands of pregnancy, having to expend additional energy to locate new roosts could result in lost reproductive fitness.

Impacts to local Indiana bats communities can vary based on the quality and quantity of habitat removed (including proximity to streams and wetlands) and connectivity and proximity to other alternate habitat of comparable quality and character. Removal of dead and dying trees or live shagbark hickories that typically provide higher quality roosting habitat would presumably have greater impact to Indiana bats than removal of young saplings or healthy older trees without exfoliating bark. Kurta (2005) suggested that the magnitude of impact from roost tree removal will vary greatly depending on the scale of roost loss (i.e., how many roosts are lost and how much alternative habitat is left for the Indiana bats in the immediate vicinity of the traditional roost sites).

Although Indiana bats are known to exhibit site fidelity to both individual roost trees and foraging areas (Cope et al. 1974, Humphrey et al. 1977, Gardner et al. 1991a, 1991b, Gardner et al. 1996, Callahan et al. 1997, Whitaker and Sparks 2003, Murray and Kurta 2004, Whitaker et al. 2004, Sparks et al. 2005b as cited in USFWS 2007), they are also known to frequently shift from one roost tree to another. Indiana bats are known to have a fission-fusion society, whereby members of a colony regularly come together to form a group (fusion), but individuals frequently depart to be solitary or to form smaller groups (fission) for some time before returning to the main unit. At any given time, many members of a colony may reside in a single tree (often known as the primary roost), while other members of the colony roost solitarily or in smaller subgroups in other trees (often known as secondary roosts) (USFWS 2007). On average, Indiana bats switch roosts every 2 days to 3 days, although female reproductive condition, roost type, and time of year affect switching (Kurta et al. 2002, Kurta 2005).

In studying 2 Indiana bat colonies located in IL for over a decade, T. Carter (Ball State University, personal communication) observed the centers of activity of both colonies shift between 1.6 km and 4.8 km (1.0 mi and 3.0 mi). Carter (2003) also observed Indiana bats traveling as far as 6.0 km (3.7 mi) between roosts. Similarly, Kurta and Murray (2002) and Kurta et al. (2002) documented shifts in the focal point of Indiana bat roosting activity by 2 km (1.2 mi) over a 3-year period.

In terms of the amount of wooded habitat that will be removed for the Project, the majority of the Project will be built in or adjacent to agricultural land that will be restored to former agricultural use after construction; cultivated crop and hay/pasture land cover types collectively comprise approximately 95% of the area that will be disturbed for the 100-turbine Project (Table 5-14, also 95% in the Redesign Option, Table 5-15). To estimate the total amount of tree clearing that is expected to occur during Project construction, the 2001 NLCD (Homer et al. 2004) together with the 2010 National Agriculture Imagery Program (NAIP)[34] ortho-aerial imagery were used to estimate areas of tree clearing for the 100-turbine layout, which was estimated as the worst-case scenario.

Based on the NAIP, no more than 6.5 ha (16.1 ac; or 6.8 ha [16.8 ac] for the Redesign Option) of wooded areas will be removed for the 100-turbine Project. NAIP tree clearing was estimated by digitizing all wooded areas into a polygon layer and then intersecting all Project facilities with the digitized forest layer. Because the NAIP provides more detailed land cover data and suggests a greater amount of tree clearing, the NAIP data were used to calculate maximum tree clearing. However, much of this area is at the edges of woodlots or along tree lines. Once final Project construction engineering is completed, it is expected that much of this area will not be subject to clearing as simple micro-siting and tree trimming will reduce the amount of tree clearing. To provide a general assessment of the quality and quantity of Indiana bat roosting and foraging habitat that may be impacted by tree removal, a ground-based habitat assessment was conducted jointly by the USFWS and Buckeye Wind in November 2010. Based on this assessment, it was found that potential roost trees occur within areas where tree clearing may occur. Therefore, the following paragraph describes micro-siting to avoid and minimize clearing of potential Indiana bat roost trees during construction activities (USFWS 2010).

Buckeye Wind will take the following steps to minimize any potential indirect effects to Indiana bats resulting from the removal of trees (also see Section 6.1.2– Project Construction):

- Buckeye Wind will not remove trees that are known to have been used as a roost site for Indiana bats.
- Buckeye Wind will avoid removal of potential roost trees identified during the November 2010 habitat assessment to the maximum extent practicable.
- Buckeye Wind will conduct habitat assessments jointly with the USFWS for the areas of planned tree clearing once Project plans are finalized and before any clearing is conducted, during which all potential roost trees will be identified and flagged.
- Buckeye Wind will use micro-siting of Project components to minimize tree clearing to the maximum extent practical.
- Prior to finalizing the detailed design of Project components, Buckeye Wind will make all reasonable attempts to offset the clearing radii around turbines or adjust roads/interconnects to preserve flagged potential roosts to avoid and minimize impacts of potential roost removal to the maximum extent practicable.
- At the time of tree clearing, a Natural Resource Specialist who is familiar with Indiana bat habitat requirements will be present and any potential roost trees not identified previously (including maternity roosts) within the clearing zone will be flagged.
- To the extent removal cannot be avoided, potential roost trees or potential maternity roost trees or other forested habitat will only be cut between 1 November and 30 March when Indiana bats would not be present.

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[34] The minimum mapping extent of the NLCD is 0.09 ha (0.2 ac; based on 30m x 30m [98 ft x 98 ft] pixels), which is likely to overestimate the actual amount of forested habitat that will be removed. By comparison, the NAIP has a minimum mapping extent of 1m x 1m [3.2 ft x 3.2 ft].

In terms of the amount of suitable alternate roosting habitat, the 6.5 ha (16.1 ac) (6.8 ha [16.8 ac] for the Redesign Option) of tree clearing planned for the 100-turbine Project represents approximately 0.2% (0.2% in the Redesign Option) of the 2,744 ha (6,779.4 ac) of wooded habitat available in the Action Area[35]. The maximum amount of clearing is based on the known 52-turbine layout plus a reasonable estimate for the additional 48 turbines (see Table 5-14 and Table 5-15). Given the small portion of the total wooded area that would be cleared for the Project, it is expected that Project-related clearing will not significantly decrease the availability of suitable habitat. Additionally, tree clearing is expected to be spread throughout the Action Area and is not expected to be extensive in any single area. Therefore, in the unlikely event that a previously unknown maternity roost was removed, female Indiana bats would not have to expend substantial amounts of energy locating alternate maternity roost trees as other suitable habitat would be expected to be present in the Action Area.

[35] Note that much of this area is located along the edges of woodlots or along thin/sparse tree lines separating parcels, resulting in a conservative estimate. Avoidance and minimization measures described in Section 5.2.1.1 – Wooded Habitat Removal will reduce the area of tree removal based on construction needs, landowner preference, and quality of habitat.

Table 5-14. Worst-case scenario impacts[a] to NLCD 2001 land cover types[b] for the 100-turbine Buckeye Wind Project, Champaign County, OH.

Land cover type	Area of disturbance						
	Total			Temporary		Permanent	
	Hectares	Acres	Percent of total	Hectares	Acres	Hectares	Acres
Cultivated crops	199.1	492.0	90.1%	157.1	388.2	42.0	103.8
Hay/pasture and herbaceous grassland	0.6	1.5	0.3%	0.2	0.5	0.4	1.0
Hay/pasture and herbaceous grassland – CRP	11.3	27.9	5.1%	9.0	22.2	2.3	5.7
Developed, open space	3.2	7.9	1.4%	2.3	5.7	0.9	2.2
Deciduous forest[c]	6.4	15.8	2.9%	0	0	6.4	15.8
Emergent herbaceous wetlands	0	0	0%	0	0	0	0
Developed, low intensity	0.2	0.4	0.1%	0.1	0.2	0.1	0.2
Evergreen forest	0.1	0.3	0.1%	0	0.1	0.1	0.2
Open water	0	0	0%	0	0	0	0
Barren land	0	0	0%	0	0	0	0
Developed, medium intensity	0	0	0%	0	0	0	0
Mixed forest	0	0	0%	0	0	0	0
Developed, high intensity	0	0	0%	0	0	0	0
Total	220.9	545.8	100%	168.8	416.9	52.2	128.9

Source: Homer et al. 2004

[a] Impacts are estimated from actual impacts calculations of the known 52 turbines and associated facilities and a reasonable estimate of impacts from the additional 48 turbines based on characteristics of the Action Area and the avoidance and minimization measures described in Sections 6.1 – Avoidance Measures and 6.2 – Minimization Measures.

[b] Numbers based on the NLCD and adjusted for impacts to wooded areas as determined with the 2010 NAIP and specific avoidance measures such as avoidance of wetlands.

[c] Included in the mitigation acres calculation as an offset for cleared wooded areas.

Table 5-15. The Redesign Option worst-case scenario impacts[a] to NLCD 2001 land cover types[b] for the 100-turbine Buckeye Wind Project, Champaign County, OH based on the collection system redesign.

	Area of disturbance						
	Total			Temporary		Permanent	
Land cover type	Hectares	Acres	Percent of total	Hectares	Acres	Hectares	Acres
Cultivated crops	196.8	486.4	89.5%	154.8	382.6	42.0	103.8
Hay/pasture and herbaceous grassland	0.7	1.8	0.3%	0.3	0.8	0.4	1.0
Hay/pasture and herbaceous grassland - CRP	12.4	30.7	5.6%	10.1	25.0	2.3	5.7
Developed, open space	3.0	7.5	1.4%	2.1	5.2	0.9	2.3
Deciduous forest[c]	6.7	16.5	3.0%	0	0	6.7	16.5
Emergent herbaceous wetlands	0	0	0%	0	0	0	0
Developed, low intensity	0.2	0.4	0.1%	0.1	0.2	0.1	0.2
Evergreen forest	0.1	0.3	0.1%	0	0.1	0.1	0.2
Open water	0	0	0%	0	0	0	0
Barren land	0	0	0%	0	0	0	0
Developed, medium intensity	0	0	0%	0	0	0	0
Mixed forest	0	0	0%	0	0	0	0
Developed, high intensity	0	0	0%	0	0	0	0
Total	219.9	543.6	100%	167.4	413.9	52.5	129.8

Source: Homer et al. 2004

[a] Impacts are estimated from actual impacts calculations of the known 52 turbines and associated facilities and a reasonable estimate of impacts from the additional 48 turbines based on characteristics of the Action Area and the avoidance and minimization measures described in Sections 6.1 – Avoidance Measures and 6.2 – Minimization Measures.

[b] Numbers based on the NLCD and adjusted for impacts to wooded areas as determined with the NAIP and specific avoidance measures such as avoidance of wetlands.

[c] Included in the mitigation acres calculation as an offset for cleared wooded areas.

Additionally, the area planned for tree clearing represents an extremely small proportion of the home range areas documented for Indiana bats in the Action Area and tri-county area. The average home range size for 1 adult male and 11 adult female Indiana bats captured in 2008 and 2009 in the tri-county area was 1,256 ha ± 900 ha [3,104 ac ± 2,223 ac]. Therefore, the maximum 6.5 ha (16.1 ac) (6.8 ha [16.8 ac] for the Redesign Option) of tree clearing represents 0.5% (0.5% for Redesign Option) of the average home range of Indiana bats in the area and will have minimal impact on the availability of foraging habitat. Habitat composition of home range areas was not available from the ODNR. However, given that 85% of the 1,124 telemetry locations from which home ranges were derived were not more than 170 m (559 ft) from a forest edge, it is likely that the majority of these areas were comprised of wooded habitat. Thus, it is unlikely that maternity colonies would have to find additional or alternate rooting or foraging areas outside their traditional areas of use. Because adult females are not likely to suffer energetic losses, it is unlikely that juvenile Indiana bats will be negatively affected. Therefore, it is unlikely that the small amount of tree clearing will result in lost reproductive fitness that would constitute take of Indiana bats.

In summary, given the very small amount of tree clearing planned for construction of the 100-turbine Project, Indiana bats are not expected to be displaced from currently occupied foraging or roosting habitat. Further, Buckeye Wind and USFWS will conduct site visits to identify and mark suitable roost trees as detailed Project planning progresses, and Buckeye Wind will use micro-siting and on-site Natural Resource Specialists during construction to avoid and minimize clearing of potential roost trees to the maximum extent practicable. In the unlikely event that a previously unidentified maternity roost tree is cut during the winter and adult female Indiana bats are subsequently displaced from previously occupied roosts the next spring, adult female Indiana bats are not expected to have to expend substantial amounts of additional energy locating suitable alternate habitat due to the amount of similar wooded habitat available in the surrounding area and because roost trees are not expected to be limited. Indiana bats regularly shift roosts and their centers of activity, and members of a maternity colony are known to have multiple roost sites. Therefore, it is likely that removal of 6.5 ha (16.1 ac) (6.8 ha [16.8 ac] for the Redesign Option) of the 2,744 ha (6,779.4 ac) of wooded habitat available in the Action Area - including a small number of potential roost trees - will not result in indirect take of Indiana bat resulting from increased energy expenditure or lost reproductive fitness due to lost foraging or roosting habitat. For these reasons, indirect effects from tree clearing are not likely to result in take of Indiana bats due to removal of trees during the non-active period and are therefore expected to be insignificant and discountable. Indirect effects to other wildlife will be discussed in detail in the EIS Section 5.6.

5.2.1.2 Impacts to Aquatic Habitats

Water quality degradation has the potential to impact Indiana bats. Reduced water quality could decrease the prey base, reduce water available for drinking, and cause need for greater expenditures of energy devoted to foraging farther distances and/or for longer periods of time. Therefore, large built components of the Project, including wind turbines, staging areas, the O&M building, access roads and collection lines, and the substation, will be sited to completely avoid any impacts to wetlands. All wetlands within the Action Area with the potential to be impacted will be delineated by a qualified wetland delineator. The field delineations in 2008 for the 52 known turbine locations were conducted in accordance with the 1987 USACE wetland manual, while the 2009 and 2011 field delineations were conducted according to both the 1987 USACE wetland manual and the 2008 Midwest Supplement. The wetland delineation is planned to be jurisdictionally confirmed by the USACE once pre-construction notifications (PCN) are submitted to the USACE for anticipated stream crossings for construction of the Project. Wetland delineations for the additional 48 turbines will also be completed to the same standards. USACE will require a site visit prior to approving the PCNs, so the wetland delineation and PCNs will be approved during the same site visit by the USACE. No wetlands will be impacted during the construction, operation, maintenance or decommissioning phases of the Project. See the EIS Section 5.4 for further description of the stream and wetland impacts.

Access roads, collection lines, and crane paths will be required to cross streams at various points within the Action Area. Buckeye Wind will obtain USACE authorization for any discharge of fill material into jurisdictional streams. The OEPA-issued Water Quality Certification (WQC) for Nationwide Permits in 2007 added state-specific conditions and exclusions. The WQC excludes certification of impacts to Ohio Exceptional Warmwater Habitat and Cold Water Habitat streams. The Project will not require an Individual WQC for impacts to Exceptional Warmwater Habitat and Cold Water Habitat streams from Ohio EPA because there will be no in-water work at any proposed crossing location and therefore there will be no impacts to these types of streams[36] (see 5.2.2.1 – Stream Crossings).

The Huntington District of the USACE has indicated that they would treat each stream crossing as separate actions. Access roads, collections lines, and crane paths for the 100-turbine Project are expected to cross no more than 32 streams (46 streams in the Redesign Option; see Table 5-16). Many of these crossings are of drainage ditches and other ephemeral waterways of low habitat quality (see Table 5-16). USGS topographic maps were used to identify streams as these streams are typically USACE jurisdictional. In addition, streams were field delineated using characteristics such as a defined bed and bank, an ordinary high water mark, and other stream morphological features. Streams that are suspected to have channels and be jurisdictional are further investigated to determine their upstream source and their downstream channel fate. The stream delineation is planned to be jurisdictionally confirmed once PCNs are submitted to the USACE for stream crossings. USACE will require a site visit prior to approving the PCNs, so both the wetland delineation and PCNs will be approved during the same site visit from USACE.

Table 5-16. Worst-case estimated stream crossings for the 100-turbine Buckeye Wind Project based on field delineation and desktop analysis of Project designs for the known 52 turbines and associated collection lines, with maximum impacts for the additional 48 turbines.

Crossing Number	Crossing Identifier	Facility Crossing Type	Estimate Stream Width (linear feet)	Maximum Impact Length (linear feet)[a]	Crossing Type[b]	Stream Type
1	Between T9 and T-13; Stream B	Access Road, Buried Interconnect & Crane Path	10.0	58	Existing, Culvert and Trenched or Directionally Bored	Unnamed: Modified Class II PHWH, intermittent
2	Between T-11 and T-16; Stream D	Temp Const Road & Buried Interconnect	7.5	58	Existing, Culvert and Trenched or Directionally Bored	Unnamed: Modified Class I PHWH, ephemeral
3	Near T-17; Stream E	Crane Path & Buried Interconnect	13.0	60	Temporary Crossing and Trenched or Directionally Bored	Dugan Run; Modified Class II PHWH, intermittent
4	Near ST HWY 814 and access road for T-27; Stream K	Crane Path	4.0	0	Temporary Crossing	Unnamed: Modified Class I PHWH, ephemeral
5	Near T-28; Stream BB	Interconnect	11.9	0	Directionally Bored	Treacle Creek; Exceptional Warmwater Habitat; intermittent

[36] Crossings will entail techniques and structures that do not disturb ground that is within the delineated edge of the stream.

Table 5-16. Worst-case estimated stream crossings for the 100-turbine Buckeye Wind Project based on field delineation and desktop analysis of Project designs for the known 52 turbines and associated collection lines, with maximum impacts for the additional 48 turbines.

Crossing Number	Crossing Identifier	Facility Crossing Type	Estimate Stream Width (linear feet)	Maximum Impact Length (linear feet)[a]	Crossing Type[b]	Stream Type
6	Access road for T-27; Stream J	Access Road, Crane Path & Buried Interconnect	12.5	60	Existing and Trenched or Directionally Bored	Unnamed; Modified Class II PHWH, intermittent
7	Near T-43; Stream W	Access Road & Buried Interconnect	16.0	48	Existing, Culvert and Trenched or Directionally Bored	Unnamed; Modified Class II PHWH, Intermittent
8	Near T-37 and T-41; Stream R	Access Road, Crane Path & Buried Interconnect	13.0	90	Culvert	Unnamed; Class II PHWH, intermittent
9	Near T-28 and T-33; Stream AA	Access Road, Crane Path and Buried Interconnect	12.0	0	Elliptical culvert and/or Directionally Bored	Buck Creek; Cold Water Habitat; intermittent
10	Between US HWY 36 and T-43; Stream I	Access Road	16.3	34	Culvert	Unnamed; Modified Class II PWHW, perennial
11	Near T-52; Stream Y	Crane Path & Buried Interconnect	12.9	0	Temporary Crossing and Directionally Bored	Buck Creek; Cold Water Habitat, intermittent
12	Near T-55 and ST HWY 29; Stream CC	Access Road & Buried Interconnect	2.5	60	Culvert and Trenched or Directionally Bored	Unnamed; Modified Class I PHWH; ephemeral
13	Near T-53; Stream DD	Access Road & Buried Interconnect	20.0	60	Culvert and Trenched or Directionally Bored	Unnamed; Modified Class I PHWH; ephemeral
14	Near T-18; Stream S	Access Road & Buried Interconnect	8.5	60	Existing; Culvert and Trenched or Directionally Bored	Unnamed; Modified Class I PHWH; ephemeral
15	Near T-42 and T-45;mj Stream V	Access Road & Buried Interconnect	16.0	60	Culvert and Trenched or Directionally Bored	Unnamed; Modified Class II PHWH; intermittent
16-32	16 Phase II Crossings estimated for additional 48 turbines	Crane Paths, Access Roads and Collection	8-10	600	As needed	Various
33-49 (for Redesign	Buried Interconnect	Buried Interconnect	8-10	350	Trenched or Directionally	Various

Table 5-16. Worst-case estimated stream crossings for the 100-turbine Buckeye Wind Project based on field delineation and desktop analysis of Project designs for the known 52 turbines and associated collection lines, with maximum impacts for the additional 48 turbines.

Crossing Number	Crossing Identifier	Facility Crossing Type	Estimate Stream Width (linear feet)	Maximum Impact Length (linear feet)[a]	Crossing Type[b]	Stream Type
Option Only)	Crossings				Bored	
Total (Without Redesign Option	Approx. 32 Crossings		-	1,248		
Total (for Redesign Option)	Approx. 49 Crossings			1,598	As needed	Various

[a] Where existing crossing are present, the *new* impact will be reduced by the impact that already exists. Advanced engineering studies will determine what (if any) additional in-water work is needed to support Project construction and operation. Temporary crossings consist of steel plates or other rigid structures that can be placed over and above a stream so no in-water work is necessary.
[b] Values do not include subtraction for existing crossings.
Source: Hull 2009 and updates, preliminary construction engineering

5.2.1.2.1 Stream Crossings

Buckeye Wind will implement all appropriate low impact stream crossing techniques for road crossings and crane path crossings. All streams to be crossed by Project facilities will undergo field screening for federally endangered and threatened species. Surface water delineations will be performed and Project facilities will be sited to avoid or minimize impacts to surface water resources. This field delineation will be done for all of the crossings associated with the 100-turbine Project. Almost all of the crossings for the additional 48 turbines will accommodate access roads and crane paths, as well as collection lines. Since the final plan layout for the additional 48 turbines has not been completed, the estimates given in Table 5-16 for the 100-turbine Project are a reasonable worst-case scenario and final impacts will almost certainly be less than what is presented, but will not be more.

Where road crossings will require in-water work, a culverted crossing will be utilized (see Figure 5-7). For culverted crossings, Buckeye Wind will obtain USACE authorization for any discharge of fill material into jurisdictional streams. Further measures to minimize impact will be utilized, such as installation of crossings "in the dry" when there is no flowing water and with no excavation equipment located in flowing waters (for ephemeral or intermittent streams).

For road crossings over high quality streams, specifically Ohio Exceptional Warmwater Habitat and Cold Water Habitat[37], open bottomed culverts, elliptical culverts, or arched bridges will be utilized to minimize

[37] According to Ohio Revised Code, Exceptional Warmwater Habitat streams are capable of maintaining an exceptional or unusual community of warmwater aquatic organisms with the general characteristics of being highly intolerant of adverse water quality conditions and/or being rare, threatened, endangered or species of special status. This is the most protective use designation assigned to warmwater rivers and streams in Ohio. A Coldwater Habitat stream is capable of supporting populations of coldwater aquatic organisms on an annual basis and/or put-and-take

loss of aquatic habitat and restriction of fish passage (see Figure 5-8). These crossings will utilize techniques and structures that do not disturb ground that is within the delineated edge of the stream. Similar methods will be used for road crossings over any streams thought to have the characteristics necessary to support federally listed threatened or endangered aquatic species (see Section 3.2.1 – Federal Threatened, Endangered, and Candidate Species). No permits will be required for these crossings.

Figure 5-7. Example of a culverted crossing that would be authorized by the USACE under Section 404 of the CWA.

Some crossings (primarily those associated with crane paths that do not follow a planned access road) will only require a temporary crossing. Temporary crossings consist of steel plates or other rigid structures that can be placed over and above the stream. These crossing techniques can be installed without disturbance to areas below the high water mark of the stream and will not impact the aquatic resource (see Figure 5-9). No permits will be required for these crossings and the crossing will be removed after construction. Depending on the stream width and the grade of the areas around the stream, this technique may not be available. In cases where temporary crossings cannot be utilized, culverted crossings will be used or, if the stream is an Ohio Exceptional Warmwater Habitat or Cold Water Habitat, open bottomed culverts, elliptical culverts, or arched bridges would be utilized.

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salmonid fishing. These water bodies are not necessarily capable of supporting the successful reproduction of salmonids and may be periodically stocked with these species. Both are afforded special protections under Ohio's CWA provisions.

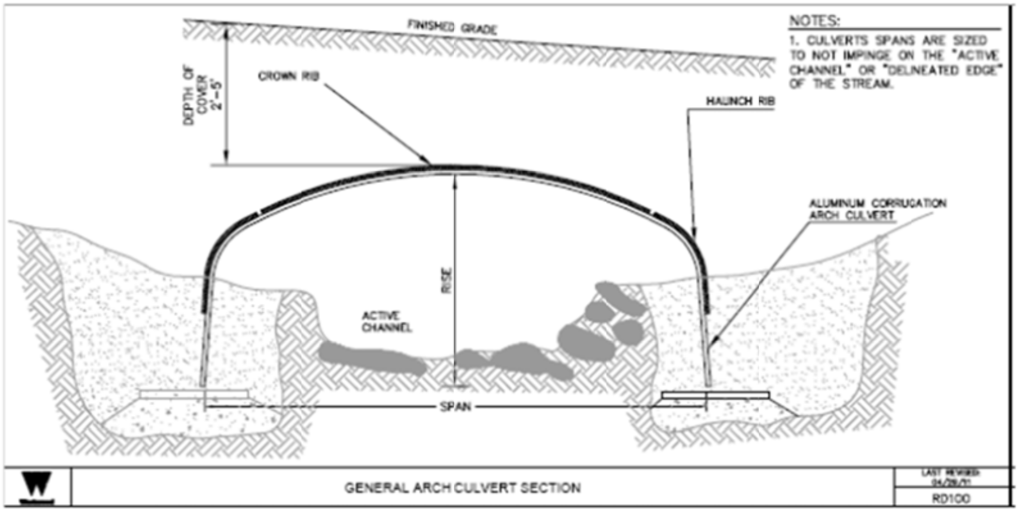

Figure 5-8. Example of an open-bottomed culvert or arched bridge that would be built above the delineate edge of the stream.

Where only collection lines cross streams, the impacts would be significantly less than the impacts for access road or crane path crossings. Most collection line crossings of intermittent and ephemeral streams will trench through the stream and will be done when the stream is dry. In those cases when only buried electrical interconnects cross a perennial stream, Buckeye Wind will horizontally directionally drill underneath the stream regardless of its beneficial use classification. In addition, if water is present at the time an intermittent or ephemeral stream is crossed, Buckeye Wind will horizontally directionally drill underneath the stream regardless of its beneficial use classification.

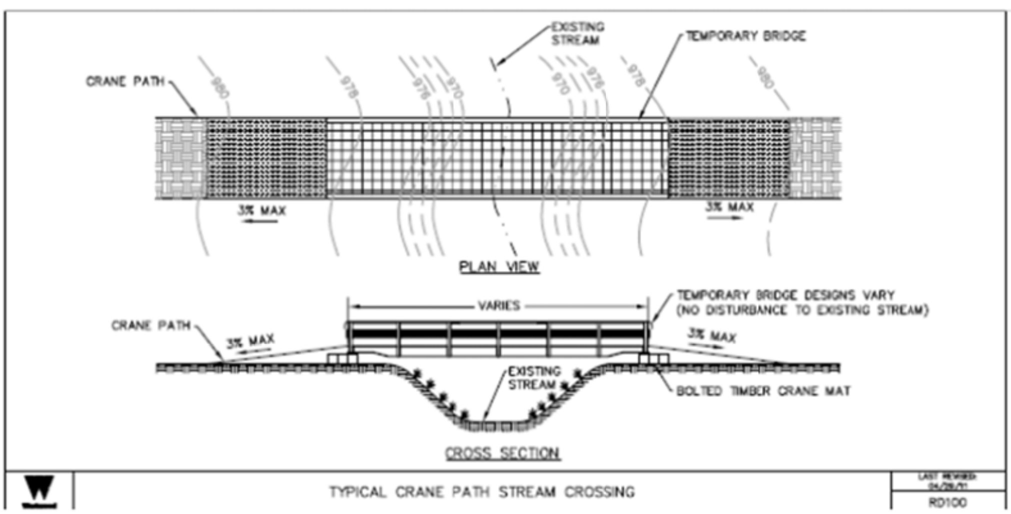

Figure 5-9. Example of a temporary construction crossing that would be placed above the delineated edge of a stream.

Some stream crossings may require clearing of trees and disturbance to the riparian zone. However, any tree clearing has already been accounted for in the total wooded habitat removal in Section 5.2.1.1 – Wooded Habitat Removal. However, removal of wooded areas in these riparian areas may cause fragmentation that could alter the behavior of Indiana bats. While Indiana bats have been known to traverse 1000 ft or more of non-wooded areas during the course of foraging activities, they have also been known to travel longer distances in order to go around open areas and stay within wooded areas. It is therefore possible that removal of trees in areas providing a wooded corridor between foraging habitats could result in increased energy expenditures and alteration of foraging behavior. However, the width of the disturbances for the Project will be less than 100 ft along any stream crossing (see Table 5-16), which is not expected to preclude Indiana bats from using that corridor.

Temporary crossings and areas of temporary construction impact will be restored and re-vegetated per the erosion and sediment control plan, consisting of planting native plant species (see Appendix D for a typical native plant mix) to provide ground stabilization. Where forest fragmentation results from construction activities, the areas will be restored using trees suitable for Indiana bat habitat, if practicable. A list of native trees suitable for planting to restore Indiana bat habitat is included in Appendix D. If existing land-use precludes the use of native species (e.g., agricultural use), restoration and stabilization will be established consistent with that land-use. Erosion and sediment control measures will limit the amount of sediment from exposed soil entering the stream, so impacts to aquatic foraging habitat will be minimized. For example, silt fences, hay bales and/or filter socks will be used to catch any sedimentation from active construction areas. Catch basins may be installed to allow sedimentation to fall out before the run-off enters the streams. Swales and ditches may be installed to divert sedimented water away from streams and into areas that have the proper sediment control measures (silt fences, catch basins, etc.) These measures will ensure that the stream quality is not degraded and that the ability of the water features in the Action Area to support prey species and hydration for the Indiana bat will not be degraded.

The Redesign Option may logically necessitate additional stream crossings and impacts because the electrical interconnect will not aerially span the streams. In many cases buried electrical interconnects will be co-located with planned access roads and crane paths, so the number of new stream crossings will be minimized. In some cases buried electrical interconnects will be the only Project component crossing a stream. In those cases when only buried electrical interconnects cross a perennial stream, Buckeye Wind will horizontally directionally drill underneath the stream regardless of its beneficial use classification. In cases where only buried electrical interconnects cross an intermittent or ephemeral stream, Buckeye Wind will open trench through the stream and conduct the trenching during periods of no water flow. In addition, if water is present at the time an intermittent or ephemeral stream is crossed, Buckeye Wind will horizontally directionally drill underneath the stream regardless of its beneficial use classification. Additionally, in order to continue to avoid any impacts to high quality potential Indiana bat foraging habitat, Buckeye Wind will use horizontal directional boring for electrical interconnect crossings of any stream Ohio designated as Exceptional Warmwater Habitat or Cold Water Habitat as well as any streams thought to have the characteristics necessary to support federally threatened or endangered species of freshwater mussels (see Section 3.2.1 – Federal, Threatened, Endangered, and Candidate Species). For each stream crossing in the Redesign Option, that is not an OH designated Exceptional Warmwater or Cold Water Habitat and that will be temporarily impacted by open trenching to install buried interconnect, Buckeye Wind will also obtain USACE authorization for any discharge of fill material into jurisdictional streams. Streams that are open trenched will be restored to their pre-existing grade and re-vegetated with appropriate native riparian species. Where forest fragmentation results from construction activities, the areas will be restored using trees suitable for Indiana bat habitat, if practicable. A list of native trees suitable for planting to restore Indiana bat habitat is included in Appendix D. If existing land-use precludes the use of native species (e.g., agricultural use), restoration and stabilization will be established consistent with that land-use. Thus, there will be no permanent impacts to any streams that are crossed with buried interconnects only. Potential impacts to wetlands due to changes to a buried interconnect system will be avoided. Buckeye Wind may remove or add measures to the planned erosion and soil control measures section in order to avoid and minimize impacts to streams due to the different construction methods necessary to cross streams with buried interconnects from those proposed.

5.2.1.2.2 Soil and Erosion Control

Without proper erosion control measures in place, earth-moving activities associated with Project construction and decommissioning have the potential to cause siltation and sedimentation impacts down slope of the area of disturbance and, in turn, affect aquatic habitats and food resources (i.e., aquatic insects).

Buckeye Wind has undertaken several steps to prevent adverse effects to water quality and aquatic habitat during construction, such as siting Project components away from wetlands and streams to the extent practicable and using horizontal directional boring to avoid in-water work at high quality stream crossings. Runoff will be managed under a National Pollutant Discharge Elimination System (NPDES) construction storm water permit and associated SWPPP. The NPDES permit program is implemented through the CWA. The NPDES permit program is authorized at the state government level by the EPA and the Ohio EPA issued construction storm water NPDES permits. The NPDES permit program is designed to reduce pollutants, sediment and erosion from impacting surface waters and aquatic habitats. Through a NPDES permit, Buckeye Wind will be required to control pollutant, sediment and erosion discharges. This protection of aquatic habitats will be implemented through erosion and sediment control measures. These measures will prevent degradation of Indiana bat foraging habitat by ensuring that stream quality does not diminish and therefore, their prey base is not negatively affected by construction activities. Pollutants and sediment can reduce the diversity and quantity of insects. Erosion and sediment control measures will protect against this and also ensure that the existing drinking water quality of the streams in the Project is not degraded. Additionally, these erosion and sediment control measures will also prevent negative impacts to any mussel or other aquatic species inhabiting streams within and downstream of the Project. Most mussel species require good water quality and erosion and sediment control measures implemented through the NPDES permit will preserve the existing water quality level.

As part of the NPDES requirements and prior to construction, an erosion and sediment control plan will be developed and will use appropriate runoff diversion and collection devices. This plan is developed and implemented by the general contractor and has not been developed, so it is not possible to know exactly where certain erosion and sediment control practices will be utilized. However, based on previous wind farm construction experience, typical erosion and sediment control best management practices may include: silt fences, filter socks, swales, temporary and permanent mulching and seeding, infiltration berms, inlet and outlet protection, construction entrances, and orange construction fencing to protect wetlands located near disturbance areas. The ODNR Division of Soil and Water Resources' Rainwater and Land Development Manual will be used as a to guide to determine the appropriate erosion and sediment control measures and the post-construction storm water practices to be used at the Project.

The NPDES permit will also include restoration measures that will ensure that disturbed ground is stabilized, preventing ongoing erosion and sedimentation of storm water run-off. These restoration measures consist of revegetation (typically using native species; and depending upon the land use), regrading and permanent swales or catch basins as needed.

In summary, as a result of the erosion and sediment control measures that will be implemented by Buckeye Wind and enforced by its NPDES permit during construction and decommissioning to avoid and minimize impacts to wetlands and streams, impacts to aquatic habitat will be minimal. Consequently, potential indirect effects on Indiana bats such as a decreased prey base, reduced water available for drinking, and the need for greater expenditures of energy devoted to foraging farther distances and/or for longer periods of time is expected to be insignificant and discountable. Refer to Section 6.2 – Minimization Measures and the EIS Section 5.4 for a detailed description of anticipated impacts to streams and wetlands in the Action Area and how they will be avoided and minimized.

5.2.2 Indirect Effects – Operation and Maintenance

5.2.2.1 Vegetative Control

During Project operations, vegetative control will be implemented for general Project operation and as part of the HCP. Periodic tree trimming will occur for safety and accessibility of the Project facilities. For example, overhead collection lines will be cleared of all overhanging limbs and trees around access roads may have to be trimmed to maintain open access. No additional clearing of wooded areas will be required during Project operation and areas that were temporarily disturbed during construction will be allowed to grow back, while cleared areas required for permanent access will be maintained. Further tree trimming performed by Buckeye Wind and associated with Project maintenance will be completed during the non-active period (1 Nov – 31 Mar) for Indiana bats to avoid potential direct impacts (disruption to roosting bats) that would result if potential roost trees were disturbed during the active period. Trimming of live or downed trees that are not suitable for roosting Indiana bats may occur during the active period. Therefore, it is not anticipated that tree trimming will result in harm to Indiana bats and indirect effects will be insignificant and discountable and will not likely rise to the level of take.

5.2.3 Indirect Effects – Mitigation

5.2.3.1 Invasive Species Control

The majority of mitigation activities are expected to be composed of preservation and enhancement in areas likely to currently support Indiana bat foraging or roosting activities (see Section 6.3 – Mitigation Measures). In order to preserve and enhance the suitable habitat, woody invasive species removal will be employed as necessary to remove species that impede flight and make snags more accessible (IN DNR 2008). Invasive species could also impede development of wooded habitats in areas where restoration activities will be implemented (corridors to connect existing wooded habitat areas).

Control of invasive species will include clearing of woody invasives such as bush honeysuckles (*Lonicera maackii, L. morrowii,* and *L. tatarica*) and tree of heaven (*Ailanthus altissima)*. Methods for clearing invasive species will include brush cutting (using bushhogs, mowers, or other similar equipment), hand cutting, and the use of herbicides if necessary. Herbicides may be used to paint cut stems and/or large shrubs too big to remove. Woody invasive species coverage will be maintained at no more than 5% of the understory cover (see Section 6.3 – Mitigation Methods). Areas around the P2 hibernacula in OH are primarily agricultural lands, where herbicides are commonly used; therefore, the use of herbicides associated with the Project will not be significant as compared to current land use practices. Clearing activities could necessitate soil and vegetation disturbance and potential vehicular traffic for site preparation and maintenance. Soil disturbance, if any, from movement of clearing equipment and the clearing activity is expected to be minor and erosion and sediment control measures would not be necessary. Invasive species control will not degrade or remove suitable habitat or potential roost trees and will be an overall enhancement of Indiana bat use areas. Please see Section 6.3 – Mitigation Measures for a more detailed discussion of restoration and enhancement measures.

In order to avoid direct impacts to the Indiana bat, including disturbance from noise, vibration, human activity, and vehicular collision, invasive species management will occur during the non-active period for Indiana bats (15 Nov to 15 Mar, also excluding swarming periods). Indirect adverse effects are expected to be insignificant and discountable and will not result in take of Indiana bats.

5.2.3.2 Tree Girdling

Reproductive females occupy roost sites under the exfoliating bark of dead, dying, or live trees, and occasionally in narrow cracks of trees located in both upland and riparian forest (Gardner et al. 1991a, Callahan 1993, Kurta et al. 1993, Kurta et al. 2002, Carter 2003, Britzke et al. 2006). Roost trees used by Indiana bats vary in size. The minimum tree size (diameter at breast height [dbh]) reported for a male roost is 6.4 cm (2.5 in; Gumbert 2001) and 11 cm (4.3 in) for a female roost (Britzke 2003). Primary maternity roosts are always found in larger diameter trees, usually more than 22 cm (8.7 in) dbh (Murray and Kurta 2004). Larger diameter trees provide thermal advantages to reproductive females and their pups by giving them more room to move around while locating appropriate temperatures. See Section 4.4.4.1 – Maternity Roosts for more information on Indiana bat use of maternity roost trees. If there is a deficiency in the number of suitable roost trees, girdling (i.e., cutting of the bark and a portion of the underlying cambium layer to create a ring-like groove encircling the base of the trunk) can create suitable Indiana bat roost trees over a period of several years. Girdling will be considered as a management action in a preservation or enhancement area if there are less than 2 natural snags or girdled trees of at least 25 cm (10 in) dbh per ac, less than 5 trees between 25 cm (10 in) and 48 cm (19 in) dbh per ac, and less than 2 trees greater than 48 cm (19 in) dbh per ac (see Section 6.3.4 – Restoration and Enhancement).

Girdling will be accomplished by using a chainsaw or handsaw to cut a 1-inch to 2-inch deep cut around the circumference of the tree. The saw cut should not exceed 5% of the diameter of the trunk at 2 feet above the ground surface.

In order to avoid impacts to the Indiana bat, tree girdling will occur during the non-active period for Indiana bats (15 Nov to 15 Mar, also excluding swarming periods). Tree girdling will enhance Indiana bat habitat by creating potential roost trees and, therefore, indirect adverse effects from tree girdling would be insignificant and discountable and will not result in take of Indiana bats.

5.3 Cumulative Effects

As described previously, the Action Area is composed of active agricultural areas, low density residential areas, and fragmented woodlots. Other than ongoing agricultural and small-scale and periodic timber harvesting activities, which are occurring or may occur in the Action Area over the ITP Term, Buckeye Wind is not aware of future state or private activities in the Action Area. According to the Logan-Union-Champaign Regional Planning Commission and Champaign County Building Regulations office, no known residential subdivisions or retail/commercial developments have been approved or are currently proposed in the general vicinity of the Action Area. However, several new private homes, pole barns, and an equipment storage yard have been approved (received building permits) and lot splits are common.

Given that agriculture has been the predominant land use in the Action Area for the past several decades and wooded habitat is already substantially fragmented, it is not likely that small-scale timber harvesting activities and the sporadic building of individual homes will result in significant reductions in available suitable habitat for Indiana bats. To the contrary, wooded habitat in the Action Area is likely to increase in the future, based on patterns of changing land use that have occurred over the past half century and are expected to continue, such as the conversion of agricultural areas back to wooded areas. As described in Section 3.1.6 – Landcover, prior to European settlement, OH was approximately 95% wooded. However, rapid conversion of woodlots to agricultural lands resulted in a steady decline of tree cover to a low of 12% in 1940 (ODNR DOW 2011). Wooded land has been increasing in OH since 1940 and in 2001 it comprised approximately 33% of the state's land area. Thus, other future state or private actions in the Action Area are not expected to result in cumulative effects to Indiana bats (See Section 5.6 of EIS for cumulative effects to other wildlife species).

5.4 Potential Beneficial Effects of Wind Energy on Indiana Bats

The expansion of wind energy may have beneficial effects on biological resources, including Indiana bats. Increases in wind power production and consumption will help to reduce reliance on fossil-fuels and will reduce carbon dioxide emissions. Coal provides 86% of electricity generated in OH and it has the highest carbon dioxide emission per unit of electricity produced in the United States (DOE EIA 2007). The state was the fourth largest contributor of carbon dioxide pollution in the country in 2007 and it was among the highest contributors internationally; only 23 countries emitted more carbon dioxide pollution into the atmosphere than the state of OH in 2007 (Gomberg 2008, EPA 2009b). Increased carbon dioxide and other greenhouse gases emissions are resulting in global climate change that includes rising temperatures and changes in temperature regimes, precipitation patterns, fire cycles, storm severity, and sea level rise, among other things (EPA 2009b). As described in Section 4.5.4 – Climate Change, Indiana bats may be negatively affected by a number of manifestations of climate change, including changes to temperature and moisture regimes within hibernacula and maternity roosts, reduced availability of insect prey, range shifts, increased forest fires and associated removal of roosting and foraging habitat, flooding, and changes in species composition within forests.

Other by-products of non-renewable energy extraction can negatively affect Indiana bats, including habitat destruction and degradation and water and air pollution. Combustion of fossil fuels produces air pollutants such as nitrogen oxides, sulphur dioxide, volatile organic compounds, and heavy metals that could negatively affect Indiana bat health and viability. Habitat destruction from surface mining of coal affects Indiana bats, both through removal of large, contiguous areas of intact forest, and through destruction and degradation of streams that provide food resources. Coal slurry, a fluid byproduct of the preparation process created when coal is washed with water and chemicals, has been known to be accidentally spilled into OH streams, resulting in mass mortality of aquatic insects and fish. According to a recent study, surface mining of coal is now the dominant driver of land-use change in the central Appalachian eco-region of the United States (Palmer et al. 2010), which includes a portion of the Midwest RU in eastern KY. Surface mining for coal is the dominant energy extraction practice in the region (i.e.., OH, WV, KY, VA, TN, and PA).

One major form of such mining, mountaintop mining with valley fills (MTM/VF), authorized under Section 515(c)(1) of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) and widespread throughout eastern KY, WV, and southwestern VA, involves the removal of extensive tracts of deciduous forests that are cleared and stripped of topsoil. Although the USACE and the EPA have issued a moratorium on new permits for MTM/VF, they are allowing existing projects to continue the practice for the duration of current permits. With regard to MTM/VF, Palmer et al. (2010) revealed that there is a "preponderance of scientific evidence that impacts are pervasive and irreversible and that mitigation cannot compensate for losses." Indiana bats are impacted by MTM/VF by the removal of roosting and foraging habitat and valley fill activities that degrade and destroy streams and Indiana bat prey species (EPA 2003).

While MTM/VF mining is not practiced in OH, states commonly sell coal amongst each other. Increased demand for energy in OH could be met by MTM/VF mining activities in adjoining states, or by surface coal mining, which causes similar landscape scale effects on forest and other natural habitats[38]. Demand for

[38] Impacts to wetlands and streams are more heavily regulated for surface coal mining than for MTM/VF mining; the USACE and EPA now require pre-project topographic and vegetation restoration following mining activities as a permit condition.

coal-generated electricity, the dominant fuel source in OH, will likely increase unless alternate energy sources are available. Increased coal mining and coal burning will continue to contribute towards the loss of forested habitat at a large scale and to pollution of air and water sources, all of which can negatively impact Indiana bats.

While the Project alone is not expected to individually slow, halt, or offset the negative effects of climate change or other by-products of non-renewable energy extraction, the Project is part of a larger state and national strategy to reduce reliance on carbon-emitting fuel sources, that together with other renewable energy projects have the potential to minimize the associated negative effects to Indiana bats.

In addition, information provided by the Project in the form of post-construction mortality monitoring results will help advance the understanding of wind-bat interactions. This information will help this Project and other wind projects implement construction, operation, and decommissioning approaches that will reduce impacts to Indiana bats, as well as non-federally listed bats and birds. Mitigation measures implemented as part of this HCP will also benefit Indiana bats and other non-federally listed bat species.

6.0 CONSERVATION PROGRAM

According to the HCP Handbook (USFWS and NOAA 1996), mitigation actions under HCPs usually take 1 of the following forms:

1) Avoiding the impact (to the extent practicable);
2) Minimizing the impact;
3) Rectifying the impact;
4) Reducing or eliminating the impact over time; or
5) Compensating for the impact.

The Handbook further states that several strategies can be used to address project effects, including:

1) Avoiding by relocating project facilities within the project area;
2) Minimizing through timing restrictions and buffer zones;
3) Rectifying by restoration and revegetation of disturbed project areas;
4) Reducing or eliminating over time by proper management, monitoring, and adaptive management; and,
5) Compensating by habitat restoration or protection at an on-site or off-site location.

In accordance with the HCP Handbook, the conservation program described in the following sections uses a combination of these strategies to achieve avoidance, minimization, and mitigation of potential direct and indirect effects to Indiana bats caused by the Project. These measures will be implemented by Buckeye Wind to meet the biological goals and objectives of this HCP, described in Section 1.2 – Biological Goals and Objectives of the HCP.

The avoidance and minimization measures and adaptive management that will be implemented as part of this HCP will minimize the incidental take to the maximum extent practicable, and mitigation measures will offset the impact of the take caused by the Project and aid in achieving goals identified in the Indiana bat 2007 Draft Recovery Plan. As described in Section 5.1.2.6 – Biological Significance of Incidental Take (Collision Mortality), the estimated level of Indiana bat mortality over the ITP Term (130.0 Indiana bats over 30 years) is not likely to measurably reduce the size of local, migratory, or Midwest RU populations of Indiana bats at current population levels. Conservation measures that will be implemented by providing funding for research on Indiana bat-wind interactions will provide valuable information that can be used to increase the effectiveness of future minimization and avoidance measures at the Project and other wind energy developments within the range of the Indiana bat. Avoidance, minimization, mitigation, adaptive management, and conservation measures for the Indiana bat will be described in the following sections.

6.1 Avoidance Measures

6.1.1 Project Planning and Siting

An iterative screening process was initiated in 2006 in Champaign and Logan counties, OH, that was very similar to the tiered process recommended by the Wind Turbine Guidelines Federal Advisory Committee Guidelines (FAC Guidelines; FAC 2010). Buckeye Wind relied on input and guidance from the USFWS and ODNR to inform their site selection process, along with standard practices utilized by the wind industry in siting of projects throughout the United States, initially settling on the initial study area that extended north from the current Action Area into Logan County (Figure 1-2). The FAC Guidelines provide a formalization of the basic approach that many wind power developers have used for many years while working with state and federal natural resources agencies.

Beginning in the summer of 2006, the Tier 1 site selection process included a broad-level review of publicly available information to evaluate potential development sites within the initial study area. The evaluation included screening for known and potential occurrence of ESA or state listed species, presence of designated critical habitat, and general ecological context of the potential locations, including the degree of fragmentation, land ownership, and land use. Landscape-level screening also identified several areas as having potentially suitable wind resources and land lease potential. This Tier 1 evaluation identified the initial study area as having among the best wind resource in OH, transmission available within a reasonable distance, and where publicly available information–such as screening federal and state species lists, migratory pathways, important bird areas, and protected areas–indicated that risks to bird and bat breeding or migratory areas, important habitat areas, and federally and state listed species would be low.

Later in 2006, for the Tier 2 site selection process, available site-specific information was gathered from public sources to further characterize sites identified as potentially suitable in terms of their potential to support state and federal listed species and other protected wildlife species. Areas with potential to support "wildlife species of concern" as described in the FAC Guidelines and that could present risk to particular species or species groups were identified, such as known or suspected hibernacula, areas of known raptor or eagle migratory corridors or nesting sites, or records of special status bird or bat species. Based on these evaluations, the initial study area was not found to have any known critical areas where wildlife congregate, was determined to be highly fragmented from previous and ongoing agricultural activities, and did not have any records of federally listed species. The site was also found to be sufficiently distant from any known Indiana bat hibernacula (the closest known hibernacula is the Lewisburg Limestone Mine in Preble County, OH, approximately 100 km [62.5 mi] southwest of the Action Area) and did not have any known Indiana bat summer records (Indiana bat summer records in western OH were only known from Greene, Montgomery, and Miami counties in OH prior to 2008). Thus, the Project site was considered suitable for further evaluation and in-depth studies to fully characterize the natural resources potentially at risk from development of the Project.

In the Tier 3 phase of site evaluation, quantitative and scientifically rigorous studies were conducted in the initial study area to assess the potential risk of the Project to species and/or habitats of concern. Beginning in 2008, a series of studies to characterize the distribution, relative abundance, behavior, and site use by birds and bats were designed based on protocols developed in consultation with the USFWS and ODNR DOW. Study work plans were discussed and shared with the USFWS and ODNR DOW beginning in fall 2007. Several meetings were held in 2007 and 2008 to discuss agency comments and several field trips were conducted with agency representatives. Agency recommendations were subsequently incorporated into final study protocols. In addition, representatives of both the ODNR DOW and the USFWS participated in several of the field studies.

In the summer of 2008, during Tier 3 studies, a new summer colony of Indiana bats was discovered in the initial study area in Logan County. Based on this finding, in consultation with the USFWS, Buckeye Wind reduced the area of proposed turbine development to avoid potential impacts to Indiana bats (see Section 1.1 – Overview and Purpose of the HCP and Figure 1-2), resulting in the current Action Area. Because the Action Area was more than 8 km (5 mi) away from the nearest capture site for Indiana bats, it appeared that impacts to Indiana bats were sufficiently avoided and Buckeye Wind, in consultation with the USFWS and ODNR, made a decision to proceed with the Project within the current Action Area. Buckeye Wind then proceeded to develop an application for a CECPN for approval through the OPSB in 2008-2009.

Despite thorough pre-planning, prior bat surveys within the Action Area that did not detect Indiana bats, due diligence, and ongoing consultation with the USFWS and the ODNR DOW, Indiana bats were unexpectedly discovered in the Action Area in summer 2009. The discoveries were made in the northern part of the Action Area during mist-netting surveys conducted by another entity as part of site evaluations for an unrelated wind project. Due to these discoveries, Buckeye Wind determined that it was appropriate to enter into discussions with the USFWS to seek an ITP under Section 10 of the ESA. Furthermore, research (Arnett et al. 2010, Baerwald et al. 2009 and Good et al. 2011; see Table 6-1) indicates that specific avoidance and minimization methodologies are effective in reducing direct and indirect impacts to bats from wind projects, making it likely that an HCP could be developed that would allow the Project to be built while avoiding and minimizing impacts to Indiana bat populations. The following sections describe additional measures that will be taken by Buckeye Wind to avoid impacts to Indiana bats and where those impacts cannot be avoided, how they will be minimized and mitigated, to the maximum extent practicable.

The following avoidance actions were taken during Project siting and planning:

1) The initial study area was reduced to remain 8 km (5 mi) away from discovery of Indiana bats in 2008.
2) Initial turbine siting avoided large blocks of contiguous forested habitat and protected areas. Instead, areas in which prior agricultural practices had created a highly fragmented landscape where wind development would pose substantially less risk to species of concern were prioritized for further consideration. For the additional 48 turbine locations, similar efforts will be taken to avoid such wooded areas, resulting in the worst-case scenario of habitat impacts for the 100-turbine Project presented in Table 5-14 (Table 5-15 for the Redesign Option);
3) None of the 100 turbines will be closer than 2.9 km (1.8 mi) to known maternity roost trees documented in 2009[39].
4) Up to 10 turbines (8%) will be located in Category 1 habitat. Table 6-2 provides the maximum number of the turbines that may be sited in each of the remaining Categories 2-4.

6.1.2 Project Construction

In addition to siting the Project away from forested areas and largely in agricultural areas, the following actions will be taken to avoid adverse effects to Indiana bats from construction activities of the 100-turbine Project. Many of these measures also assist in avoidance of impacts to other bats such as the little brown and northern long-eared bat. These cave bats also roost in trees and forage in forested habitat, so avoidance and minimization of tree clearing will benefit these species as well as the Indiana bat (see EIS Section 5.6 and Chapter 5 of the ABPP).

1) Buckeye Wind will not remove the 3 known Indiana bat roost trees in the Action Area for the 100-turbine Project.

2) Buckeye Wind will avoid potential direct effects from habitat loss to roosting Indiana bats in unidentified maternity roost trees:

[39] The primary benefit from siting turbines at some distance from maternity roost trees is that it would tend to reduce risk of impact or barotrauma. While there is no evidence to suggest that shadow flicker or sound from operating turbines would impact Indiana bats in roost trees, greater distances also reduces the potential for disturbance.

   a. All tree clearing activities will be conducted outside the period when Indiana bats are expected to be roosting in the Action Area. Any tree clearing will be conducted between 1 Nov and 31 Mar.

3) Prior to any tree removal, the limits of proposed clearing will be clearly demarcated on-site with orange construction fencing (or similar) to prevent inadvertent over-clearing of the site.

4) A Natural Resource Specialist knowledgeable on Indiana bats and their habitat requirements will be present at the time of tree clearing:
   a. Buckeye Wind will conduct habitat assessments jointly with the USFWS for the areas of planned tree clearing once Project plans are finalized and before any clearing is conducted, during which all potential roost trees will be identified and flagged.
   b. Prior to the finalization of the detailed design of Project components, Buckeye Wind will make all reasonable attempts to offset the clearing radii around turbines or adjust roads/interconnects to preserve any potential roosts and avoid any unnecessary clearing.

5) Measures will be taken to avoid impacts to high quality potential Indiana bat foraging riparian habitat and the prey that it supports:
   a. Horizontal directional boring will be used to avoid impacts to any Ohio designated Exceptional Warmwater Habitat or Coldwater Habitat stream.
   b. Wetlands will not be impacted by construction activities for the 100-turbine Project (includes Redesign Option).
   c. The Project was designed to avoid stream crossings whenever possible. Due to the nature of this type of project, there is some flexibility in selecting turbine locations and, more so, access road and electric collection line locations. As such, great care was taken to design Project facilities to avoid tree clearing and in-water work associated with stream crossings to the maximum extent practicable. See Section 5.2.1.2 – Impacts to Aquatic Habitats for a discussion of stream impacts.
   d. Horizontal directional boring for collection lines will be used to avoid impacts to all perennial streams. In addition, if water is present at the time an intermittent or ephemeral stream is crossed, Buckeye Wind will horizontally directionally drill underneath that stream.

6.2 Minimization Measures

6.2.1 Project Construction

In addition to avoidance measures listed above, the following actions will be taken to minimize adverse effects to Indiana bats from construction activities for the 100-turbine Project:

1) Buckeye Wind will limit the amount of tree removal:
   a. Only 6.5 ha (16.1 ac), or 6.8 ha (16.8 ac) for the Redesign Option, of forest habitat will be cleared for the 100-turbine Project; or 0.2% (0.2% for the Redesign Option) of the 2,744 ha (6,779.4 ac) of forested habitat available in the Action Area (see Section 5.2.1.1 – Wooded Habitat Removal).
   b. Areas where tree removal is planned will be spread throughout the Action Area and tree removal will not be concentrated in in any single area.
   c. Forest patches cleared will be small, with an average size for the known 52 turbine locations of 0.2 ha ± 0.4 ha (0.4 ac ± 0.9 ac) and a maximum size of approximately 1.1 ha (2.7 ac). The other areas of tree clearing are less than 0.2 ha (0.4 ac). For the additional 48 turbines, a maximum forest patch size of approximately 1.1 ha (2.7 ac) may be cleared.

   d. Only 3.2 ha (8.0 ac, or 3.3 ha [8.2 ac] for the Redesign Option) of wooded areas within habitat Categories 1, 2 or 3 (see Appendix B) will be removed for the 100-turbine Project: 1.0 ha (2.5 ac) of Category 1, 1.3 ha (3.3 ac) of Category 2, and 0.9 ha (2.2 ac) of Category 3. In the Redesign Option, removed wooded areas would include 1.1 ha (2.6 ac), 1.3 ha (3.3 ac), and 0.9 ha (2.3 ac) in each Category, respectively.

2) Measures will be taken to minimize impacts to high quality potential Indiana bat foraging riparian habitat and the prey that it supports:
   a. Only streams that are not designated Coldwater Habitat or Exceptional Warmwater Habitat will be impacted. USACE authorization for any discharge of fill material into jurisdictional streams will be secured for each stream crossing involving in-water work (see Section 5.2.1.2 – Impacts to Aquatic Habitats).
   b. Crossing widths and clearing of wooded riparian areas for crossings will be limited to the minimum required for the crossing methods (see Table 5-16).
   c. A plan note will be incorporated into the construction contract requiring that contractors adhere to all provisions of the SWPPP and NPDES permits, which will specify Best Management Practices for construction activities to minimize stormwater runoff and sedimentation from construction areas into adjacent water bodies and provide adequate restoration measures (see Section 5.2.1.2 – Impacts to Aquatic Habitats).
   d. Horizontal directional boring for collection lines will be used to avoid impacts to all perennial streams. In addition, if water is present at the time an intermittent or ephemeral stream is crossed, Buckeye Wind will horizontally directionally drill underneath that stream.
   e. Temporary crossings of stream corridors will be restored using native plants (see Appendix D for a typical native plant mix). Where forest fragmentation results from construction activities, the areas will be restored using trees suitable for Indiana bat habitat, if practicable. A list of native trees suitable for planting to restore Indiana bat habitat is included in Appendix D. If existing land-use precludes the use of native species (e.g., agricultural use), restoration and stabilization will be established consistent with that land-use.

6.2.2 Project Operation and Maintenance

As described in Section 5.0 – Impact Assessment, direct and indirect effects to Indiana bats from forested habitat removal, disturbance from construction activities, noise from operating turbines, displacement from operating turbines, and lighting are expected to result in insignificant and discountable effects that do not rise to the level of take of Indiana bat. The following actions will be taken to minimize adverse effects to Indiana bats from operations and maintenance activities for the 100-turbine Project:

   a. Minimal FAA lighting will be utilized (see Section 5.1.2.2 – Lighting). Any ground-based lighting at the turbines or substation necessary for safety or security will be controlled by motion detectors or infrared sensors.
   b. Regularly scheduled tree trimming for maintenance purposes will not be conducted in the active period for Indiana bats. Some minor clearing of fallen trees or safety trimming may be conducted during the active period. No potential Indiana bat roost trees will be trimmed or cleared during the active period.
   c. Access roads built for the Project will be posted with a 25 mile per hour speed limit to minimize risk of collision with Indiana bats and other wildlife.

Due to measures taken by Buckeye Wind to avoid and minimize impacts to Indiana bats during construction and operation and maintenance described in this and in preceding sections, it is anticipated that operation of the Project is the only activity covered by this HCP that will result in unavoidable incidental take of Indiana bats. As such, the primary method to minimize impacts to Indiana bats will be operational restrictions.

Operational restrictions (see Section 6.2.3 – Feathering Plan Phases) will dictate that turbines are feathered (i.e., not spinning) until a designated cut-in speed is reached. This cut-in speed is generally higher than the wind speed at which the turbine is technically able to begin spinning and producing power. A number of studies have now shown that increased cut-in speed can be expected to reduce mortality of bats (Arnett et al. 2010, Baerwald et al. 2009 and Good et al. 2011; see Table 6-1; see Section 5.1.2.5.3 – Estimated Take with Feathering), although a statistically significant correlation between increased cut-in speeds and Indiana bat mortalities cannot be made with existing data. It is, however, expected that the overall reduction in mortalities from feathering that has been observed in other bat species will also be observed for Indiana bats.

As described in Section 4.5.5.4 – Influence of Weather, 4 studies that evaluated the effects of increasing turbine cut-in speed on bat fatalities during the fall migration period (PA [Arnett et al. 2010], Alberta [Baerwald et al. 2009] and IN [Good et al. 2011]) found that reductions between 38% and 93% (median of 68.3% across all studies) were achieved by curtailing or feathering turbine operations at wind speeds of 5.0 m/s and 6.5 m/s (Table 6-1). Although site-specific factors such as turbine model, local weather patterns, and bat populations may affect the relative effectiveness of operational adjustments at different wind facilities, the finding that similar reductions in bat mortality were achieved in areas as geographically diverse as PA, Alberta and IN holds promising support for broad application of curtailing or feathering as a take minimization technique.

Table 6-1. Observed range in reductions in bat fatalities and median values for 4 operational effectiveness studies. Turbines were feathered at Casselman and in Southwest Alberta, and curtailed at Fowler Ridge.

Study	Observed fatality reduction[a]			Source
	Min	Max	Average	
Casselman 2008[b]	52.0%	93.0%	82.0%	Arnett et al. 2010
Casselman 2009[b]	44.0%	86.0%	72.0%	Arnett et al. 2010
Fowler Ridge 2010[c,d]	38.0%	85.0%	64.5%[e]	Good et al. 2011
Southwest Alberta[f]	NA	NA	60.0%	Baerwald et al. 2009
Median fatality reduction	44.0%	86.0%	68.3%	

[a] All studies used a combination of cut-in speeds of 5.0 m/s to 6.5 m/s except Baerwald et al. 2009, which used 5.5 m/s
[b] Based on a 95% confidence interval
[c] Based on a 90% confidence interval
[d] Good et al. 2012, published after completion of the Draft HCP, considered fatality reductions at cut-in speeds of 3.5 m/s, 4.5 m/s and 5.5 m/s at Fowler Ridge in 2011with a mean reduction of 36.3%, 56.7% and 73.3%, respectively. While these data were not included in calculation of the estimated reduction because they are a range of cut-in speeds not in the Proposed Action, it is noted that the reductions in mortality by 73.3% at cut-in speeds of 5.5 m/s (the only tested cut-in speed included in this HCP) is similar to the median fatality reduction (68.3%) presented in this Table. Further a reduction in mortality of 73.3% at a cut-in speed of 5.5 m/s is within the range of reductions seen at cut-in speeds between 5.0 m/s-6.5 m/s at the facilities presented in this Table.
[e] Based on the median of the reported average reductions from each treatment (5.0 m/s = 50%; 6.5 m/s = 79%)
[f] Study did not provide confidence intervals for appropriate min and max comparison to other studies

Results from post-construction mortality monitoring suggest non-operating turbines pose little to no risk to bats; of 44 wind turbines studied at the Mountaineer facility, the only turbine with no reported fatalities was non-operational during the study period (Kerns et al. 2005). Although the cut-in wind speed may be the most significant factor determining the effectiveness of feathering, other variables to consider include seasonal and nightly timing of feathering, number of turbines feathered, habitat type surrounding turbines, and other weather factors, as described in the following sections.

Seasonal Considerations

Seasonal patterns of bat mortality documented in post-construction monitoring studies at wind facilities across North America have consistently documented the highest mortality in the late summer/early fall period (see Section 4.5.5.2 – Geographic Variation for further details). Lower levels of mortality have consistently been documented during the spring and after 31 October in monitoring studies that included surveys during the early spring and after 31 October, with a few noted exceptions for silver-haired bat mortality in the spring (refer to Section 4.5.5.2 – Geographic Variation). Specifically, from 2007 – 2009, 0% of all bat mortality in Pennsylvania was observed in March, while just 2% of all bat mortality was observed in April. This includes results from 8 different sites and 11 seasons of monitoring (Capouillez 2011). Also, 7 studies that conducted monitoring for the spring through fall period documented *Myotis* fatality rates of 8%, 34%, and 58% in the spring, summer, and fall, respectively (Jennifer Szymanski and Megan Seymour, USFWS, personal communication). As such, the feathering plan will vary seasonally, based on 3 periods in which Indiana bats display distinct behavioral characteristics that could differentially affect their exposure to wind turbines:

- Spring emergence and migration, or "spring" (1 Apr to 31 May);
- Early summer habitat use, or "summer" (1 Jun to 31 Jul); and
- Late summer and fall migration, or "fall" (1 Aug to 31 Oct).

Weather Considerations

Bats are known to suppress their activity during periods of rain, low temperatures, or strong winds (Erkert 1982, Adam et al. 1994, Erickson et al. 2002, Russo and Jones 2003). Weather variables such as wind speed, temperature, and barometric pressure have been found to influence bat activity and mortality rates at some wind facilities. Of the 21 post-construction monitoring studies reviewed by Arnett et al. (2008), studies that addressed relationships between bat fatalities and weather patterns found disproportionate numbers of bats were killed on nights with low wind speed (<6 m/s) and fatalities increased immediately before and after passage of storm fronts. Horn et al. (2008) also reported blade rotational speed was a significant negative predictor of observed collisions and/or barotrauma with turbine blades, suggesting that bats may be at higher risk of fatality on nights with low wind speeds.

Positive correlations between bat activity and temperature have been documented, both on a nightly basis (Lacki 1984, Negraeff and Brigham 1995, Hayes 1997, Vaughan et al. 1997, Gaisler et al. 1998, Shiel and Fairley 1998) and annual basis (O'Farrell and Bradley 1970, Avery 1985, Rydell 1991). Associations between temperature and bat fatalities in post-construction monitoring studies have been less consistent than for wind speed. While a correlation between temperature and bat fatalities was not documented at Mountaineer, a positive association between temperature and fatalities was documented at Meyersdale (Kerns et al. 2005). Pre- and post-construction acoustic surveys at wind facilities have found bat activity to be negatively correlated with low nightly mean temperatures (Fiedler 2004, Reynolds 2006). For example, Reynolds (2006) found no detectable spring migratory activity on nights when daily mean temperature was below 10.5°C (50.9°F).

During the entire Indiana bat active period, turbines will be allowed to operate at full capacity at temperatures below 10 °C (50°F), based on a multitude of studies that have documented low levels or no bat activity at low temperatures; refer to Section 4.5.5.4 – Influence of Weather for details. Turbines will be allowed to operate at manufacturer specified cut-in speeds if nighttime temperatures fall below 10 °C (50°F) for a period of 15 consecutive minutes. Likewise, the cut-in speeds as specified by the feathering plan and any subsequent adaptive management actions will be implemented if the nighttime temperature has risen above 10 °C (50°F) for a period of 15 consecutive minutes.

Barometric pressure, temperature, and relative humidity are all interrelated and are associated with passing storm fronts. There seems to be some evidence that higher barometric pressure is associated with higher mortality. Good et al. (2011) found that mortality increased with increasing barometric pressure; and barometric pressure was higher than normal on the night when an Indiana bat mortality occurred. However, barometric pressure was lower than normal on the night with the most overall mortality, which included mainly migratory tree bats (Good et al. 2011). Barometric pressure was positively associated with mortality at Mountaineer and Meyersdale (Arnett et al. 2008).

Fiedler (2004) found that mortality was positively associated with average nightly wind direction. One explanation may be that mortalities increased as wind direction deviated from the predominant, southwestern, wind direction. Further, increased mortalities on nights with more northerly winds may be a result of more bats moving during weather conditions conducive to migration.

Habitat Considerations

As is evident in the results of the habitat suitability model detailed in Appendix B, habitat in the Action Area is not uniform with respect to its suitability for Indiana bat roosting and foraging activities. The suitability of habitat in which turbines are placed is expected to influence risk to Indiana bats during the summer maternity period, as risk of encounters is expected to be greatest at turbines placed in areas where Indiana bats are most likely to be actively foraging and traveling to and from their roosts. The habitat suitability model resulted in 4 risk categories within the Action Area, with Category 1 being the most suitable for Indiana bat foraging and roosting activities and presenting the highest risk of exposure to operating turbines and Category 4 being the least suitable and presenting the least risk. For purposes of the risk analysis, Categories 1, 2 and 3 were considered suitable roosting and foraging habitat (although Category 3 is 87% non-forested) and Category 4 was excluded on the basis of being entirely agricultural land (See Table 6-2 for habitat categories).

Although these habitat categories were developed based on telemetry data from summer foraging and roosting Indiana bats, they may also present varying levels of risk during migration. While some migration studies suggest that Indiana bats follow vegetative or other landscape features, other studies suggest that Indiana bats fly direct routes without respect to landscape structure or habitat (see Section 4.4.3 –Migration for more detail). The 2 documented Indiana bat fatalities at an IN wind facility were both found during the fall migration period in a largely agricultural area (Good et al., 2011), while the documented Indiana bat fatality in PA was also during the fall migration period, but in a forested ridge line.

However, there is likely overlap in seasonal behaviors (i.e., migration and summer habitat use) and weather conditions and other stochastic factors can affect the exact timing of annual chronology from year to year. Additionally, Indiana bats that migrate to and from the Action Area during spring and fall may be at higher risk than Indiana bats merely passing through the Action Area, because migratory activity may coincide with foraging activity that is associated with their return or departure from their local roosts. Therefore, it is appropriate to consider these habitat categories when evaluating potential risk to Indiana bats from operating turbines during active periods.

6.2.3 Feathering Plan Phases

While some type of feathering will likely be in place over the ITP Term, the Project will have 3 distinct phases: 1) Evaluation Phase, 2) Implementation Phase, and 3) Re-evaluation Phase. An adaptive management framework will be used to apply the results of the Evaluation Phase, Implementation Phase, and each Re-evaluation Phase, as well as new information from research or increases in scientific understanding, to guide the ongoing implementation of this HCP. The following section focuses on the specific details of the Evaluation Phase, as the details of the other 2 phases will be informed by results of the Evaluation Phase and consultation with the USFWS and ODNR DOW. Buckeye Wind will work cooperatively with the USFWS and the ODNR DOW throughout the Evaluation Phase to implement the appropriate Adaptive Management measures. The feathering plan during each of the 3 phases will be described in the following sections. Monitoring methods during each of the phases will be summarized in Section 6.5 – Monitoring and Adaptive Management. All turbines in all habitat categories will be feathered at night until the specified cut-in speed is reached (See Table 6-2).

6.2.3.1 Evaluation Phase

The Evaluation Phase will begin once a turbine becomes operational and will encompass spring, summer, and fall (1 April through 31 October) for at least the first 2 years of operation of that turbine. If a turbine becomes operational prior to 1 April, that year will constitute a full Evaluation year. If operation begins after 1 April, monitoring will proceed for the remainder of the active period and the turbine(s) will be subject to trigger point adaptive management as described in Section 6.5.3.4 – Trigger Point for Immediate Adaptive Management, but the following year will constitute Year 1 Evaluation Phase monitoring. Each year of the Evaluation Phase will be subdivided into the 3 seasonal periods described previously, each with a slightly different feathering strategy suited to the expected behavior of Indiana bats and corresponding risk during that period. In addition to reducing Indiana bat mortality to the maximum extent practicable, the feathering strategy, detailed in Table 6-2, is intended to meet the biological goals of the HCP and Biological Objectives 1, 3 and 4. The basis for the feathering strategy in each season will be described in the following sections.

Spring Feathering Plan

The spring feathering plan will be applied over a period of approximately 8.5 weeks from 1 April to 31 May during the nighttime period, ½ hour before sunset to ½ hour after sunrise. Because post-construction mortality studies at wind facilities across the country have consistently documented lower levels of bat mortality during the spring migration period (refer to Section 4.5.5.2 – Geographic Variation), feathering levels during this period will be the least restrictive of all seasons in the Indiana bat active period. Feathering will be applied to turbines in the 3 highest habitat risk categories at wind speeds of 5.0 m/s (Table 6-2). Feathering of turbines in Category 4 will occur up until the manufacturer-set cut-in speed is reached. The basis for selecting this cut-in speed, as discussed previously, was operational adjustment studies that documented cut-in speeds of 5.0 m/s and above substantially reduced bat mortality in fall (see Table 6-1). Two years of study at the Casselman wind facility (Arnett et al. 2010) in PA and 1 year of study at the Fowler Ridge facility (Good et al. 2011) in IN found evidence to suggest that a cut-in speed of 5.0 m/s significantly reduces bat mortality[40] in fall. The Fowler Ridge study report indicates that increasing cut-in speeds from 5.0 m/s to 6.5 m/s significantly reduced all bat fall mortality by an additional 29% (Good et al. 2011); however, the costs to implement higher cut-in speeds increase exponentially with wind speed (see Section 6.6.2 – Practical Implementation by Buckeye Wind). Given that in 7 studies that conducted monitoring for the spring through fall period, only 8% of *Myotis* fatalities occurred in the spring (Jennifer Szymanski and Megan Seymour, USFWS, personal communication), the application of the 5.0 m/s cut-in speed as an effective minimization approach during the spring represents a conservative approach and a higher cut-in speed is not practicable, given the substantially higher costs (refer to Section 6.6 – Issuance Criteria – Maximum Extent Practicable).

[40] Note that the studies did not document reductions in impacts to Indiana bats specifically (because of lack of data) nor did they occur over the spring and summer time frames. However, it is assumed that the beneficial effects will be similar to fall feathering.

Table 6-2. Summary of nighttime (½ hour before sunset to ½ hour after sunrise) operational feathering that will be applied to turbines during Evaluation Phase Year-1*.

Habitat risk category	Estimate for 52-Turbine Layout	Maximum for 100-Turbine Layout***	Cut-in speed - m/s**		
			Spring (1 Apr - 31 May)	Summer (1 Jun - 31 Jul)	Fall (1 Aug - 31 Oct)
Category 1 - Highest Risk	4	10	5.0	6.0	6.0
Category 2 - Moderate Risk	9	15	5.0	5.75	5.75
Category 3 - Low Risk	6	15	5.0	5.5	5.75
Category 4 - Lowest Risk	33	85	None****	5.25	5.75
Totals	52	125			

* Any turbines installed after the first year of operation will be feathered using the cut-in speeds for the respective risk Category as adjusted through adaptive management, if those cut-in speeds differ from those in this table.
** During all seasons, turbines may be operated normally when temperatures are below 10 °C (50°F).
*** The breakdown for the known 52 turbine locations is given for reference. The table shows the maximum number of turbines in each category, resulting in a sum >100. No more than 100 turbines will be built.
**** Turbines will be cut-in at the manufacturer's specified cut-in speed. The turbine will be feathered below the cut-in speed.

Feathering will not be applied to all turbines equally because risk is expected to be lower overall during the spring. Instead, feathering will be focused on turbines located in habitat Category 1, 2 and 3, which represent the most suitable roosting and foraging habitat in the Action Area, because some Indiana bats that spend the summer reproductive period in the Action Area may arrive prior to 31 May to establish summer maternity colonies. It is likely that these Indiana bats would engage in foraging and commuting behavior, and turbines located in the most suitable roosting and foraging areas could present greater risk to these Indiana bats. Category 4 habitat has been established in the habitat suitability model as being unsuitable for roosting and foraging. Furthermore, post-construction mortality studies at wind facilities across the country have consistently documented lower levels of bat mortality during the spring migration period (refer to Section 4.5.5.2 – Geographic Variation). Therefore, turbines will only be feathered until manufacturer-set cut-in speed is reached in the spring in Category 4 habitat, which should represent the lowest risk time period for Indiana bats.

Summer Feathering Plan

The summer feathering plan will be applied over a period of approximately 8.5 weeks from 1 June to 31 July during the nighttime period, ½ hour before sunset to ½ hour after sunrise. Although mortality monitoring at wind facilities during the early summer reproductive period has consistently documented less bat mortality than the fall period (refer to Section 4.5.5.2 – Geographic), feathering will be applied to all turbines during this period because risk to Indiana bats in the Action Area during this time is uncertain and higher mortality during late summer has been demonstrated. The summer feathering plan was based on the results of the habitat suitability model (Appendix B). Using a tiered approach, the highest cut-in speeds (6.0 m/s) will be applied to turbines located within habitat category 1, which was predicted to have the highest suitability for Indiana bat roosting and foraging activities (refer to Table 6-2 and Figure 4-5 for the distribution of the 52 known turbine locations relative to the predicted habitat suitability). This is based on 3 studies that have consistently documented that fall bat mortality is substantially reduced at wind speeds of 5.0 m/s and higher (Baerwald et al. 2009, Arnett et al. 2010, and Good et al. 2011; (see Table 6-1). The cut-in speed in this Category is the most conservative of any cut-in speed throughout the active period because there is a higher level of uncertainty as to the impacts to Indiana bats and bats in general. Assuming there is a reduced risk in increasingly lower suitability habitats, cut-in speeds will be stepped down evenly in 0.25 m/s increments in habitat Category 2 through Category 4 (see table 6-2).

Fall Feathering Plan

The fall feathering plan will be applied over a period of approximately 13 weeks from 1 August to 31 October[41] during the nighttime period, ½ hour before sunset to ½ hour after sunrise. Mortality monitoring at wind facilities during the fall period has consistently documented the greatest numbers of bat fatalities relative to other seasons. Therefore, equal or more restrictive cut-in speeds will be applied to all turbines during this period to minimize impacts to Indiana bats. The late summer/early fall cut-in speeds were selected based on acoustic and post-construction mortality monitoring studies that consistently documented substantially reduced bat activity and mortality at cut-in speeds of 5.0 m/s and 6.5 m/s (refer to HCP Section 4.5.5.4 – Influence of Weather for detailed information). These cut-in speeds were also informed by 3 operational adjustment studies (Baerwald et al. 2009, Arnett et al. 2010, Good et al. 2011) that documented substantial reductions in bat fatalities (between 38% and 93%, median of 68.3% across all studies) at curtailed and feathered turbines during the fall period using cut-in speeds of 5.0 m/s and above (Table 6-1). The cut-in speed for turbines located in Categories 2-4 will be 5.75 m/s. As noted previously, the seasonal definitions do not define a hard switch from foraging to migration behaviors, and there will inevitably be cross-over of behaviors between the defined seasonal periods. In order to ensure that pre-migratory Indiana bats are afforded the same protection as is provided in the summer feathering plan, cut-in speeds for turbines located in Category 1 habitat areas will be 6.0 m/s.

6.2.3.2 Implementation and Re-evaluation Feathering Plan Phases

The results of post-construction monitoring during the Evaluation Phase will be used to adjust the feathering plan to effectively maintain Indiana bat mortality within levels authorized in the ITP, while maximizing production of renewable energy. The Implementation Phase will begin once the feathering plan has been demonstrated to be effective at keeping mortality within expected levels for a minimum of 2 years. The Implementation Phase will continue throughout the ITP Term, as long as take levels allowed under the ITP are not being exceeded or until Buckeye Wind initiates, at its discretion or through Implementation Phase mortality results, a Re-evaluation Phase. The purpose of the Re-evaluation Phase will be to evaluate the effectiveness of a new operational feathering plan or test other emerging methods or technologies available to reduce mortality of Indiana bats, if approved by the USFWS and per the adaptive management section of this HCP. Each Re-evaluation Phase will allow Buckeye Wind to modify the feathering plan or test new avoidance or minimization techniques, in consultation with the USFWS, as new information or technology becomes available in order to effectively meet the biological goals and objectives of this HCP. The adaptive management criteria defined in Section 6.5.3 – Adaptive Management for Minimization will be used to guide any adjustments to the feathering plan.

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[41] While the Fall Feathering Plan ends on 31 October, Evaluation Phase monitoring will extend to 15 November in order to comply with the ODNR Protocol (see Section 6.5.2.2 – Survey Period).

6.2.4 Project Decommissioning

Decommissioning of the 100-turbine Project entails many of the same activities as Project construction, although no new impacts are expected as existing access and facilities can be used for decommissioning. The following measures will be undertaken to minimize any impacts to Indiana bats and their habitat:

1) Limited tree clearing may be needed to expand existing access. Buckeye Wind will avoid potential direct effects to roosting Indiana bats in unidentified maternity roost trees:
    a. Tree clearing activities will be conducted outside the period when Indiana bats are expected to be roosting in the Action Area. Any tree clearing will be conducted between 1 Nov and 31 Mar.

2) Measures will be taken to avoid impacts to high quality potential Indiana bat foraging riparian habitat and the prey that it supports:
    a. No new stream crossings resulting in in-water work will be utilized and clear span methods, such as open bottomed culverts, elliptical culverts, arched bridges, or temporary crossings (see Section 5.2.1.2 – Impacts to Aquatic Habitats) will be employed.
    b. Wetlands will not be impacted by decommissioning.

3) To the extent that soil disturbance will be needed and a NPDES permit is necessary (for removal for access roads or bridges), all appropriate best management practices for soil and erosion control and restoration will be implemented and USACE authorization for any discharge of fill material into jurisdictional streams will be secured.

4) Temporary crossings and areas of temporary construction impact will be restored and re-vegetated per the erosion and sediment control plan (consisting of planting native plant species to provide ground stabilization (see Appendix D for a typical native plant mix). Where forest fragmentation results from construction activities, the areas will be restored using trees suitable for Indiana bat habitat, if practicable. A list of native trees suitable for planting to restore Indiana bat habitat is included in Appendix D. If existing land-use precludes the use of native species (e.g., agricultural use), restoration and stabilization will be established consistent with that land-use. Erosion and sediment control measures will limit the amount of sediment from exposed soil entering the stream, so impacts to aquatic foraging habitat will be minimized. For example, silt fences, hay bales and/or filter socks will be used to catch any sedimentation from active construction areas. Catch basins may be installed to allow sedimentation to fall out before the run-off enters the streams. Swales and ditches may be installed to divert sedimented water away from streams and into areas that have the proper sediment control measures (silt fences, catch basins, etc.). These measures will ensure that the stream quality is not degraded and that the ability of the water features in the Action Area to support prey species and hydration for the Indiana bat will not be degraded

6.3 Mitigation Measures

As described in Section 5.1.2.6 – Biological Significance of Incidental Take (Collision Mortality), total annual Indiana bat mortality, including adult females, adult males, and juveniles, is estimated to range from approximately 1.0 Indiana bat per year to 14.2 Indiana bats per year, but is expected to be approximately 5.2 Indiana bats per year, with no more than 26.0 individual Indiana bat mortalities over a 5-year period. Based on the 5-year take limit, a total take of 130.0 Indiana bats would be requested over the ITP Term. The impact of this taking is the loss of an estimated 130.0 Indiana bats, or 5.2 Indiana bats per year, across the Midwest RU. Of those mortalities, approximately 57.5, or 2.3 per year, are estimated to come from local populations (see Section 5.1.2.6.1 – Impacts to Local Maternity Colonies Pre-WNS). Of those local Indiana bats, 27.5, or 1.1 per year, are estimated to be local females (see Section 5.1.2.6.1 – Impacts to Local Maternity Colonies Pre-WNS). Objective 2 specifically relates to mitigation:

Objective 2: Mitigate for the impacts of the incidental taking of 130.0 Indiana bats over the 30-year ITP Term through the purchase or easement acquisition and subsequent restoration and/or enhancement (if necessary), with permanent preservation of 87.8 ha (217.0 ac) of suitable Indiana bat habitat within 11.2 km (7 mi) of a P2 Indiana bat hibernaculum in OH (see Section 6.3 – Mitigation Measures for more details);

Meeting Objective 2 will offset the impact of the incidental take caused by the Project by helping enhance the reproductive success and survival probability of local and migratory Indiana bat populations. Mitigation will consist of permanent preservation of 87.8 ha (217.0 ac) of habitat within 11.2 km (7 mi) of a P2 Indiana bat hibernaculum in OH (see Section 6.3.1 – Acres of Mitigation Calculation). Mitigation habitat will be restored or enhanced if it does not meet the criteria addressed in Section 6.3.4. – Restoration and Enhancement. Protection of hibernacula remains a focus of the 2007 Indiana bat Recovery Plan, with conservation and management of swarming habitat identified as a key recovery strategy (USFWS 2007). The recovery plan states:

> The habitat surrounding hibernacula may be one of the most important habitats in the annual cycle of the Indiana bat. This habitat must support the foraging and roosting needs of large numbers of bats during the fall swarming period. After arriving at a given hibernaculum, many bats build up fat reserves (Hall 1962), making local foraging conditions a primary concern. Migratory bats may pass through areas surrounding hibernacula, apparently to facilitate breeding and other social functions (i.e., bats that utilize the area for swarming may not hibernate at the site) (Barbour and Davis 1969; Cope and Humphrey 1977). Modifications of the surface habitat around the hibernacula can impact the integrity, and in turn the microclimate, of the hibernacula. Areas surrounding hibernacula also provide important summer habitat for those male Indiana bats that do not migrate, which is thought to be a large proportion of the male population. Loss or degradation of habitat within this area has the potential to impact a large proportion of the total population.

Delisting of the species will be attained by meeting Delisting Criteria; Delisting Criterion 1 requires protection of at least 50% of P2 hibernacula in each RU (USFWS 2007). Protection of hibernacula includes conserving a buffer zone around a hibernaculum to ensure that land clearing or development does not result in hibernaculum disturbance. Per the Indiana bat Recovery Plan (USFWS 2007):

> Further, forested buffer areas surrounding known hibernacula should be established. Current understanding of the species' biology may warrant buffers as large as 0.4 km (0.25 mi) in diameter. However, boundaries of forested buffer zones ideally should be custom designed to conform to the unique topography and natural features surrounding each hibernaculum rather than drawn as a generic circle. The goal of these buffer areas is to conserve the integrity of the entrance and hibernacula.

There are several options that can be utilized for mitigation:

a) Acquiring or otherwise providing protection to of 87.8 ha (217.0 ac) of suitable Indiana bat swarming habitat within 11.2 km (7 mi) of a P2 Indiana bat hibernaculum in OH through acquisition of a conservation easement into perpetuity or purchase of the property and then assigning a conservation easement in perpetuity.

i. Within the easement areas, restore travel corridors between woodlots and/or along stream corridors to increase availability of suitable Indiana bat habitat through enhanced connectivity.

ii. Within easement areas, enhance suitable habitat through ensuring an adequate number of suitable roost trees and through managing woody invasive species.

b) Buying credits from an USFWS approved Indiana bat mitigation bank whose geographical range service area includes the Project (USFWS 2009b; see Section 7.3.4 – Change in Mitigation Acres).

Preservation and enhancement of land within 11.2 km (7 mi) of a P2 Indiana bat hibernaculum in OH will protect valuable fall roosting, foraging, and swarming habitat. During the fall swarming period, female, juvenile, and male Indiana bats arrive at hibernacula after migrating potentially long distances from summer habitat (distances up to 575 km [357 mi] have been documented; Winhold and Kurta 2006). Migration is an energetically expensive undertaking (Fleming and Eby 2003), and bats therefore require roosting and foraging opportunities outside hibernacula in order to increase fat stores prior to hibernation. Hall (1962) found that bats returning to Coach Cave, KY, in the fall had no stored fat reserves, and that weight was the lowest measured at any point during the annual cycle. Weight peaks in September or October as a result of foraging outside hibernacula (Hall 1962, LaVal and LaVal 1980). Entering hibernation with ample energy reserves is key to surviving winter hibernation for all bats, and for adult females it is critical for ovulation (Humphries et al. 2003, Jonasson and Willis 2011, Kunz et al. 1998). Increasing opportunities for juveniles to build up energy stores prior to their first winter hibernation has the potential to increase survivorship (Jonasson and Willis 2011). In sum, protection and enhancement of foraging and roosting habitat outside a P2 hibernaculum will provide roosting and foraging resources for swarming adult female, adult male, and juvenile Indiana bats in the fall, which will reduce competition for limited resources at a time when building energy reserves for the winter hibernation period is critical.

Similarly, Indiana bats may remain in close proximity to a hibernaculum for a short period of time after emerging from hibernation in spring. At this time, individuals have used much of their fat stores during hibernation and food resources are low, which may contribute to increased risk of mortality immediately following emergence (Tuttle and Stevenson 1978 as cited in USFWS 2007). Habitat around hibernacula has been identified as being critically important for the health of Indiana bat populations. The Indiana bat Recovery Plan (USFWS 2007) includes extensive discussions on the importance of this habitat:

> Biologically intrinsic needs of this species include limiting use of fat during hibernation, obligate colonial roosting, high energy demands of pregnant and nursing females, and timely parturition and rapid development and weaning of young. Factors that may exacerbate the bats vulnerability because of these constraints include energetic impacts of significant disruptions to roosting areas (both in hibernacula and maternity colonies), availability of hibernation habitat, and connectivity and conservation of roosting-foraging and migration corridors.

And

> Threats to the Indiana bat vary during its annual cycle. At the hibernacula, threats include modifications to caves, mines, and surrounding areas that change airflow and alter microclimate in the hibernacula… During summer months, possible threats relate to the loss and degradation of forested habitat. Migration pathways and swarming sites may also be affected by habitat loss and degradation.

As a result of the recognized importance of habitat around hibernacula, 1 of the 4 broad components of the recovery plan (USFWS 2007) is the "conservation and management of habitat (hibernacula, swarming and, to a degree, summer)."

Therefore, preservation or enhancement of land surrounding a hibernaculum will provide individuals with permanent roosting and foraging resources and reduce competition for those resources during swarming periods when replenishing energy reserves is critical.

Resources directly outside a hibernaculum are becoming even more important as WNS spreads throughout the range of the Indiana bat. Infected bats exhibit premature loss of critical fat reserves which is thought to lead to starvation prior to spring emergence (Frick et al. 2010). Indiana bats that survive winter hibernation in affected caves/mines will benefit from ample roosting and foraging habitat immediately outside cave/mine entrances, which they can utilize in order to quickly build up fat stores. Similarly, Indiana bats returning to hibernacula in the fall are in need of readily available foraging resources directly outside hibernacula to encourage accumulation of fat stores for hibernation, particularly if WNS causes premature loss of fat. In both cases, presence of permanent available fall and spring suitable habitat near hibernacula has the potential to increase survivorship.

Further benefit is realized when proposing to preserve land that is at risk of development. Development would remove roosting and foraging resources that Indiana bats rely upon prior to hibernation in the fall and after hibernation in the spring. Permanent protection of this land will ensure that development does not occur, leaving habitat available for roosting and foraging activities.

Finally, this habitat would also be suitable for use during the summer for Indiana bats that remain near the hibernaculum and for Indiana bats that potentially migrate to the area from other hibernacula. Males and non-reproductive females typically do not form large colonies and can remain close to hibernacula during the active period, roosting in nearby trees (Brack 1983, Gardner and Cook 2002, USFWS 2007, Whitaker and Brack 2002). In counties containing hibernacula, "most" summer records are for males and nonreproductive females (Gardner and Cook 2002). However, Gardner and Cook (2002) do not claim that "all" summer records near hibernacula are of males and non-reproductive females, implying that some maternity colonies are located within counties containing hibernacula. Indeed, fall swarming habitat can be similar in composition to summer roosting habitat (Kiser and Elliot 1996, Gumbert et al. 2002, as cited in USFWS 2007). Therefore, suitable summer habitat near a hibernaculum also has the potential to support maternity colonies and will be improved by the same beneficial characteristics as described in Section 6.3.4 – Restoration and Enhancement.

Also, preserved habitat has the potential to benefit Indiana bats utilizing different hibernacula, as Indiana bats (particularly males) may stop at several hibernacula during fall migration and swarming period (Cope and Humphrey 1977, LaVal and LaVal 1980). Increased foraging and roosting opportunities relative to existing conditions, and protection of existing suitable habitat from future development, will allow swarming adults and juveniles in the fall, and staging adults in the spring, to rebuild their energy stores more readily by reducing competition and ensuring that limited resources are protected into the future.

Potential methods, expected outcomes, and measurable variables for protection and restoration of Indiana bat fall swarming habitat are summarized in Table 6-3 and detailed below; also see Section 6.5.4.1 – Adaptive Management for Mitigation.

Table 6-3. Summary of mitigation measures that will be implemented to offset the impact of the take of Indiana bats from the 100-turbine Buckeye Wind Project (selection of most effective measures will be finalized in consultation with the USFWS).

Mitigation measures	Expected outcomes/benefits	Measurable variables	Population Segment Benefit
Protect and enhance P2 habitat around hibernacula			
Establish conservation easement in perpetuity, for 87.8 ha (217.0 ac) within 11.2 km (7 mi) of a P2 hibernaculum in OH	Permanently protect existing fall swarming, foraging, and roosting areas, sustain overwinter survival of male and female Indiana bats, sustain breeding success, increase spring fitness of males and reproductive females, provide summer habitat for males, nonreproductive females, and maternity colonies.	87.8 ha (217.0 ac) protected	Adult female, adult male and juvenile
Within permanently protected area, enhance or restore roosting/foraging areas by girdling, planting trees, invasives species management, creating travel corridors or other USFWS approved measures.	Shorten distance Indiana bats travel to forage before entering and when emerging from hibernation, improve roosting opportunities near hibernacula, increase overwinter survival of males and females, increase breeding success, increase spring fitness of males and reproductive females.	Enhance quality of habitat within purchased/protected land by effecting: number of roost trees, survival of planted trees invasive species composition	Adult female, adult male and juvenile

After suitable land is acquired and/or placed in conservation easement in perpetuity, subsequent enhancement and/or restoration of land will be undertaken to improve habitat for Indiana bats. Methods used to restore or enhance degraded or suboptimal habitats will be informed by the Range-wide Indiana Bat Protection and Enhancement Plan Guidelines (PEP Guidelines; USFWS 2009b), as well as other relevant literature and input from appropriate technical experts and agencies including USFWS and ODNR DOW.

To ensure that the habitat is adequately protected with the conservation easement, any conservation easement will be provided to the USFWS and the ODNR DOW for comment, be held by a third-party conservation group approved by USFWS and ODNR DOW, and will include, at a minimum, the restriction as included in the conservation easement template (see Appendix C – USFWS Template Language to be Included in Easement and Fee Simple Conveyances):

- No Industrial Use
- No New Residential Use
- No Commercial Use
- No Agricultural Use
- No Vegetative Clearing
- Development Rights Extinguished

Because there are multiple wind projects currently being proposed within the Indiana bat range, Buckeye Wind is aware of various efforts to establish an Indiana bat mitigation bank. A mitigation bank would generally consist of blocks of suitable habitat that have been identified by the bank manager as being beneficial to Indiana bats and suitable for offsetting the effects of take. A mitigation bank could help provide a more effective mitigation strategy since resources from multiple sources could be combined. A mitigation bank would only be considered if all of the following conditions are true:

1) Use of the mitigation bank has been approved by USFWS.
2) The mitigation bank includes lands within OH.
3) If the mitigation bank has established a ratio of Indiana bat habitat acres to offset the impact of Indiana bat take, and such ratio is approved by the USFWS, then that ratio will be used to calculate the habitat mitigation required at the bank for the Buckeye Wind project. If the mitigation bank has not established such a relationship, Buckeye Wind, ODNR DOW and the USFWS may agree upon a number of acres within the mitigation bank that could be used to fulfill the remainder of the mitigation obligation to offset the impacts of take by the project.

6.3.1 Acres of Mitigation Calculation

Using best available information from fall swarming studies at known Indiana bat hibernacula, the density of Indiana bats per unit area surrounding hibernaculum was estimated to determine the land area size that would need to be protected and enhanced to mitigate for the impact of the take of 130.0 Indiana bats over the ITP Term. The distance traveled from hibernacula to roost trees or foraging areas was summarized from 7 telemetry studies conducted outside hibernacula during the fall swarming season (Brack 2006, Gumbert 2001, Hawkins et al. 2005, Kiser and Elliot 1996, Kurta 2000, Rommé et al. 2002, USFWS 2007; see Section 4.4.6 – Fall Swarming and Roosting). Distances traveled were associated with the population size of Indiana bats roosting in the local hibernaculum (see Figure 4-8). A linear regression line was used to summarize the pattern of increasing distances traveled from hibernacula with increasing population size at hibernacula; this formula (maximum distance traveled = 0.0006 * hibernating population + 4.8681) was then used to estimate the expected distance traveled for a P2 hibernaculum with a population size of 10,000 individuals (representing the maximum population size in a P2 Hibernaculum; Section 4.4.6 – Fall Swarming and Roosting).

Using this method, individuals using P2 hibernacula could be expected to travel a distance of 10.87 km (6.75 mi) from the hibernacula for roosting or foraging activities when they emerge from hibernation in the spring or immediately prior to winter hibernation. However, not all areas within 10.87 km (6.7 mi) of a hibernaculum would be expected to support Indiana bats. Forested areas or areas near forest edges or streams would be most likely to support Indiana bat activities. Thus, Buckeye Wind estimated the amount of forested area, plus a 60 m buffer representing the average distance between telemetry locations and the forest edge (see Figure 4-7), within an 11.2 km (7 mi) buffer around a known P2 hibernaculum in OH. This resulted in 6,370 ha (15,741 ac) of suitable habitat within an 11.2 km (7 mi) circle centered on the hibernaculum. For a P2 hibernaculum with population size of 10,000 individuals, the density of Indiana bats per area of suitable habitat is therefore 1.6 Indiana bats/ha (0.63 bat/ac). Given that density, a total of 81.3 ha (200.9 ac) would need to be conserved or restored in order to mitigate for the impact of take of 130.0 Indiana bats.

This method results in a conservative estimate of acres necessary to offset the impacts of the taking. It is known that Indiana bats may visit several hibernacula during the swarming season. Thus, densities outside hibernacula could be larger than those calculated, which would in turn decrease the amount of acres necessary to preserve for 130.0 individuals. Furthermore, Buckeye Wind used maximum distance traveled during swarming instead of average distance traveled to account for studies in which some bats with transmitters were never found (which may indicate that they traveled beyond the maximum distance observed). Still, the majority of individuals likely require an area around the hibernaculum that is smaller than that indicated by the maximum distance traveled. By using the maximum distance traveled, Buckeye

Wind calculated a larger area of use around the hibernaculum, resulting again in smaller densities and thus requiring a larger amount of acres to protect and enhance for 130.0 Indiana bats.

While it is not expected that tree clearing during Project construction will result in take of Indiana bats, Buckeye Wind proposes to mitigate for the forested areas that will be cleared during Project construction. No more than 6.5 ha (16.1 ac), or 6.8 ha (16.8 ac) for Re-design Option, of forested habitat will be cleared for the 100-turbine Project (see Section 5.2.1.1 – Wooded Habitat Removal). Buckeye Wind proposes to add an additional 6.5 ha (16.1 ac), of proposed mitigation land to the 81.3 ha (200.9 ac) to compensate for habitat lost during construction. Therefore, a total of 87.8 ha (217.0 ac) of suitable habitat within 7 miles of a Priority 2 hibernaculum in OH will be permanently protected and restored or enhanced to mitigate for the impact of the taking of 130.0 Indiana bats and to replace Indiana bat habitat that will be removed during Project construction. Because the Redesign Option will only result in impacts to an additional 0.7 acres of wooded habitat, the number of acres conserved for mitigation will not be adjusted if the Redesign Option is implemented.

6.3.2 Selection of Mitigation Areas

Mitigation will occur at a P2 hibernaculum in OH to maximize chances for offsetting incidental take attributable to the Project and to meet the biological goal and objective 2 of the HCP. Final selection of suitable areas for mitigation and appropriate restoration actions will be identified in cooperation with the USFWS and ODNR. The amount of funding dedicated to mitigation and the mechanism that will be used to provide funding will be detailed in Section 6.7 – Funding for the HCP.

6.3.3 Timing of Mitigation

Buckeye Wind proposes a 2-stage process for implementation of the mitigation plan. A staged process will help maximize efficiency of the plan and to allow for practical limitations of full plan implementation. In stage 1, Buckeye Wind will have in place all funds required to purchase and manage habitat sufficient to mitigate the first 10 years of expected Indiana bat take. At an expected average of 5.2 Indiana bats per year, the first 10 years of operation would result in the loss of 52 Indiana bats (40% of total estimated take). To offset the impacts of take for 52 Indiana bats, 35.1 ha (86.8 ac) would need to be protected (taken as a simple percentage of the total 87.8 ha [217.0 ac] as calculated in Section 6.3.1 – Acres of Mitigation Calculation). Before beginning of commercial operation, Buckeye Wind will acquire and/or place in conservation easement the initial 35.1 ha (86.8 ac). For any amount that Buckeye Wind has not yet purchased and/or protected at the time operation begins, sufficient funds would be placed in a form of surety acceptable to the USFWS (Surety; for example, an escrow account, cash, or bond). The Surety will be sufficient to purchase and/or protect the remaining mitigation acres. While Buckeye Wind will aim to purchase and/or protect the entire 35.1 ha (86.8 ac) before the beginning of operation, all of the lands will be purchased and/or protected no later than 1 year after the beginning of operation.

Before the beginning of the eleventh year of operation (stage 2), Buckeye Wind will acquire and/or place in conservation easement the additional 52.7 ha (130.2 ac). For any portion of the 52.74 ha (130.2 ac) not actually purchased or protected by the beginning of the eleventh year of operation, sufficient funding will be provided in a Surety to purchase and/or protect the remaining mitigation acres. While Buckeye Wind will aim to purchase and/or protect the entire 52.7 ha (130.2 ac) before the beginning of the eleventh year of commercial operation, all of the lands will be purchased and/or protected no later than 1 year after the beginning of the eleventh year of commercial operation.

Alternatively, the mitigation plan could utilize any mitigation bank that has been set up and approved by the USFWS for mitigation of Indiana bats in the Midwest RU. Any mitigation bank utilized must have a geographical service area range that includes the Project and include lands within OH. Buckeye Wind will have the option to contribute to the mitigation bank at a level sufficient to offset the impacts of take for any remaining take that has not yet been mitigated (for example, if Stage 1 mitigation is complete, the mitigation bank may be used to offset the effects of take for the remaining 78 Indiana bats). The sufficient level of contribution will be determined in coordination with the USFWS and ODNR DOW (see Section 7.3.4 – Change in Mitigation Acres).

If Buckeye Wind does not ultimately erect and operate all 100 turbines, all obligations to reach the appropriate acreage in both stage 1 and stage 2 will be reduced by a proportion equal to the number of turbines erected. For example, if only 52 turbines are erected out of a planned 100 turbines, then only 52% of Incidental Take is expected: 52% of 130.0 Indiana bats, or 67.6 Indiana bats, will be the estimated total take for a 52-turbine Project. Based on the calculations described in Section 6.3.1 – Acres of Mitigation Calculation, the density of Indiana bats per acre outside a P2 hibernaculum supporting 10,000 bats would remain at 0.63 bat/ac. Given that density, a total of 43.3 ha (107 ac), plus the amount of forest cleared for a 52-turbine Project, would need to be conserved or restored in order to mitigate for the mortality of 67.6 Indiana bats.

6.3.4 Restoration and Enhancement

Some amount of mitigation land may require restoration and/or enhancement of wooded travel corridors and wooded riparian habitat. In general, Indiana bats have been shown to be reluctant to cross open areas. Travel corridors linking roosting and foraging habitats are an important feature of Indiana bat habitat. Therefore, a minimum travel corridor of 4 rows of trees may be planted to establish a suitable travel corridor at least 15 m (50 ft) wide (USFWS 2009b). Indiana bats may also use such corridors for foraging and roosting during swarming activities. Priority should be given to restoring riparian habitat along existing stream corridors, particularly unchannelized streams, as these would provide both travel corridors and foraging habitats. Further, existing forest stands that have been preserved as part of the mitigation plan will be assessed and enhanced if necessary by girdling to create roost trees, conducting invasive species management, or creating and/or connecting travel corridors.

Methods used to restore degraded or suboptimal habitats will be informed by the Range-wide PEP Guidelines and existing forest management plans. Currently there are 3 states that have forest management plans specific to Indiana bat habitat: IN (Indiana Department of Natural Resources 2001), MO (Missouri Department of Conservation 2009), and VT (Vermont Fish and Wildlife Department 2008). In addition, 2 USFWS Field Offices have developed forest management plans: IN (USFWS – BFO 2008a) and NJ (USFWS – New Jersey Field Office 2008b). Each characterize Indiana bat habitat in the state and recommend a minimum number of snags and/or potential roost trees per acre within 3 size classes (Table 6-4).

Following these existing recommendations, tree planting and girdling will be used to create suitable Indiana bat roosting habitat in restoration areas such that, on average, there are:

- 2 small roost trees/ac less than 25 cm (10 in) dbh;
- 5 medium roost trees/ac between 25 cm (10 in) and 48 cm (19 in) dbh; and
- 2 large roost trees/ac greater than 48 cm (19 in) dbh.

Table 6-4. Summary of recommended number of potential roost trees per acre in existing Indiana bat forest management plans (DBH range for each size class).

Entity	Small	Medium	Large	Tree Condition
IN Department of Natural Resources		6 (11 – 19")	3 (> 20")	snag
MO Department of Conservation				
Heavily Forested	2 (< 10")	4 (10 - 19")	0.5 (> 19")	snag
Open/Semi-Open	2 (< 10")	4 (10 - 19")	1 (> 19")	snag
Riparian Corridor	4 (< 10")	7 (10 - 19")	1 (> 19")	snag
Bottomland Hardwood	2 (< 10")	4 (10 - 19")	1 (> 19")	snag
VT Fish and Wildlife Department	2 (< 10")	4 (10 - 18")	1 (> 18")	live and snag
USFWS Bloomington, IN Field Office		6 (11 - 20")	3 (> 20")	live
USFWS NJ Field Office		6 (11 - 20")	3 (> 20")	live
USFWS PEP Guidelines		6 (> 9")		snag

In unwooded corridors, or where tree density is deficient, tree planting will be used to restore Indiana bat swarming, foraging and roosting habitat. Assuming a 70% survival rate (Davis et al. 2010), approximately 430 stems/ac (less existing tree densities, if any) will be planted to achieve no less than 300 stems per acre, on average, per Planting Area (stems/ac/PA). Following planting (in Year 1), Year 2 habitat assessments will determine whether an average of 300 stems/ac/PA have survived. If not, the ratio of surviving stems to total stems planted will be calculated to determine the stem survival rate. The actual survival rate will be used to determine the number of trees necessary to plant in Year 2 in order to achieve an average of 300 stems/ac/PA in Year 3. For example, if an average of 430 stems/ac/PA are planted in Year 1, and an average of 258 stems/ac/PA survive to Year 2, the result is a success rate of 60%. In order to achieve an average of 300 stems/ac/PA, 42 (300 minus 258) additional stems/ac/PA need to survive. Since a 60% survival rate of trees planted in Year 1 was observed in Year 2, an additional 70 stems/ac/PA, on average (42 divided by 0.6) will be planted in Year 2.

Annual habitat assessments will occur in Years 1 to 5, or beyond Year 5 until an average of 300 stems/ac/PA have survived. After Year 5, or after at least an average of 300 stems/ac/PA, have been established (whichever is greatest), habitat assessments will be conducted every 5 years to ensure continued survival of planted trees and to enumerate the number of trees within each size class described above. Restoration or enhancement activities will be initiated within 1 year of the land being purchased or placed in conservation easement.

Tree Girdling

Girdling trees (i.e., cutting of the bark and a portion of the underlying cambium layer to create a ring-like groove encircling the base of the trunk) can create suitable Indiana bat roost trees over a period of several years. Girdling may be considered as a management action in a restoration area if there are less than 2 natural snags or girdled trees of at least 25 cm (10 in) dbh per ac, less than 5 trees between 25 cm (10 in) and 48 cm (19 in) dbh per ac, and less than 2 trees greater than 48 cm (19 in) dbh per ac. Trees selected for girdling will be based on the following characteristics identified by previous research to be suitable for Indiana bat roosting: a species known to be used by Indiana bats, the tree's solar exposure and location in relation to other trees, the tree's spatial relationship to water sources and foraging areas, and tree size (USFWS 1999, 2007, Kurta et al. 2002, Kurta 2005). Trees on north-facing slopes are not recommended for girdling. Trees would be selected and marked for girdling by a person with expertise in Indiana bat biology and habitat requirements. Tree girdling will occur during the period of time when Indiana bats would not be swarming, staging, roosting, or foraging near the hibernacula (16 November – 14 March).

Tree Planting

A minimum of 6 different tree species from the list found in Appendix L of the PEP Guidelines (USFWS 2009b) will be targeted for planting in riparian and travel corridor restoration. The 6 species of tree will be native to OH and will consider the species composition of nearby mature forest stands with similar soil composition and landscape position. Species selection will be determined based on site-specific characteristics (soil moisture, sun exposure, etc.) and seedling availability. In order to maximize Indiana bat habitat benefits, a stocking success rate of "not less than 300 stems per acre" will be achieved (USFWS 2009b). A minimum of 4 species identified as "Exfoliating Bark Species" on the Appendix L species list will be planted, such that they comprise at least 40% of planted trees. Ash and elm tree species will be avoided due to Dutch elm disease and emerald ash borers. Low compaction grading techniques, such as the Forestry Reclamation Approach, will be used where possible to increase the survival rate of planted trees (Burger et al. 2005 as cited in USFWS 2009b). To promote survival of planted trees, tree planting may occur during the timeframe of 1 April-31 October, during the period of time when Indiana bats are active.

Invasive Species Control

Non-native woody and shrubby invasive species will be reduced by periodically thinning the understory to remove invasive species that would out-compete native species (USFWS 2009b). Invasive species control will occur during the period of time when Indiana bats would not be swarming, staging, roosting, or foraging near the hibernacula (16 November – 14 March). In no instance will woody invasive species be allowed to represent more than 5% of the understory. A particular focus will be given to bush honeysuckles (*Lonicera* spp.) and tree of heaven (*Ailanthus altissima*). Bush honeysuckle, tree of heaven and other non-native, woody, invasive shrubs will be controlled through brush cutting (using bushhogs, mowers, or other similar equipment), hand cutting, and the use of herbicides if necessary (see Section 5.2.3.1 – Invasive Species Control). Herbicides may be used to paint cut stems and/or on large shrubs too big to dig or pull.

6.4 Conservation Measures

To help further the conservation of Indiana bats and increase knowledge related to Indiana bat-wind energy interactions, Buckeye Wind will allocate $200,000 from operating revenues for research. Funding for conservation measures will be made available from Project revenues to a qualified research program(s) after 1 year of Project operation has been completed. The funding will be assigned within 5 years of the beginning of Project operation and will be provided to appropriate private or academic institutions to conduct research on Indiana bat behavior relative to wind energy development.. . Research efforts will focus on the known population of Indiana bats in the Action Area, or on other summer or hibernating populations of Indiana bats in OH that would provide valuable information. Results of the research will be incorporated into the adaptive management of the Project, where appropriate. The assignment of funds and all research and sampling protocols will be developed in consultation with the USFWS, ODNR DOW, and appropriate scientific experts. The amount of funding dedicated to research and the mechanism that will be used to provide funding will be detailed in Section 6.7 – Funding for the HCP. Possible research topics are described below and potential methods, expected outcomes, and measurable variables are summarized in Table 6-8.

Indiana Bat Wind Turbine Interaction Studies

To better understand Indiana bat behavior in the vicinity of operating wind turbines, mist-netting and radio-telemetry could be used to capture and track Indiana bats in the Action Area. The 3 known roost trees in the northern portion of the Action Area or nearby suitable habitat could be targeted for mist-netting. Certain techniques could be used to investigate Indiana bat behavior, such as radio-telemetry, light-tagging or TIR camera recordings at turbines. Important behavioral characteristics or other variables that could be measured include:

- Flight height relative to the rotor swept-zone;
- Spatial use patterns relative to turbines;
- Potential attraction or avoidance of turbines;
- Activity during different weather (wind speeds, temperature, barometric pressure, and humidity);
- Nightly timing of activity; and
- Accuracy of habitat suitability model and collision risk model.

Indiana Bat Migration Studies

There is a paucity of information about how Indiana bats migrate, particularly during the fall, when bats, in general, are most susceptible to collision or barotrauma at wind facilities. Such information could help to validate the assumptions of the collision risk model and help to understand the extent to which Indiana bats are at risk of collision or barotrauma with wind turbines during migration at the Buckeye Wind Project or other wind facilities. Funding provided by Buckeye Wind could be used to conduct telemetry studies to better understand aspects of fall migration that may result in greater risk from wind power projects.

For fall migration studies, Indiana bats would be captured in mist nets in late August/early September, radio-tagged and followed using aircraft and/or vehicles as they depart for fall migration. Important behavioral characteristics or other variables that could be measured include:

- Whether Indiana bats follow landscape or habitat features;
- Migration speed, flight height, and duration; and
- Avoidance behavior of potential barriers to migration, such as wind power projects, urban areas, or major transportation thoroughfares.

Bat Specimen Collection

Wing and Hair tissue samples from each dead bat may be collected to support USFWS-requested research projects by entities other than Buckeye Wind. Wing tissue and hair samples would be collected and stored following USFWS recommended protocol at the time of collection. Specimens would be stored such that details on the individual bat from which samples were collected are known (either store data sheet with sample, or cross reference sample to database of mortality records). Specimens would be provided to USFWS on a periodic basis, to be determined at the start of each post-construction monitoring period. Collection of specimens will not affect the subsequent use of the carcasses for searcher efficiency or carcass persistence trials.

Table 6-5. Summary of conservation measures to be implemented by Buckeye Wind to increase scientific knowledge of Indiana bat behavior as it relates to wind power (selection of an appropriate conservation measure will be finalized in consultation with the USFWS and ODNR DOW).

Conservation measures	Expected outcomes	Measurable variables
Fund Indiana bat wind interaction research		
Conduct radio-telemetry, light-tagging, mist netting, and/or TIR camera studies on Indiana bats during summer in Action Area	Increased understanding of Indiana bat/wind power interactions that will increase effectiveness of future minimization and avoidance measures at wind power facilities	Data on: a. Flight height relative to the rotor swept-zone, b. Spatial use patterns relative to turbines, c. Potential attraction or avoidance of turbines, d. Activity during different weather conditions including wind speed, temperatures, barometric pressure, and humidity, e. Nightly timing of activity, f. Accuracy of habitat suitability model and collision risk model
Fund Indiana bat migration research		
Conduct fall migration telemetry studies of Indiana bats	Increased understanding of Indiana bat migration patterns that will increase effectiveness of future minimization and avoidance measures at wind power facilities	Data on: a. Whether or not Indiana bats follow landscape or habitat features, b. Migration flight height, speed, and duration, c. Avoidance behavior of potential barriers to migration, such as wind power projects, urban areas, or major transportation thoroughfares.
Bat Specimen Collection		
Wing and Hair tissue samples from each dead bat may be collected to support USFWS-requested research projects by entities other than Buckeye Wind		

6.5 Monitoring and Adaptive Management

Monitoring will be used to ensure that the goals and objectives set forth in Section 1.2 – Biological Goals and Objectives of the HCP are being met. In addition, monitoring studies are designed to provide information pertaining to 3 key factors:

1) Post-Construction Monitoring (PCM): PCM will be conducted at every turbine location from 1 April to 15 November during the first 1 to 2 years of monitoring, to comply with ODNR DOW's "On-Shore Bird and Bat Pre- and Post-Construction Monitoring Protocol for Commercial Wind Energy Facilities in Ohio" (ODNR Protocol; ODNR 2009). Each subsequent monitoring year, monitoring will occur from 1 April to 31 October unless otherwise amended through adaptive management as described in this chapter. The purpose of the PCM is to provide assurance that the Project is in compliance with the authorized take limits as specified in Biological Objective 1. In addition, PCM will inform changes to the feathering plan through adaptive management, which may result in increased environmental benefits from wind energy generation, thus providing a means by which to achieve Biological Objective 4.
2) Monitoring of mitigation actions will allow Buckeye Wind to measure the success of Biological Objective 2. In the case of restoration/enhancement of habitat, Buckeye Wind will monitor the habitat features within the mitigation areas subject to enhancement, including number and diameter of potential roost trees, survival of planted trees, and status of invasive species management.
3) Monitoring of potential factors influencing Indiana bat mortality: in order to enhance our understanding of the factors that contribute to increased risk of Indiana bats (Biological Objective 3), and potentially refine the feathering plan and maximize operational output of the Project (Biological Objective 4), Buckeye Wind will monitor the following factors:
   - Seasonal variation of mortality;
   - Variation in mortality with respect to turbine location and habitat; and,
   - Variation in mortality with respect to weather characteristics, including wind speed, barometric pressure, temperature, and humidity.

While this section and this HCP are focused on the Indiana bat, the post-construction monitoring methods were developed in cooperation with ODNR and will be used to also monitor for mortality of non-federally listed species. The Buckeye Wind ABPP (Stantec 2011a) provides a more specific discussion of how these approaches will be applied to monitoring for non-federally listed species.

6.5.1 Monitoring for Minimization

The first biological goal described in Section 1.2 – Biological Goals and Objectives of the HCP pertains to minimizing take of Indiana bats to the maximum extent practicable. There are 3 biological objectives that describe measureable targets needed to achieve the goal of minimizing take:

Objective 1: Implement an operational feathering strategy that will limit mortality of Indiana bats due to collision with the turbines or barotrauma resulting from near collisions with moving blades to no more than 26 Indiana bats over any 5-year period beginning in any year in which more than the expected average morality of 5.2 Indiana bats is estimated, and not more than 130.0 Indiana bats over the 30-year ITP Term;

Objective 3: Enhance understanding of the factors that contribute to increased risk of Indiana bat collisions and barotrauma resulting from near collisions with moving blades and tailor the conservation program to meet the biological goals. Specific factors that will be considered include:

- Seasonal variation in mortality;
- Variation in mortality with respect to turbine location and habitat; and
- Variation in mortality with respect to weather characteristics (wind speed, temperature, barometric pressure, and humidity).

Objective 4: Maximize operational output of the Project, such that the environmental benefits of wind energy are maximized, thereby reducing potentially harmful effects of other energy products. In particular, increased generation from wind energy facilities will offset carbon emissions from other electric generation technologies. Carbon emissions contribute to global climate change, which has been identified as a potential risk to Indiana bats (USFWS 2007). Other environmental benefits are also associated with wind energy (see Section 1.3.1 – Fossil Fuel Offsets and Reductions, and Section 5.4 – Potential Beneficial Effects of Wind Energy on Indiana Bats).

Monitoring the Indiana bat mortality levels at the Project will help to ensure that the Biological Goals and Objectives 1, 3 and 4 are being achieved. Post-construction mortality monitoring will be used to ensure compliance with the terms of the ITP, and will be used to inform adaptive management actions. The specific goals of the post-construction monitoring protocol are to:

- Ensure that USFWS-authorized take of Indiana bats is not exceeded;
- Identify the circumstances and conditions under which Indiana bat fatalities are likely to occur;
- Use adaptive management to identify the operational strategies that maintain Indiana bat mortality rates within those authorized by the ITP and allow for maximal production of renewable energy;
- Provide a mechanism to evaluate the use of new technology that can be used to reduce uncertainty about Project impacts to Indiana bats over time; and
- Provide information that will increase knowledge of Indiana bat-wind energy interactions and contribute to reducing the negative impacts of current and future wind energy development on Indiana bats.

Mortality monitoring will be conducted throughout the ITP Term with a frequency and intensity that is sufficient to document that Indiana bat take is not exceeding the level authorized by the ITP. Feathering will be applied to turbines during 3 phases: 1) Evaluation Phase, 2) Implementation Phase, and 3) Re-evaluation Phase. The objective of the Evaluation Phase is to monitor Indiana bat mortality to ensure that it is at or below the authorized threshold. During the Implementation Phase, the results of the Evaluation Phase will be used to implement the most appropriate operational feathering plan as informed by adaptive management. Monitoring will be conducted during the Implementation Phase to ensure that incidental take of Indiana bats remains at or below Expected Average Mortality levels. Each Re-evaluation Phase will allow Buckeye Wind to incorporate a modified feathering plan according to the adaptive management approach described below. The Re-evaluation Phase will also allow Buckeye Wind to test new avoidance or minimization techniques that may become available, as described in Section 6.5.3.6 – Special Cases, in order to effectively minimize Indiana bat mortality while operating the Project in the most cost-effective manner. In addition, Re-evaluation Phase monitoring will be used if estimated mortality in any Implementation Phase monitoring year meets certain adaptive management criteria as described in Section 6.5.3.5 – Implementation Phase Adaptive Management.

Consistent with adaptive management, it is expected that changes may be made to monitoring methods as appropriate and in consultation with the USFWS. Changes are addressed in Section 6.5.2.9 – Adaptive Management for Minimization Monitoring.

6.5.2 Methods for Minimization Monitoring

Mortality monitoring will be conducted to document mortality of Indiana bats throughout the ITP Term, in accordance with the HCP and ITP. Monitoring will also document annual estimated bird and non-federally listed bat mortality caused by the Project (Stantec 2011a). The ODNR Protocol was used to guide the development of this monitoring plan, in consultation with the ODNR DOW and the Ohio Ecological Services Field Office of the USFWS. Over the ITP Term, modifications to this monitoring plan may be appropriate and will be made as part of the ongoing adaptive management of the Project and in compliance with the terms of the HCP.

Buckeye Wind will enlist the services of an independent consultant to conduct mortality monitoring. Buckeye Wind will select the consultant based on qualifications, experience, and costs and will receive a scope of work proposal from the selected consultant that provides detailed information on the consultant's qualifications. The scope will include detail on adequate implementation of the monitoring methods described in this Section 6.5.2 – Methods for Minimization Monitoring. A qualified project manager (PCM Manager) and field technicians will be assigned to oversee the day-to-day monitoring efforts. Before awarding a contract, Buckeye Wind will provide the proposal to the USFWS and ODNR DOW for approval. Within 24 hours advance notice, the Applicant will provide representatives of the USFWS with access to the site in order to inspect and/or participate in the day-to-day implementation of the mortality monitoring.

If Buckeye Wind decides to change the consultant at any point during the ITP Term, the same process for selection and USFWS and ODNR DOW approval will be followed.

6.5.2.1 Monitoring Phases

Post-construction mortality monitoring will be conducted within 3 phases: the Evaluation Phase, Implementation Phase, and Re-evaluation Phase. Monitoring will be most intensive during the first years of Project operation, during the Evaluation Phase. It is expected that the Evaluation Phase will provide sufficient information to identify the level of risk to Indiana bats and to monitor compliance with the ITP. The Evaluation Phase will last for a minimum of 2 years, and will result in a feathering plan that maintains Indiana bat take at Less than Expected or Expected levels (Table 5-7).

Once a feathering plan has been identified to maintain mortality at these levels during the Evaluation Phase, the Implementation Phase will begin. Post-construction mortality will be monitored biennially during the Implementation Phase (beginning with a year of no monitoring). The level of mortality during a year when no monitoring occurs will be assumed to be the same as that from the previous year when monitoring occurred. On years when monitoring occurs, monitoring effort (i.e., search frequency, search area, vegetation management, weather monitoring, data collection, data analysis, and reporting) will be the same as during the final year of Evaluation Phase monitoring. The only difference between Evaluation and Implementation monitoring methods may be Survey Period (see Section 6.5.2.2), Search Frequency (see Section 6.5.2.3), and Search Area (see Section 6.5.2.4), all of which may change as a result of Adaptive Management as described in Section 6.5.2.9 – Adaptive Management for Minimization Monitoring. After 4 calendar years of Implementation Phase monitoring (at which time a minimum of 2 Evaluation Phase monitoring years have been conducted as well as 2 biennial search years under the Implementation Phase), if take remains at Less than Expected or Expected levels, mortality monitoring may move to once every 3 years following the adaptive management strategy outlined in Section 6.5.3 – Adaptive Management for Minimization.

Provided that annual Indiana bat take levels are Less than Expected or Expected, the Implementation Phase will be in effect until Buckeye Wind, at their discretion, implements a Re-evaluation Phase or until/if results from Implementation Phase monitoring dictate the need to alter operations in a way that would necessitate Re-evaluation Phase monitoring. The purpose of the Re-evaluation Phase will be to monitor compliance with the ITP once new minimization measures are implemented, such as changes to operational feathering or other emerging methods or technologies to reduce mortality of Indiana bats, per Section 6.5.3 – Adaptive Management for Minimization. Because testing of new minimization techniques will introduce additional uncertainty with regard to risk to Indiana bats, methods and sampling intensity will be the same as those used during the Evaluation Phase; therefore, a minimum of 2 consecutive years of mortality searches will be conducted. Implementation Phase monitoring will again be implemented at the conclusion of each Re-evaluation Phase. The following sections will describe the details of the monitoring methods under each monitoring Phase in more detail.

6.5.2.2 Survey Period

During the initial Evaluation Phase, mortality searches will be conducted for approximately 32 consecutive weeks within 3 seasonal periods that correspond to unique seasonal behaviors of Indiana bats: spring (1 Apr to 31 May), summer (1 Jun to 31 Jul), and fall (1 Aug to 15 Nov). This will be referred to as the survey period or monitoring period. The fall monitoring period here is longer than the fall season discussed in Section 1.1 – Overview and Purpose of the HCP and elsewhere to be consistent with ODNR Protocol.

The Evaluation Phase will begin once a turbine begins to produce electricity and is operational and will encompass the spring, summer, and fall (1 April through 15 November) for at least the first 2 years of operation of that turbine. If a turbine becomes operational prior to 1 April, that year will constitute a full Evaluation year. If operation begins after 1 April, monitoring will proceed for the remainder of the active period and the turbine(s) will be subject to trigger point adaptive management as described in Section 6.5.3.4 – Trigger Point for Immediate Adaptive Management, but the following year will constitute Year 1 Evaluation Phase monitoring.

6.5.2.3 Search Frequency

Monitoring will be conducted with a sampling scheme and intensity that will ensure that the authorized level of Indiana bat mortality is not exceeded and that will provide data necessary to evaluate the feathering regime. In order to address these objectives, all operating turbines will be searched during annual Evaluation Phase monitoring, biennial or greater Implementation Phase monitoring, and Re-evaluation Phase monitoring.

Searches will be conducted using a 3-day search interval for every turbine. Under a 3-day search interval, mortality searches will occur every day of the week throughout the survey period, with approximately one third of the turbines searched every day (i.e., turbines searched on Monday would have 3 nights of potential mortality and would then be searched again on Thursday). By using a 3-day search frequency and searching every turbine, there is a higher probability of detecting an Indiana bat fatality if it occurs; whereas, if only a subset of turbines is searched, the Detection Probability for Indiana bats would necessarily be smaller (see Section 6.5.2.7 – Estimating Unobserved Mortality, for discussion of detection probability).

In order to balance the objective of assessing Indiana bat mortality at all turbines while also providing the ODNR DOW with annual data that is more closely compatible with current ODNR Protocol (ODNR 2009), during the first 1 to 2 years of monitoring, additional searches may be conducted at a portion of turbines using a shorter search interval.

. The resulting combination of search intervals will be designed to meet the data needs of the ODNR DOW while always meeting the objectives of the HCP. Buckeye Wind and ODNR DOW will re-evaluate the combined search intervals after the first year of monitoring and determine what percent of the turbines, if any, would still need to be searched using a shorter search interval.

Mortality searches may also be conducted at all MET towers in the Action Area during the first year of Project operation, as recommended in the ODNR Protocol. Depending on the results of the first year of monitoring, Buckeye Wind and ODNR DOW will determine if monitoring at MET towers during the optional second year of post-construction monitoring may be waived, reduced, or continued. Since MET towers are not expected to pose risks to Indiana bats (See Section 4.5.5.6 – Bat Collision with Other Structures), monitoring will not continue past the first or second year after erection.

Searches will be initiated at sunrise and end by 1:00 PM in an effort to recover carcasses before removal by diurnal scavengers, as well as to increase the chances of recovering live Indiana bats (coincidentally, chances of recovering live birds and non-federally listed bats will also be increased).

6.5.2.4 Search Area

Plot size will include an area that extends 2.0 times the blade length from the base of the turbine (i.e., radius of 100 m (328 ft) for a 50 m [164 ft] blade). Results from mortality monitoring studies indicate that the majority of bird and bat carcasses fall within 50% of the maximum height of turbines (Kerns and Kerlinger 2004, Arnett 2005, Fiedler et al. 2007, Young et al. 2009a, Jain et al. 2007, 2009ab, Piorkowski and O'Connell 2010), with most bat fatalities falling within 30 m to 40 m (98 ft to 130 ft) of turbines (Kerns and Kerlinger 2004, Johnson et al. 2003a[42]). In PA, 95% of detected bat fatalities fell within 50 m (164 ft) of the turbine and 85% of bat fatalities fell within 40 m (130 ft) of the turbine at 9 sites studied between 2007 and 2009 (PGC 2011).

Search transects will be positioned north-to-south and will be spaced 5 m (16 ft) apart across search plots. In an attempt to standardize time spent searching each turbine, carcasses will be marked in the field when they are found, and will be processed after the turbine search is complete.

The entire plot size will be searched, subject to a measurable probability of finding carcasses and worker safety. In many cases, the full plot size at each turbine cannot be completely searched because of factors that make areas within the plot too difficult or too dangerous to search (Strickland et al. 2011, USFWS 2011c). Areas will be considered too difficult to search if there is little to no bare ground cover and more than 25% of the ground cover is over 12 inches in height. The PCM Manager will determine what areas and conditions present conditions that deem it too dangerous to search.

Wind facilities located largely in agricultural settings, such as the Project, can present difficult searching conditions (e.g., 3 m [10 ft] tall corn). Pesticide use in agricultural settings can make conditions unsafe for workers for short periods of time after pesticide application. ODNR Protocol (2009) states that transects should not venture into hazardous areas such as steep slopes or water. Further, vegetative conditions such as tall corn can make searching difficult. In conditions of tall corn, the probability of finding a carcass along the transect line itself will be similar to the probability found in other vegetative cover; however, the probability of finding a carcass off the transect line will be close to 0. Searcher efficiency trials (see Section 6.5.2.7.1 – Searcher Efficiency Trials) are designed to adjust observed mortality by the probability that a searcher will find a carcass, given it is present. However, these trials are conducted under the assumption that a searcher is walking a transect line and searching several meters off each side of the line, which cannot be done in extremely low visibility, such as tall corn. If the probability of detecting a carcass is un-measureable given current searcher efficiency methods, or extremely low, searching these areas will likely bias mortality estimates.

ODNR Protocol (2009) requires that an estimate of searchable area be provided for each searched turbine. Most post-construction mortality monitoring uses an area correction factor to adjust mortality estimates by the amount of area searched beneath turbines (for example, see Kerns et al. 2005, Arnett et al. 2009, and Strickland et al. 2011). A simple adjustment by the proportion of areas searched below turbines cannot be used, as density of carcasses is known to decrease as distance from turbine increases (Kerns et al. 2005) –

[42] During avian and bat mortality monitoring at the Buffalo Ridge wind facility in MN in which all areas within 50 m (164 ft) of turbines were searched, only 1 of 184 bats was found greater than 30 m (98 ft) from a turbine.

unsearched areas tend to be farthest from turbines in areas of low carcass density, so a simple adjustment based on proportion of area searched would over-estimate mortality (Arnett et al. 2009). Therefore, a function is used to relate density of observed carcasses with distance from the turbine. Within each standardized search plot, searches will therefore be focused within areas where probability of detection is measurable and search areas will be delineated by the area around each turbine that is clear of dense crops, shrubs, forested habitat, open water, large rock or rubble, or conditions that otherwise prohibit effective or safe searching conditions. For these reasons, searchable area may vary by turbine and month.

6.5.2.5 Vegetation Management and Mapping

Because vegetation influences carcass detectability, a minimum of 25% of turbine search plots (i.e., 13 for the 52-turbine Project, and 25 for the 100-turbine Project) will be regularly mowed or chemically treated to remove vegetation. For those turbines where mowing will be utilized, vegetation will be maintained at a height of 4 inches or less, with less than 2% of interspersed vegetation no higher than 12 inches. Should mowing be used, Buckeye Wind will ensure scheduled mowing occurs during the day in which the turbine was searched, and after the search is completed (within 12 hours after last mortality search), to avoid carcasses being destroyed by mowing. Should other acceptable means to maintain searcher efficiency become available during the ITP Term, Buckeye Wind may change its methods (See Section 7.2.1.9 – Use of New Methods, Information, or Technological Advances).

Vegetation in all search plots will be monitored on a weekly basis by a Buckeye Wind employee or contractor hired by Buckeye Wind; the aerial extent of each ground cover type and respective vegetation heights will be recorded. Any significant changes in ground cover type will be noted (e.g., plowing, mowing, harvesting). Once during each of the seasonal periods in which searches are conducted, the aerial extent of each cover type within search plots will be mapped using a global positioning system (GPS) unit. Vegetation height and percent cover will be recorded at 10 m (33 ft) distances along each transect of the search plot. Additional GPS points will be taken at points of abrupt ground cover transition and to document conditions that cause the searchable area to be reduced (e.g., forest edge). All records and documentation will be kept on file and/or in electronic format and may be provided to USFWS on request. See Section 6.5.2.7.1 – Searcher Efficiency Trials and Section 6.5.2.7.2 – Carcass Persistence Trials for information on how ground cover will be used as a factor to estimate unobserved mortality.

6.5.2.6 Weather Monitoring

On nights preceding mortality searches, general weather conditions in the vicinity of the Project (i.e., precipitation, cloud type, cloud height, percent cloud cover, and moon phase) and notable weather events (e.g., storm or passage of a front) will be recorded on standardized datasheets. Additional weather data (i.e., wind speed, wind direction, temperature, and barometric pressure) will be downloaded by meteorological professionals associated with Buckeye Wind from an on-site permanent MET tower and a turbine nacelle for the entire survey period. At the beginning of each turbine search effort, the surveyor will record weather conditions including sky conditions, precipitation, and visibility. In addition, the surveyor will record his/her name, date, estimated wind speed, wind direction, temperature, and time searches are initiated and completed. Weather data may be used to determine conditions that influence mortality and may be incorporated into the adaptive management regime (see Section 6.5.3 – Adaptive Management for Mitigation).

6.5.2.7 Estimating Unobserved Mortality

Not all fatalities will be found by surveyors during turbine searches, and the need to adjust observed carcasses by some factor in order to estimate total mortality has long been recognized (Huso 2010, Strickland et al. 2011, USFWS 2011c). Carcasses within the search area may be missed by searchers, carcasses may be removed by scavengers prior to the next scheduled search, or carcasses may land outside the searched area. If there was a direct relationship between observed carcasses and the number of individuals actually killed, then observed carcasses could be used as an index of fatalities (Huso 2010). Unfortunately, there is no direct relationship, as factors leading to imperfect detection of carcasses (i.e., searcher efficiency, scavenger removal rate, searchable area) can be site-specific and variable (Huso 2010, Strickland et al. 2011).

Many approaches have been developed to estimate fatality from observed carcasses (e.g., Erickson et al. 2004, Johnson et al. 2003b, Kerns and Kerlinger 2004, Shoenfeld 2004, Fiedler et al. 2007, Jain et al. 2009a, Arnett et al. 2010, Huso 2010, Tidhar 2010,). These approaches continue to be developed and refined as more information becomes available. In their draft Land Based Wind Energy guidance document (USFWS 2011c), the USFWS strongly recommends "that only the most contemporary equations for estimating fatality be used, as some original versions are now known to be extremely biased under many commonly encountered field conditions." Section 6.5.2.7 – Estimating Unobserved Mortality contains information on methods for calculating bias-correction factors, which will then be applied to observed mortality in order to estimate total fatality. However, in the time between creation of this HCP and commencement of post-construction mortality monitoring, and at times throughout the term of the ITP, it is highly likely that new formulas for estimating mortality based on observed carcasses will be developed.

At this time, several formulas exist that are considered to be appropriate to use under certain conditions. For example, the Huso estimator (Huso 2010) appears to be most accurate when there are low detection rates and high carcass persistence rates; the Shoenfeld estimator (Shoenfeld 2004) or the Huso estimator may be employed when carcass persistence time is shorter than the search interval; when carcass persistence time is greater than the search interval, both the Shoenfeld and Huso estimators may underestimate or overestimate (respectively) fatalities (Strickland et al. 2011). While currently appropriate formulas are described in Section 6.5.2 – Methods for Minimization Monitoring, it is expected that, as recommended by the USFWS draft guidance document (2011c), the most contemporary and most accurate equations for estimating fatality available at the time of analysis will be used. In the case that other formulas will be more appropriate, Buckeye Wind would propose to utilize those formulas for estimating unobserved mortality. The utilization of any new formulas will be made in coordination with and with the approval of the USFWS and ODNR and will be based on site-specific information.

The following sections contain information on methods for calculating bias-correction factors, which will then be applied to observed Indiana bat mortality in order to estimate total fatality. Example formulas are provided to demonstrate the basic inputs of each correction factor, though as stated above, the most appropriate formula for use will be determined based on the results of annual monitoring.

In the case that no Indiana bats are observed in any one year, Buckeye Wind will also estimate the confidence that 5.2 Indiana bats or fewer were taken in that year. A joint effort between the USFWS and U.S. Geological Survey has recently begun to develop methodologies for evaluating the probability that rare events, such as the mortality of an Indiana bat, were missed during post-construction mortality monitoring. The methodology first calculates the probability of detecting an Indiana bat, given paramters of the mortality monitoring methodology. Detection probability is determined by multiplying the fraction of turbines searched (n/N), the searcher efficiency (SE), the carcass persistence rate between searcher intervals (r) and the proportion of carcases expected to fall within the area searched (dw) (Detection Probability = n/N * SE * r * dw). Detection probability is highest (e.g., detection of dead Indiana bats is most likely) when a large percent of the turbines are searched, when searcher efficiency is high, when the search interval is shorter than the mean carcass persistence time, and when searches occur within a large percent of the area where carcasses are expected to fall. The probability of not detecting an Indiana bat would be given as 1 – the Detection Probability. Finally, the probability of missing 5.2 Indiana bats

(Probability of Miss) would be given as (1-Detection Probability)^5.2. The Probability of Miss is not an estimate of mortality; rather it is an expression of the confidence that greater than 5.2 Indiana bats were "missed." A low Probability of Miss is preferred, indicating that it is less likely that searchers missed more than 5.2 Indiana bats, given that none were observed.

In the case that 1 or greater Indiana bat mortality is documented in a year, the bias-correction factors will be adequate for estimating total take. In the case that no Indiana bat mortality is documented in a monitoring year, the Probability of Miss will be calculated but the estimated take will be zero for that year.

6.5.2.7.1 Searcher Efficiency Trials

Searcher efficiency rates are variable among studies at wind facilities in the United States and are largely dependent on ground cover conditions. Searcher recovery rates have ranged from 25% to 56% for small carcasses, and as high as 100% for large carcasses (Arnett 2005, Erickson et al. 2003a, Jain et al. 2007). Therefore, trials will be conducted by the PCM Manager in each year that mortality monitoring is performed to estimate searcher efficiency and carcass removal rates. Both searcher efficiency and carcass removal trial methods will remain the same during the Evaluation, Implementation, and Re-evaluation phases.

Trials will involve the placement of a minimum of 200 carcasses over the course of the monitoring year (where 1 carcass equals 1 trial) per ODNR Protocol. The same individual trial carcasses will be re-used in multiple trials over the course of the study period, and up to 20 trial carcasses may be used on a single trial day. Given that it is rare to find multiple carcasses at a single turbine (NRC 2007), "over-seeding" may occur if too many trial carcasses are placed in a small area (which may increase scavenger activity). Therefore, no more than 2 trial carcasses will be placed at any time at a single turbine (Strickland et al. 2011, USFWS 2011c). On trial days, carcasses will be placed at multiple turbines scheduled to be searched that day and will be placed at random distances from turbine towers and in a variety of cover types.

Multiple trials (at least 200) will be conducted throughout the survey period to account for changes in ground cover conditions. Recommended placement procedures range from distributing carcasses equally across ground cover types (USFWS 2011c) to having higher sample sizes in low visibility ground cover in order to obtain more precise estimates of searcher efficiency in areas contributing to higher uncertainty in overall fatality estimates (Strickland et al. 2011). No studies to date have suggested a preferred method for stratifying trial carcass placement (Strickland et al. 2011). As ground cover conditions will be highly variable throughout the survey period and from year to year, and trial schedule will be dependent upon carcass availability, the PCM Manager will attempt to distribute trials evenly across ground cover types to his or her best ability.

Bat trial carcasses in varying stages of decomposition will be marked by the PCM Manager so that trial carcasses may be distinguished from actual fatalities without the surveyor's knowledge. Non-bat surrogates (for example, mice or birds) will not be used to estimate searcher efficiency for bats. If a sufficient number of trial carcasses cannot be obtained from on-site mortality, then Buckeye Wind will attempt to obtain carcasses from outside sources. Buckeye Wind will first consult with the USFWS and ODNR DOW to identify whether either agency has a source of additional carcasses. If not, then Buckeye Wind will attempt to find a source of additional carcasses from other sources, such as academia, the Ohio Department of Health, or other wind facilities, as long as precautions can be followed to avoid spreading WNS. These precautions will follow USFWS and ODNR Protocol. To the extent that it is feasible (i.e., carcasses are in good condition and do not show signs of WNS), carcasses from Project fatalities or carcasses from elsewhere that are of species expected to be encountered during the searches will be used in trials. If nothing else is available, non-bat surrogates may be used if necessary in coordination with USFWS and ODNR DOW (see Section 6.5.2.9 – Adaptive Management for Minimization Monitoring).

A *Myotis* carcass will not be used in a trial unless its identification has been verified. Negative identification of the carcass will be verified by the USFWS and ODNR DOW through agreed upon means, which may include, but not be limited to, DNA testing by an appropriate lab (as determined in coordination with the USFWS), examination by a recognized expert or some other mutually agreeable method.

Surveyors being tested will be unaware of trial dates and locations. The PCM Manager will leave carcasses out before sunrise at search turbines and will make every effort to leave no evidence of trial set-up (e.g., vehicle or foot prints in wet grass or mud). The PCM Manager will record the following information for each carcass placed and will use the Searcher Efficiency Form as provided in the ODNR Protocol:

- Date, time of set-up, PCM Manager, and surveyor being tested;
- Turbine number;
- Carcass identification;
- Carcass distance and direction from tower;
- Ground cover type and vegetation height where carcass was placed; and
- GPS location.

After searches are completed on trial days, the PCM Manager will determine how many trial carcasses were recovered. Trial carcasses that were not found the first day will be left in place for possible detection on subsequent days. The presence of the trail carcass (i.e., availability for detection) will be determined and recorded by the PCM Manager each day immediately after the completion of each searcher efficiency trial day.

Searcher efficiency rate will be expressed as the proportion of trial carcasses found by searchers (the number of trial carcasses found by searchers divided by the total number of trial carcasses placed during searcher efficiency trials, i.e., searcher efficiency = number found/total number placed). Searcher efficiency will be calculated separately by season and by vegetation cover type (such as cleared versus uncleared plots) as trial carcasses are available and as sample sizes allow. Each trial carcass collected during mortality surveys will be associated with a searcher efficiency value specific to the season, trial carcass type, and cover type in which it was found. If alternative formulas are developed over time, the formula determined to be most applicable to the Project and most accurate at the time of analysis will be chosen in coordination with the USFWS and ODNR DOW (see Section 6.5.2.7 – Estimating Unobserved Mortality). Separate searcher efficiency rates will be developed for all bats and *Myotis* bats, as trial carcasses are available and as sample sizes allow.

6.5.2.7.2 Carcass Persistence Trials

Trials will be conducted to estimate the carcass persistence rate, or the average length of time carcasses remain in the area prior to removal by scavengers. Per ODNR Protocol (2009), a minimum of 50 trial carcasses will be placed at random distances and directions from turbines over the course of each monitoring year (subject to carcass availability). Several trial carcasses will be placed per month during the course of the survey year in order to account for seasonal changes of scavenger activity, per ODNR protocol (2009). Carcasses in fresh condition will be used in trials and will be marked discreetly to differentiate them from actual fatalities. Non-bat surrogates (for example, mice or birds) will not be used to estimate carcass persistence rates for bats, unless nothing else is available. If nothing else is available, non-bat surrogates may be used if necessary in coordination with USFWS and ODNR DOW (see Section 6.5.2.9 – Adaptive Management for Minimization Monitoring). Preferably, carcasses used for trials will be those collected from the site (ODNR 2009).

Trial carcasses will be randomly placed and stratified across various habitat types in proportion to their occurrence (for example, if 90% of the area under turbines is agricultural, then 90% of trial carcasses will be randomly placed in agricultural settings). Carcasses will be placed at cleared and uncleared search plots. Trial carcasses will be randomly placed at multiple turbines throughout the monitoring area and will be checked daily for the first 7 days, then every 2 days until the trial carcass is removed or completely decomposed, per ODNR (2009) protocol. On each day the trial carcass is checked, surveyors will indicate whether the trial carcass is present (intact, or partially scavenged but readily detectable) or absent (completely removed, or with so few feathers or tissue that they are not readily detectable). The following additional information will be recorded on standardized datasheets for each trial carcass:

- Date, time of set-up, PCM Manager;
- Turbine number;
- Carcass identification;
- Carcass distance and direction from tower;
- Ground cover type and vegetation height where carcass was placed;
- Detailed notes describing any scavenging and evidence of scavenger identification; and
- GPS location.

There are several formulas currently available to estimate carcass persistence rate, and new methods are continuously being developed (see Section 6.5.2.7 – Estimating Unobserved Mortality). In coordination with the USFWS, the formula determined to be most applicable to the Project and most accurate at the time of analysis will be used. Using an example estimator employed by Erickson et al. (2004) and Tidhar (2009), the average number of days a carcass remained at a site before it was removed by scavengers ($\bar{t}$) was expressed as:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}$$

- Where s is the number of test carcasses used in the search trials,
- s_c is the number of test carcasses remaining in the study area at the end of the trial, and
- t_i is the number of days carcass i remained in the study area.

If all trial carcasses are removed before the end of the 14-day trial, then s_c is equal to 0 and t is equal to the arithmetic average number of days each carcass remained in the study area.

Other methods currently in use calculate the number of trial carcasses remaining after the average time between impact and discovery (Jain et al 2009a) or calculate the probability that a trial carcass was not removed in the interval between searches (Arnett et al. 2010). The formula determined to be the most applicable to the Project and the most accurate at the time of analysis will be used, pending USFWS approval (USFWS 2011c). Separate carcass persistence rates will be developed for all bats and *Myotis* bats, as trial carcasses are available and as sample sizes allow. Carcass persistence will also be calculated separately by season and by vegetation cover type (such as cleared versus uncleared plots) as trial carcasses are available and as sample sizes allow. Each carcass collected during mortality surveys will be associated with a carcass persistence value specific to the season, carcass size, and cover type in which it was found.

It is expected that, as recommended by the USFWS draft guidance document (2011c), the most contemporary and most accurate equations for estimating fatality available at the time of analysis will be used. In the case that other formulas will be more appropriate, Buckeye Wind would propose to utilize those formulas for estimating unobserved mortality. The utilization of any new formulas will be made in coordination with and with the approval of the USFWS and will be based on site-specific information (see Section 6.5.2.7 – Estimating Unobserved Mortality).

6.5.2.7.3 Searchable Area

Searchable area around each turbine may vary by turbine and month; therefore, vegetation mapping will be conducted on a weekly basis to record the aerial extent of each ground cover type and respective vegetation heights. There are several methods currently available to adjust estimated mortality by searchable area, and new methods are continuously being developed (see Section 6.5.2.7 – Estimating Unobserved Mortality). In coordination with the USFWS, the method and formula determined to be most applicable to the Project and most accurate at the time of analysis will be used.

One method is to adjust mortality estimates to account for area searched and distribution of carcasses around turbines following Young et al. (2009a). Density of carcasses decreases as distance from turbines increases (Kerns et al. 2005). Therefore, an area adjustment calculates the density of carcasses within distance bands, centered on the turbine. The adjustment relates the density of carcasses within each distance band with the proportion of area searched in the same band, resulting in a factor by which estimated mortality is adjusted to account for unsearched areas.

With this example method, a multiplier, *A*, is calculated based on the percentage of area searched within circular bands of fixed radius surrounding each turbine, searcher efficiency, and numbers of carcasses found within each band. An estimate of *A* is then calculated according to the following formula:

$$A = \frac{\sum_{k'=1}^{7} \frac{c_{k'}}{p_{k'} s_{k'}}}{\sum_{k'=1}^{7} \frac{c_{k'}}{p_{k'}}}$$

- Where c_k = the number of carcasses within the kth distance band,
- p_k = searcher efficiency, and
- s_k = the proportion of area searched within the kth distance band across turbines.

Estimates of *A* are calculated separately for season and carcass type. Estimated mortality is derived by multiplying total observed mortality "*m*" (see Section 6.5.2.8.2 – Data Analysis) by *A*.

6.5.2.8 Data Collection and Analysis

6.5.2.8.1 Data Collection

The staff from the independent consultant, under the supervision of the PCM Manager, will collect and analyze mortality data. During searches, a trained surveyor will walk slowly looking for carcasses on either side of the search transect. All intact bat (and bird) carcasses or remnants of scavenged carcasses (e.g., a cluster of feathers representing more than a molt, or a patch of skin and bone) will be documented at fatalities. Surveyors will be trained by the PCM Manager to follow the appropriate protocol when performing the transect searches:

- Surveyors will be trained to walk proper transects in the appropriate time intervals within search plots (see Section 6.5.2 – Methods for Minimization Monitoring).
- For each individual carcass found, the site will be flagged and returned to after the turbine search has been completed.
- Once relocated, a photograph and GPS point will be taken of the carcass before it is moved.
- The carcass will be collected in individual re-sealable plastic bags, and the carcass identification number will be written in pencil on a piece of write-in-the-rain paper and enclosed with the carcass.
- To the extent possible, the PCM Manager will distinguish turbine-related fatalities from those that occurred as a result of collisions with MET towers, electrical collection lines, vehicles, or other sources of mortality.
- For the first 2 years, all carcass data will be recorded on the ODNR DOW's standard Fatality Reporting Form as provided in the ODNR Protocol. After the first 2 years, Buckeye Wind will use a form suitable to record all relevant data, with a preference for the Fatality Reporting Form, or some derivative thereof, to allow for consistency. Whatever form is used, the information detailed below will be recorded for each carcass or injured bat (and bird) found.
- If an injured bat is encountered, a qualified and licensed rehabilitator will be contacted by the PCM Manager as soon as possible and at least within 24 hours. All data collected for fatalities will be collected for injured bats.

Carcasses or injured animals found incidentally (i.e., in non-search areas or outside the study period) within the Action Area, either by surveyors or other site personnel, will also be documented and/or collected, but will be reported separately from those found during planned searches and will not be included in calculations of fatality estimates. If a carcass is found incidentally within a standard search area, the carcass will be left undisturbed. Operations and maintenance personnel will be instructed to notify the PCM Manager and to document incidental findings but instructed not to pick up carcasses, unless the carcass is found in a search area, in which case no action will be taken and the carcass will be left for formal searchers. The following information will be recorded for each carcass found, whether during a search or incidentally using the Fatality Reporting Form, or some derivative thereof:

- If the individual is alive, the PCM Manager should be immediately notified.
- For each deceased individual, the site should be flagged and returned to after the turbine search has been completed. Once relocated, the following data will be collected:
    - A photograph should be taken of the carcass before it is moved;
    - Date, time, and surveyor identification;
    - Location (turbine, MET tower, etc.) at which the carcass was found;
    - Search type during which the carcass was found (i.e., turbine search, MET tower search, or incidentally);
    - Distance (determined with a laser range finder) and compass direction of carcass from turbine tower, etc.;
    - GPS location of carcass;
    - Ground cover type, height, and condition (i.e., wet, dry) where carcass was found, as well as proximity to habitat features (stream, forest, wetland);
    - All other information on the "Fatality Reporting Form" should be recorded.
- The carcass should be collected in individual re-sealable plastic bags and the carcass identification number written in pencil on a piece of write-in-the-rain paper and enclosed with the carcass.

- Carcass species identification, age (juvenile or adult), sex, and reproductive condition (to the extent possible); the PCM Manager will be available to identify species as needed.
- Carcass condition (estimate of number of days decomposed, if they are live/injured, intact or scavenged and/or level of scavenging activity).
- If applicable, notes will be recorded to indicate why a carcass was not believed to be a turbine-related fatality.
- Evidence of scavenger activity (e.g., tracks or scat) in the vicinity of the carcass.

Prior to initiation of mortality searches, Buckeye Wind and its contractors will obtain the appropriate state and federal permits necessary for the collection and possession of Indiana bats (and other bats and birds), including permits for euthanizing bats if necessary. Surveyors will be trained by the PCM Manager on the proper handling of live birds and bats in the event that they are found. Any individual that handles live bats will maintain an up-to-date rabies vaccination.

During Implementation Phase monitoring years in which no formal post-construction monitoring is performed, carcasses found incidentally will be reported in a similar way. Because a PCM Manager will not be on site during non-monitoring years, incidentally found carcasses will not be collected and will not be included in calculation of fatality estimates.

If allowed under the conditions of state and federal collection permits, efforts will be made to bring live but injured animals to the closest licensed wildlife rehabilitator able to take that species. A list of local, licensed wildlife rehabilitators that are capable of accepting regional bird and bat species will be developed and provided to searchers and the PCM Manager. A qualified and licensed rehabilitator will be contacted by the PCM Manager as soon as possible and at least within 24 hours to ensure that the animal has the best chance of survival. If rehabilitator determines that successful rehabilitation is not likely, then the individual will be humanely euthanized through cervical dislocation. If the individual is a state or federal protected species, the appropriate agency will be contacted immediately upon detection of the live individual and before it is euthanized (if necessary), per the ODNR Protocol. If rehabilitation efforts are not successful, the fatality will be recorded as an incidental fatality and included in annual reports as such. It will be recorded as incidental because it will likely not be possible to confirm that the mortality was caused solely by turbine-related collision or barotraumas or if other factors contributed to the mortality.

The ODNR DOW and USFWS OH field office supervisor and project biologists will be notified within 24 hours via email if a suspected or confirmed Indiana bat carcass or other federally listed species carcass is found. All *Myotis* bats that are not suspected or confirmed to be an Indiana bat will be collected and provided to ODNR DOW and/or USFWS for inspection and identification verification. These carcasses should be frozen and given to the ODNR DOW at a prearranged date (at least annually). Bats within the *Myotis* genus are difficult to differentiate and should not be used for scavenging rate or searcher efficiency trials unless negative identification is achieved and approved by ODNR DOW and USFWS. Identification of *Myotis* carcasses will be verified by the USFWS and ODNR DOW through agreed upon means, which may include, but not be limited to, DNA testing by an appropriate lab (as determined in coordination with the USFWS), examination by a recognized expert or some other mutually agreeable method. Genetic testing may be performed if the species of a bat is unclear and it is necessary to confirm the carcass identification. Buckeye Wind may elect to conduct a DNA analysis to accurately identify a *Myotis* carcass. If any other OH endangered or threatened species is found, it will be reported to the ODNR DOW within 48 hours and arrangements will be made to deliver the carcass to the ODNR DOW.

6.5.2.8.2 Data Analysis

To estimate total annual bat and Indiana bat fatalities on a total Project, per turbine, per MW, and per rotor-swept area basis, the following data from mortality monitoring will be used:

- Number of carcasses found;
- Searcher efficiency rate, expressed as the percentage of carcasses recovered during searcher efficiency trials;
- Carcass persistence rate, expressed as the length of time a carcass is estimated to remain at a turbine and be available for detection by the searchers;
- Proportion of searchable area below each turbine; and
- Estimate of the number of carcasses that fell in unsearchable areas.

If searcher efficiency and carcass persistence rates specifically for *Myotis* bats are available, these will be used to estimate annual Indiana bat mortality.

There are a variety of estimators that have been developed to establish annual mortality at wind facilities and new methods are constantly evolving (see Section 6.5.2.7 – Estimating Unobserved Mortality). In coordination with the USFWS, the formula determined to be most applicable to the Project and most accurate at the time of analysis will be used. One example method currently in use is to estimate the probability that a carcass remains in the study area (i.e., is not scavenged) and is detected by a searcher (Erickson et al. 2004, Tidhar 2009):

$$\hat{\pi} = \frac{\bar{t} \cdot p}{I} \cdot \left[\frac{e^{\frac{I}{t}} - 1}{e^{\frac{I}{t}} - 1 + p} \right]$$

- Where *I* is the search interval (equals 1 for daily searches or 7 for weekly searches);
- *p* is the searcher efficiency rate; and
- *t* is the carcass persistence rate.

In this example, the mortality adjustment (*π*) represents the likelihood that a carcass would be found by searchers after multiple survey days, combining search interval, searcher efficiency, and carcass persistence rates. Total mortality (*m*), or the number of mortalities estimated per turbine during a survey period, can be calculated as:

$$m_i = A \cdot \frac{\overline{c_i}}{\hat{\pi}}$$

- Where *A* = the adjustment for unsearchable areas under turbines;
- *c* = the average number of fatalities documented per searched turbine; and
- *π* adjusts for searcher efficiency and scavenger removal rates.

Since there is no way to directly estimate variances for any of the available formulas, bootstrapping methods will be used to estimate 95% confidence intervals surrounding each estimate. Confidence intervals for searcher efficiency are calculated by choosing 5,000 random samples (with replacement) from the trial data set and calculating a searcher efficiency rate for each sample. Confidence intervals for carcass persistence rates are calculated by choosing 5,000 random samples (with replacement) from the trial data set and calculating a carcass persistence rate for each sample. An additional 5,000 samples of observed mortality are derived by choosing random turbines 5,000 times and summing the total number of carcasses found at each turbine in the sample. The mortality adjustment (π) and total mortality (m) are calculated for each bootstrapped sample (Erickson et al 2004).

Model results, calculated as the mortality rate per-turbine, will be used to estimate annual mortality of Indiana bats and other bat species (as well as birds, concurrently) on a total Project, per turbine, per MW, and per rotor-swept area basis. It should be noted that the mortality estimators developed for wind facilities to date have been designed to determine overall estimated mortality rates for bats for a project, rather than to determine estimates of mortality for certain species or species groups. The precision of mortality estimates increases with the number of carcasses found (Sonnenberg and Erickson 2010). Therefore, extrapolating estimated mortality from rare events can increase the uncertainty in resulting mortality estimates.

However, mortality estimate precision is improved with increased effort, increased carcass persistence, and increased searcher efficiency (Sonnenberg and Erickson 2010). The reliability of mortality estimates can also be improved by having accurate searcher efficiency and carcass persistence rates. Indiana bat mortality should be calculated based on searcher efficiency and carcass persistence rates derived specifically from Indiana bat carcasses; however, Indiana bats cannot be used for carcass trials. Therefore, searcher efficiency and carcass persistence rates for little brown, northern long-eared and big brown bats, or other appropriate non-federally and non-state listed bat species will be used as a surrogate for Indiana bats (in consultation with USFWS), if sufficient numbers of carcasses from these species are available. If insufficient numbers of appropriate surrogate bat species are available, searcher efficiency and carcass persistence rates derived from trials using all bats will be used to estimate take of Indiana bats.

Because these efforts are expected to result in reliable detection probabilities, mean estimates of annual Indiana bat mortality will be used to determine compliance with the authorized level of Indiana bat take. Further, if no Indiana bats are found during mortality searches, then estimates of Indiana bat mortality cannot be reasonably made (M. Huso, Oregon State University, personal communication) and mortality will be presumed to be zero for purposes of evaluating ITP compliance.

A report will be prepared annually containing a presentation of the information as described in the HCP Section 6.5.5 – Reporting.

6.5.2.9 Adaptive Management for Minimization Monitoring

Buckeye Wind may adjust certain parameters of the minimization monitoring as additional information becomes available. Adjustments may be based on making improvements to the Detection Probability (see Section 6.5.2.7 – Estimating Unobserved Mortality.

6.5.2.9.1 Detection Probability

Post-construction mortality monitoring is needed to document compliance with the take limits specified in the ITP. Take of Indiana bats is expected to occur rarely, approximately 5.2 times per year, across the entire 100 turbine facility. Thus, Buckeye Wind may adjust the monitoring protocol according to ongoing efforts to develop post construction monitoring approaches that improve Detection Probability (see Section 6.5.2.7

– Estimating Unobserved Mortality) and provide greater certainty that take levels did not exceed the Expected Average Mortality in monitoring years in which no Indiana bat mortality is documented[43].

Detection Probability is determined by multiplying the fraction of turbines searched (n/N), the searcher efficiency (SE), the carcass persistence rate between searcher intervals (r), and the proportion of carcasses expected to fall within the area searched (dw) (Detection Probability = n/N * SE * r * dw). Detection probability is highest (i.e., detection of dead Indiana bats is most likely) when a large percent of the turbines are searched, when searcher efficiency is high, when the search interval is shorter than the mean carcass persistence time, and when searches occur within a large percent of the area where carcasses are expected to fall. By applying the best scientific information available on the four factors described above, a monitoring protocol with a high probability of detecting rare events could be generated.

Buckeye Wind may modify the Evaluation or Implementation Phase post-construction mortality monitoring protocol in order to improve the likelihood of detecting Indiana bat mortality as compared to the Method for Minimizing Mortality described in Sections 6.5.2.1 to 6.5.2.6. Any modification to the post-construction monitoring methodology will be implemented with the approval of USFWS and ODNR DOW. Potential amendments to the post-construction monitoring include:

- Searcher frequency could be adjusted as a result of scavenging trials conducted at the site. The purpose would be to identify the mean carcass persistence time (r) and adjust searcher frequency to be less than that. This adjustment, along with adjustments to other parameters, should increase overall Detection Probability, or Probability of Miss goals in Section 6.5.3.2 - Expected or Less than Expected Average Mortality of Indiana Bats in Year-1 are met.
- The Search Area could be reduced to a search radius in which a significant portion of bat carcasses have been documented if other parameters are adjusted such that overall Detection Probability is increased, or Probability of Miss goals in Section 6.5.3.2 - Expected or Less than Expected Average Mortality of Indiana Bats in Year-1 are met.
- Vegetation clearing (e.g., mowing or herbiciding) could occur at most or all turbines within the Search Area (compared to 25% of turbines within the search area as is currently proposed), to significantly increase SE, if other parameters are adjusted such that overall Detection Probability is increased, or Probability of Miss goals in Section 6.5.3.2 - Expected or Less than Expected Average Mortality of Indiana Bats in Year-1 are met..
- The number of turbines searched could be reduced if other parameters are adjusted such that overall Detection Probability is increased, or Probability of Miss goals in Section 6.5.3.2 - Expected or Less than Expected Average Mortality of Indiana Bats in Year-1 are met.

Adaptive Management actions described in this section may be implemented at any point during the ITP Term with USFWS and ODNR DOW approval.

[43] If 1 or greater Indiana bat mortality is documented, the estimates of total Indiana bat mortality described in Section 6.5.2.7 – Estimating Unobserved Mortality adequately estimate total Indiana bat mortality.

6.5.2.9.2 Results of Post Construction Monitoring

Buckeye Wind will adjust monitoring protocol according to the results of the first 2 years of Evaluation Phase monitoring. Specifically, adjustments to Survey Period, survey frequency and Search Area will be made.

During the initial Evaluation Phase, mortality searches will be conducted for approximately 32 consecutive weeks within 3 seasonal periods that correspond to unique seasonal behaviors of Indiana bats: spring (1 Apr to 31 May), summer (1 Jun to 31 Jul), and fall (1 Aug to 15 Nov). The fall monitoring period here is longer than the fall season discussed in Section 1.1 – Overview and Purpose of the HCP and elsewhere to be consistent with ODNR protocol. After 2 years of study, if no Indiana bat carcasses are documented at the site after 31 October, and if less than 5% of all documented bat carcasses occur after 31 October, the monitoring period will be shortened to end on 31 October. The monitoring period will not be shortened such that it would end earlier than the latest discovery of an Indiana bat. If the monitoring season is shortened to end on 31 October in the Evaluation Phase, any Re-evaluation Phase monitoring will also end on 31 October.

At each searched turbine, north-south oriented transects will be established every 5 m (16 ft). The length of transects and the perpendicular distance that transects will extend from the turbine base will be equal to twice the blade length of the turbine being searched, resulting in a search area with radius of 100 m (328 ft). If no adjustments to the search area were made related to the Detection Probability as described in Section 6.5.2.9.1 above, then after 1 calendar years of monitoring during the complete monitoring period, the search area may be adjusted to the distance within which 90% of all bat carcasses, or 100% of Indiana bat carcasses are found, whichever is greater.

A minimum of 200 searcher efficiency trials and 50 carcass persistence trials will be conducted during monitoring, subject to carcass availability. However, the more successful the Project is at minimizing mortality, the more difficult it will be to obtain sufficient carcasses for trials. Further, sensitive species cannot be used for trials, so if additional bat species become federally or state listed during the course of Project operation, then these carcasses will be unavailable for trials. Finally, given the yearly spread of WNS it may not be advisable to import carcasses from other sources.

If a sufficient number of trial carcasses cannot be obtained from on-site mortality, then Buckeye Wind will attempt to obtain carcasses from outside sources. Buckeye Wind will first consult with the USFWS and ODNR DOW to identify whether either agency has a source of additional carcasses. If not, Buckeye Wind will attempt to find a source of additional carcasses from other sources, such as academia, the Ohio Department of Health, or other wind facilities, as long as precautions can be followed to avoid potential spreading of WNS. These precautions will follow USFWS and ODNR Protocol. If nothing else is available, non-bat surrogates may be used if necessary in coordination with USFWS and ODNR DOW.

6.5.3 Adaptive Management for Minimization

Based on the best scientific information available, Buckeye Wind expects this HCP to achieve the goals and objectives set forth in Section 1.2 – Biological Goals and Objectives of the HCP. However, since there have been only 3 documented cases of Indiana bat mortality due to wind turbines, uncertainty exists regarding Project impacts to Indiana bats. Therefore, implementation of this HCP will adopt an adaptive management approach. A key aspect of adaptive management will be the "systematic acquisition of reliable information" (Wilhere 2002), which will be used to refine the management of the Project over time. In accordance with the Five-Point Policy (65 Fed. Reg., 35241-35257), information collected through the monitoring program will be used to examine the effectiveness of minimization measures and to develop alternative strategies to refine management actions over time. By integrating new information as it becomes available, adaptive management will be used to help reduce uncertainty in the effectiveness of avoidance and minimization measures and maximize protection of Indiana bats.

Currently, key uncertainties exist regarding wind power and Indiana bats in the following areas: which cut-in speed(s) reduces mortality to the maximum extent practicable; the weather conditions that influence mortality; the exact dates and the extent to which key seasonal periods influence risk to Indiana bats; and, the extent to which locating turbines in various habitat categories influences risk. Buckeye Wind proposes to monitor the factors relating to each of these uncertainties, as described in the previous section, in conjunction with post-construction mortality monitoring. The results of post-construction monitoring will be analyzed to document relationships between mortality and any of the above uncertainties. Based on the findings of post-construction monitoring and monitoring of these additional factors, the feathering regime will be adjusted as prescribed below.

Mortality monitoring will be the primary method used to acquire new information about Project effects, and adaptive management decisions will be made within the context of the take thresholds defined in Section 5.1.2.5.3 – Estimated Take with Feathering. Broadly speaking, results of the Evaluation Phase could range from Less than Expected Average Mortality of Indiana bats (i.e., 5.2 or less per year) to Greater than Expected Average Mortality of Indiana bat mortality (i.e., greater than 5.2 per). If Greater than Expected Average mortality is observed in any single year, adaptive management will be implemented to bring mortality to Expected or Less than Expected Average (i.e., 5.2 or fewer Indiana bats) in order to maintain mortality to within authorized 5-year and 30-year annual take levels. Because mortality rates can vary seasonally as well as spatially, and a complex matrix of possible mortality patterns could be observed, a range of possible adaptive management actions may be employed based on an evaluation of impacts to the Indiana bat:

- Adjusting cut-in speeds based on Indiana bat mortality rates;
- Adjusting cut-in speeds based on mortality rates as they correlate to weather conditions (wind speeds, temperature, barometric pressure and humidity;
- Adjusting cut-in speeds based on mortality rates as they correlate to habitat categories;
- Based on the temporal distribution of mortality rates, modifying the seasonal timing of feathering (i.e., the dates that define each season) and/or the cut-in speeds in particular seasons;
- Changing specific turbines subject to feathering; and
- Changing specific turbines included in Implementation or Re-evaluation Phase monitoring.

6.5.3.1 Adaptive Management Criteria

At the end of Year-1 of the Evaluation Phase, annual mortality of Indiana bats will be calculated. To calculate the estimated Indiana bat take number from the results of monitoring, a correction factor using searcher efficiency and carcass removal rates and searchable area will be used (see Section 6.5.2.7 – Estimating Unobserved Mortality). Confidence intervals will indicate the degree of precision associated with estimates of annual mortality; however, adaptive management decisions will be based on the average annual mortality estimate and not on the confidence intervals surrounding it. Adjustments to the feathering plan may be implemented during subsequent years of the Evaluation Phase based on the results of the monitoring efforts and as appropriate to meet the Biological Goal and Objectives 1, 3 and 4, as described in the following sections. Typically, adjustments to the feathering plan will be based on estimated mortality levels from observed levels corrected for unobserved mortality as described in Section 6.5.2.7 – Estimating Unobserved Mortality. However, if observed Indiana bat mortalities are higher than expected, trigger points for adaptive management will be used to indicate the need for immediate action before end of the year estimates for unobserved mortality can be made and will use raw data rather than the estimated mortality levels. If trigger point adaptive management is implemented in any year (see Section 6.5.3.4 – Trigger Point for Immediate Adaptive Management), the following year will proceed as if Greater than Expected Average mortality was observed in Year 1 (increase cut-in speeds and proceed with at least 2 more years Evaluation Phase monitoring [see Section 6.5.3.3 – Greater than Expected Average Mortality of Indiana Bats in Year 1]).

Since it is not expected that significant numbers of Indiana bat carcasses will be documented, some adaptive management will be informed by observations of other *Myotis* species. While the correlation between Indiana bat mortality and overall *Myotis* mortality has not been definitively established, it is expected that there are substantial similarities within the species group and the use of *Myotis* mortality data will provide additional confidence for adaptive management decisions in the absence of significant numbers of Indiana bat carcasses.

6.5.3.2 Expected or Less than Expected Average Mortality of Indiana Bats in Year-1

If Expected or Less than Expected Average Take is estimated to have occurred during Year-1 based on post-construction mortality monitoring data (i.e., 5.2 Indiana bats or less estimated), cut-in speeds can be reduced by 0.5 m/s for Year-2 at all turbines. Buckeye Wind may also choose to maintain the same cut-in speeds for Year-2 (Figure 6-1). Buckeye Wind will not reduce cut-in speeds if no Indiana bat mortality is documented and the Probability of Miss is greater than 0.10 (See Section 6.5.2.7 – Estimating Unobserved Mortality, not depicted in Figure 6-1).

If Expected or Less than Expected Average mortality is again estimated at the conclusion of Year-2, the Project could enter the Implementation Phase of monitoring using the Year-2 cut-in speeds, or cut-in speeds can again be adjusted an additional 0.5 m/s downward during Year-3 at all turbines, followed by an additional year (Year-3) of Evaluation phase monitoring. This annual reduction of cut-in speeds can be continued as long as Expected or Less than Expected Average mortality levels are calculated. However, a minimum of 1 additional year of Evaluation Phase-level monitoring will be conducted for any adjusted feathering level to verify its effectiveness prior to the initiation of the Implementation Phase.

If no Indiana bat mortality is detected in Year-1 or Year-2, and if Probability of Miss in Year-1 is greater than 0.10 but less than 0.20 and Probability of Miss in Year-2 is less than 0.20, Buckeye Wind may reduce cut-in speeds by 0.5 m/s. A minimum of 1 additional year of Evaluation Phase-level monitoring will be conducted to verify effectiveness of reduced cut-in speeds prior to the initiation of the Implementation Phase.

If, after 2 years of Evaluation phase monitoring, or after any additional year of Evaluation phase monitoring, mortality patterns suggest certain factors pose significantly less risk to Indiana bats, additional adaptive management actions could be implemented:

- **Seasonal Considerations:** If it is observed that between 0% and 5% of the cumulative number of all documented Indiana bat fatalities occurs in any season(s) and less than 10% of the cumulative number of all *Myotis* fatalities is also documented in the same season (not limited to just 1 season), cut-in speeds can be reduced by 0.5 m/s within that season(s).

- **Habitat Considerations:** If it is observed that between 0% and 5% of the cumulative number of all documented Indiana bat fatalities occurs in 1 habitat category, and less than 10% of the cumulative number of all *Myotis* fatalities is also documented in the same habitat category, cut-in speeds can be reduced by 0.5 m/s within that habitat category.

  - For example, if 65% of all turbines are located in habitat Category 4, cut-in speeds could be reduced if 3.25% (65% x 5%) or less of all observed Indiana bat mortality and 6.5% (65% x 10%) or less of all observed *Myotis* mortality is observed for all Category 4 turbines.

- **Weather Considerations:** If it is observed that 0% of all documented Indiana bat fatalities occurs above or below any particular extreme in any one weather condition, and less than 5% of the cumulative number of all *Myotis* fatalities is also documented beyond the same weather extreme, cut-ins speeds can be reduced by 0.5 m/s beyond that weather extreme. The evaluation and any adaptive management actions that would adjust cut-in speeds will be implemented on a season specific basis. Specific weather conditions that will be monitored include:
  - Wind speed
  - Barometric pressure
  - Temperature
  - Humidity

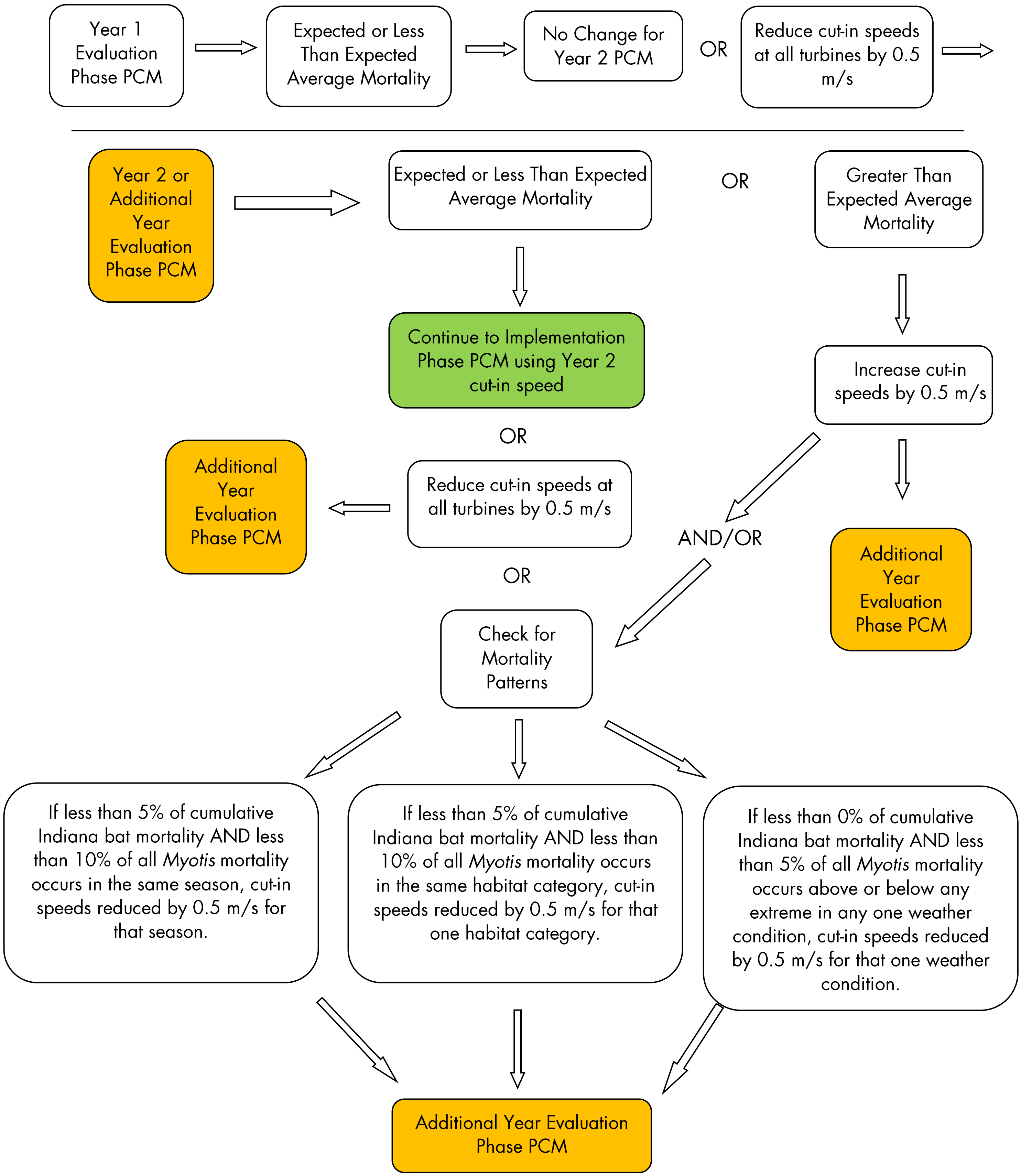

Figure 6-1. Adaptive management decisions for Expected or Less Than Expected average mortality of Indiana bats in Year 1.

Any adjustments will be followed by an additional year of Evaluation phase monitoring. If subsequent Evaluation phase monitoring indicates that Expected or Less than Expected Average mortality occurs with implementation of adaptive management, the adjusted cut in speeds will be utilized throughout the Implementation phase. If Greater than Expected Average mortality occurs, the feathering plan will revert to the previous levels and an additional year of Evaluation phase monitoring will occur to confirm that the mortality levels have returned to Expected Average or Less Than Expected Average levels. Implementation Phase monitoring will not begin until at least 1 year (and 2 years total) of Expected or Less Than Expected Average has been recorded. In no instance will the cut-in speeds of any particular turbine be decreased by more than 0.5 m/s in any one year.

6.5.3.3 Greater than Expected Average Mortality of Indiana Bats in Year-1

If Greater than Expected Average annual Indiana bat mortality (i.e., more than 5.2 Indiana bats) is estimated to occur during Year-1 based on the post-construction mortality monitoring data, or at any point during the monitoring year, but the triggers for immediate adaptive management as specified in Section 6.5.3.5 are not reached, then cut-in speeds at all turbines will be immediately raised by 0.5 m/s. The increased cut-in speeds will apply to all turbines during Year-2 unless mortality patterns suggest certain factors pose significantly less risk to Indiana bats (Figure 6-2):

- **Seasonal Considerations:** If it is observed that between 0% and 5% of the cumulative number of all documented Indiana bat fatalities occurs in any one season and less than 10% of the cumulative number of all *Myotis* fatalities is also documented in the same season (not limited to just 1 season), cut-in speeds can remain unchanged within that season for Year 2 Evaluation phase monitoring.

- **Habitat Considerations:** If it is observed that between 0% and 5% of the cumulative number of all documented Indiana bat fatalities occurs in 1 habitat category, and less than 10% of the cumulative number of all *Myotis* fatalities is also documented in the same habitat category, cut-in speeds can remain unchanged within that habitat category for Year 2 Evaluation phase monitoring.
  - For example, if 65% of all turbines are located in habitat category 4, cut-in speeds could remain unchanged if 3.25% (65% x 5%) or less of all observed Indiana bat mortality and 6.5% (65% x 10%) or less of all observed *Myotis* mortality is observed for all category 4 turbines.

- **Weather Considerations:** If it is observed that 0% of all documented Indiana bat fatalities occurs above or below any particular extreme in any one weather condition, and less than 5% of the cumulative number of all *Myotis* fatalities is also documented beyond the same weather extreme, cut-ins speeds can be reduced by 0.5 m/s or remain unchanged beyond that weather extreme. The evaluation and any adaptive management actions that would adjust cut-in speeds will be implemented on a season specific basis. Specific weather conditions that will be monitored include:
  - Wind speed
  - Barometric pressure
  - Temperature
  - Humidity

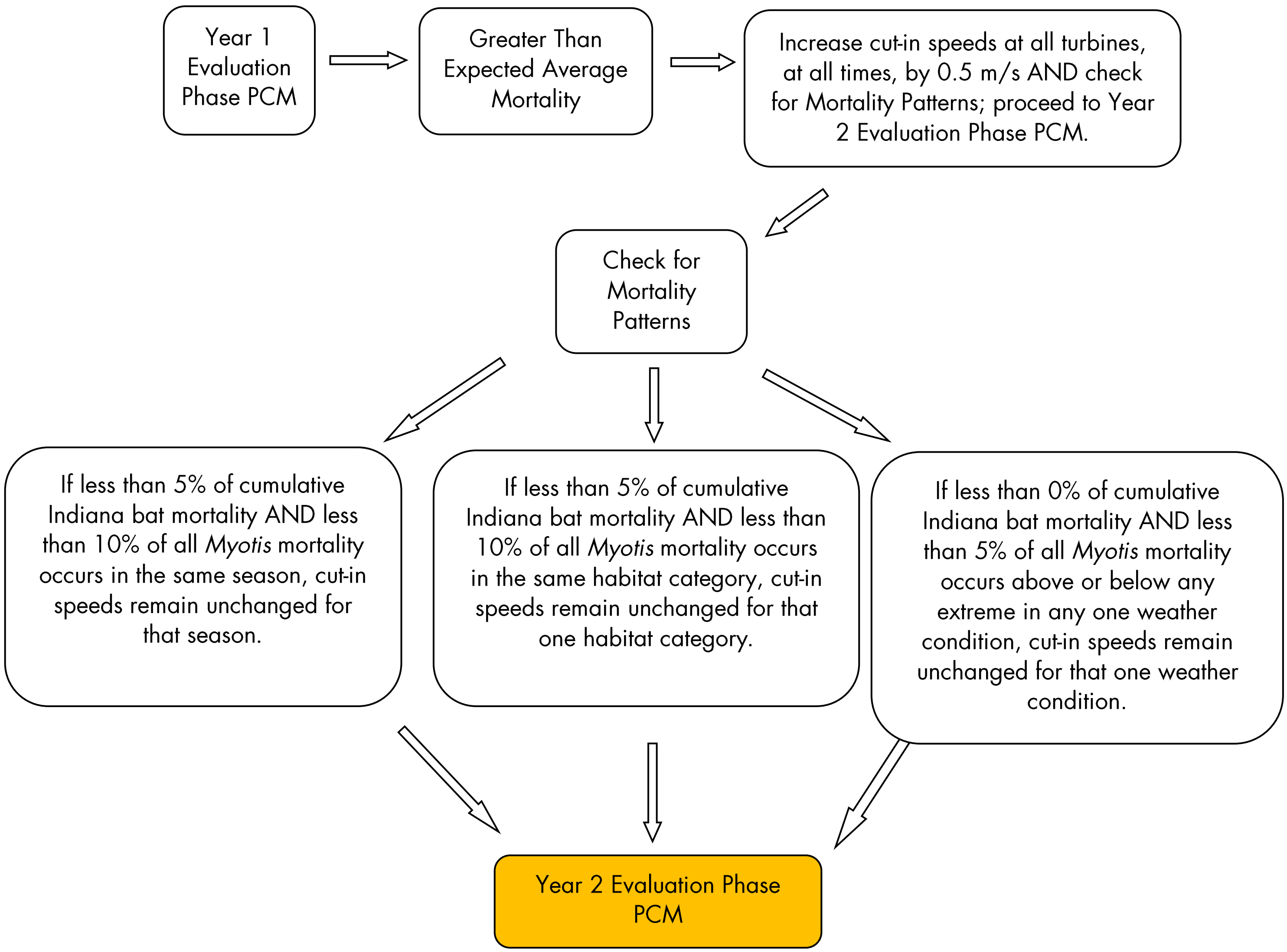

Figure 6-2. Adaptive management decisions for Greater Than Expected average mortality of Indiana bats in Year 1.

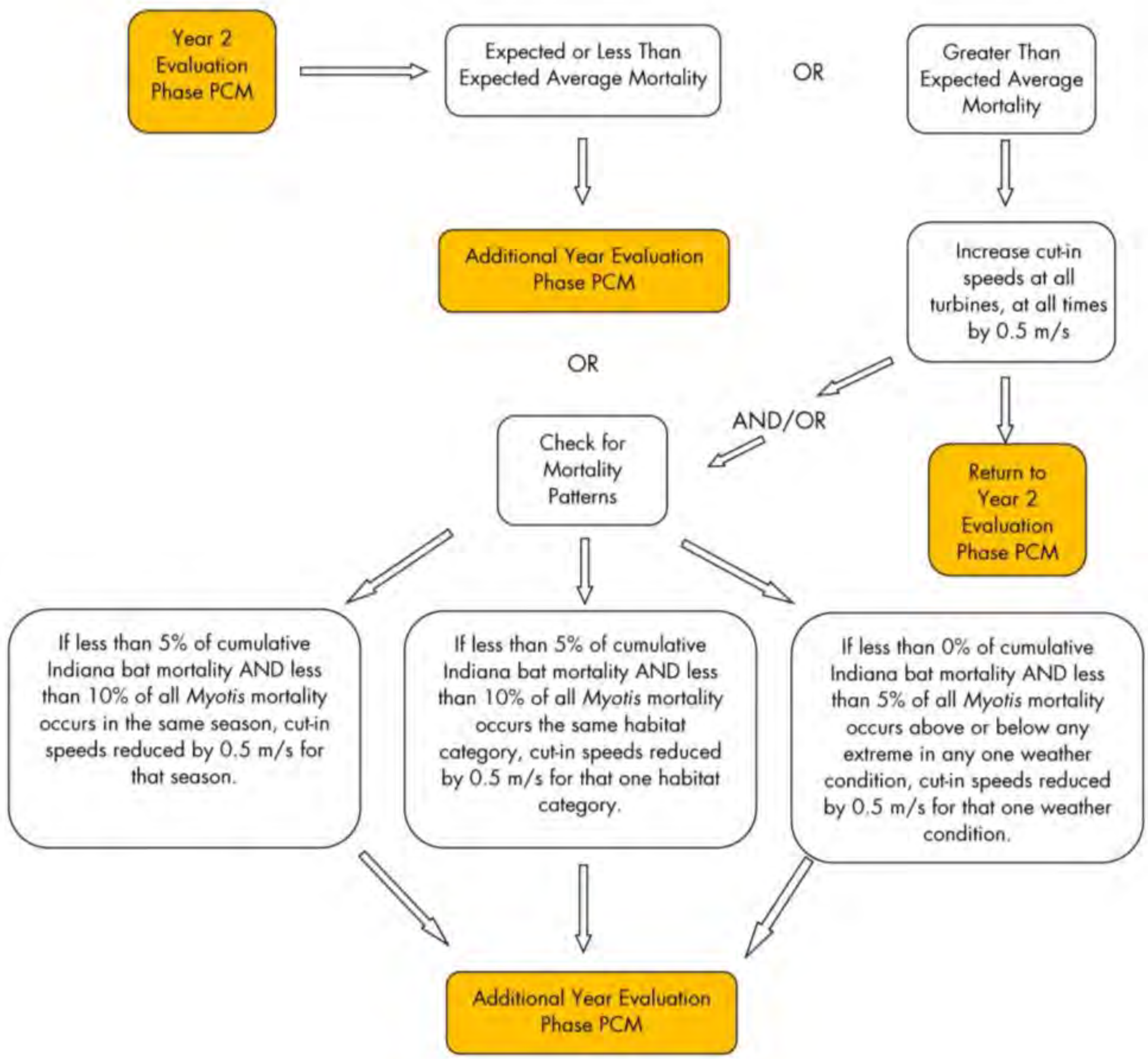

Figure 6-3. Adaptive management decisions for Greater Than Expected average mortality of Indiana bats in Year 2.

If Greater than Expected Average annual mortality is again estimated to have occurred at the conclusion of Year-2, or at any point during the monitoring year, cut-in speeds will again be increased by 0.5 m/s at all turbines and during all seasons, again unless mortality patterns suggest certain factors pose significantly less risk to Indiana bats as described above (Figure 6-3). This upward adjustment to the feathering plan and subsequent Evaluation phase monitoring will continue every year that Greater than Average Expected mortality is observed and until Expected or Less Than Expected mortality is achieved. In no instance will the cut-in speeds of any particular turbine be increased by more than 0.5 m/s in any one year, unless trigger point adaptive management requires additional adjustment (see Section 6.5.3.4 – Trigger Point for Immediate Adaptive Management).

Once Expected or Less than Expected Average mortality is achieved and the most effective feathering plan is decided upon at the conclusion of a given Evaluation Phase year, a minimum of 1 additional year of Evaluation Phase-level monitoring will be implemented to verify the effectiveness of the new feathering plan, prior to the initiation of the Implementation Phase (Figure 6-4), unless mortality patterns suggest certain factors pose significantly less risk to Indiana bats and Buckeye Wind chooses to implement further adjustments to cut-in speeds (see Figure 6-3).

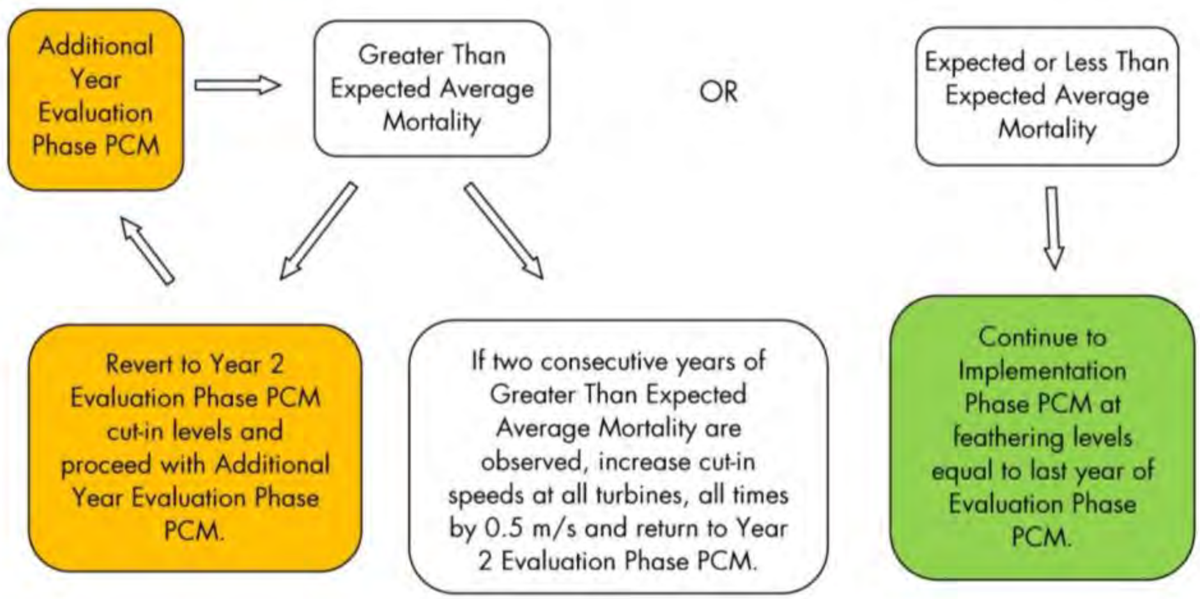

Figure 6-4. Adaptive management decisions for Greater Than Expected average mortality of Indiana bats, Additional Evaluation Phase.

6.5.3.4 Trigger Point for Immediate Adaptive Management

During any year of post-construction monitoring, observed Indiana bat mortality rates may trigger the need for immediate adaptive management. If 2 Indiana bat mortalities are documented at the site before the fall season, cut-in speeds will be increased by 1.0 m/s at all turbines for the remainder of the active period (Figure 6-5). Any additional documented Indiana bat mortality before the fall season or 2 additional fatalities during the fall season will result in all turbines being operated with a cut-in speed of 7.0 m/s. After the cut-in speeds are increased to 7.0 m/s, if additional Indiana bat mortality is documented all turbines will be turned off from 1 hour before sunset to 1 hour after sunrise for the remainder of the active period.

If less than 2 Indiana bat mortalities are documented before the fall season, 2 Indiana bat mortalities in the fall season will trigger immediate adaptive management. If no Indiana bat mortalities are documented before the fall season and 3 Indiana bat mortalities are documented at the site during the fall season, immediate adaptive management will be triggered. In either scenario cut-in speeds will be increased by 1.0 m/s for the remainder of the active period. Any additional documented Indiana bat mortality will result in all turbines being operated with a cut-in speed of 7.0 m/s. If additional Indiana bat mortality is documented, all turbines will be turned off from 1 hour before sunset to 1 hour after sunrise for the remainder of the active period.

Without knowing the scavenger rate and searcher efficiency correction factors at this time, it is not possible to predict how many "estimated" Indiana bats would be calculated from a particular number of "observed" Indiana bats. However, once a "trigger point" is reached, adaptive management is designed to identify when "observed" Indiana bats would indicate exceptionally high numbers of "estimated" Indiana bats and to ensure that the elevated take does not occur in any one year. If a trigger event occurs in any year, adaptive management will be applied the following year according to the procedure following Greater than Expected Average mortality as described in section 6.5.3.4 – Greater Than Expected Average Mortality of Indiana Bats in Year-1.

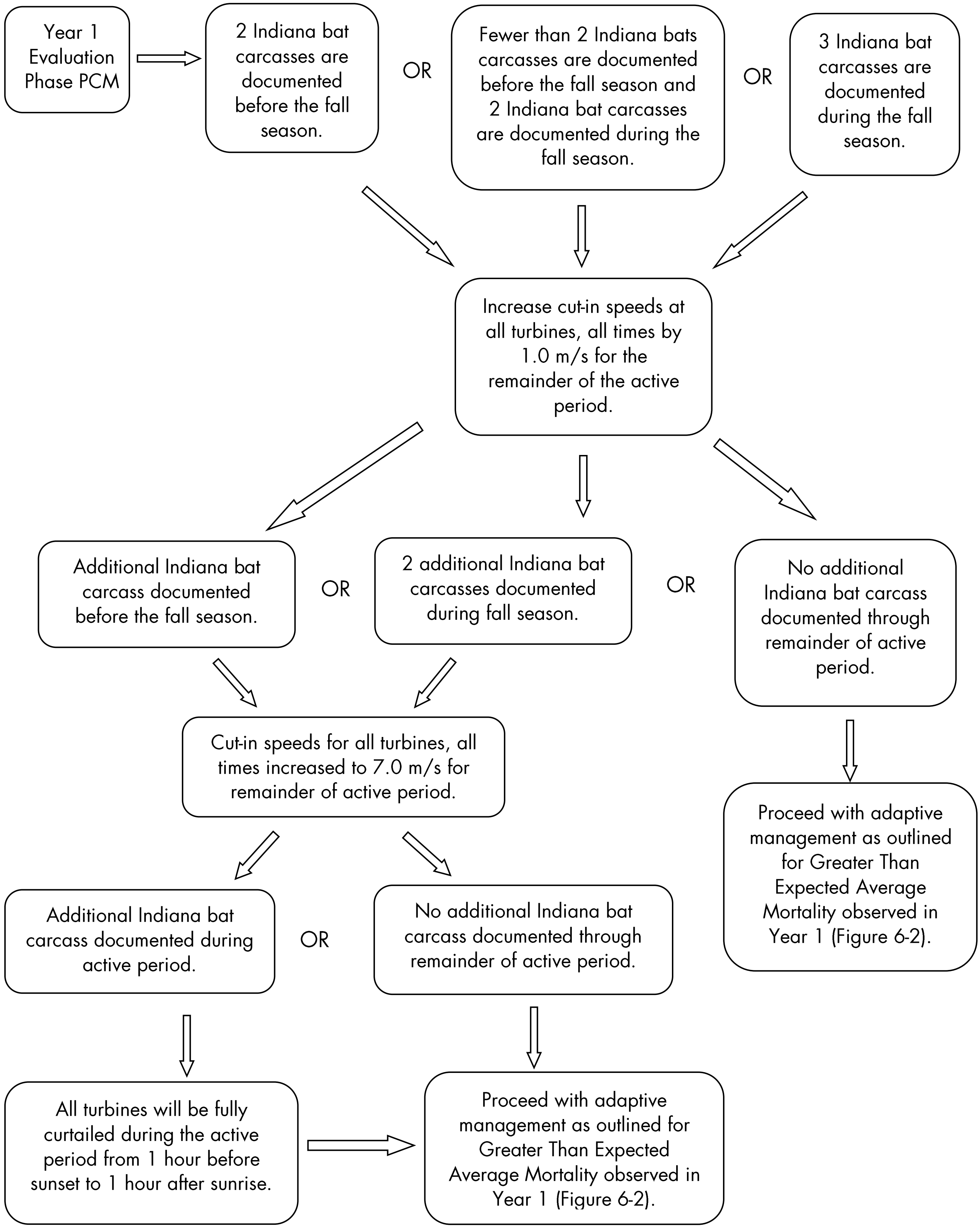

Figure 6-5. Within-season Trigger Points for adaptive management.

6.5.3.5 Implementation Phase Adaptive Management

After the Evaluation Phase monitoring, efforts will be made to continue meeting the Biological Goals and Objectives 1, 3 and 4. Results of Implementation phase monitoring, as well as other factors, may be used to incorporate adaptive management actions, resulting in the need for a Re-evaluation Phase. There are 3 circumstances that could result in adaptive management and re-evaluation:

1) If Greater than Expected Average Mortality is estimated for any monitoring year without reaching trigger points for immediate adaptive management (see Section 6.5.3.4 – Trigger Point for Immediate Action), post-construction monitoring will be conducted in the subsequent year.
    a. If the Greater than Expected Average Mortality is again estimated, Re-evaluation would be warranted. Re-evaluation will enter a Year 2 Evaluation phase process as if Greater than Expected mortality was observed in Year 1 (see Section 6.5.3.3 – Greater than Expected Average Mortality of Indiana Bats in Year-1), including an increase in cut-in speeds of 0.5 m/s at all turbines, unless mortality patterns suggest otherwise (see Figure 6-2).
    b. If in that subsequent monitoring year, Expected or Less than Expected Average Mortality is estimated, the Implementation Phase will continue without Re-evaluation Phase, beginning with a year that does not include post-construction monitoring.

2) If in any year trigger points for immediate action are reached (see Section 6.5.3.4 – Trigger Point for Immediate Action), adaptive management will proceed as described in Section 6.5.3.5, and enter a Year 2 Evaluation phase process as if Greater than Expected mortality was observed in Year 1 (see Section 6.5.3.3 – Greater Than Expected Average Mortality of Indiana Bats in Year-1).

3) Results of Implementation Phase monitoring indicates that certain factors contribute more or less risk to Indiana bats: Continued monitoring of the potential mortality factors could provide more confidence in the observations and criteria for adjustments to cut-in speeds due to seasonal, habitat and weather considerations may become apparent. In this case, Buckeye Wind could elect to apply adaptive management, which would require Re-evaluation phase monitoring to verify that Biological Goals and Objectives are still met. Re-evaluation phase monitoring in this case would occur for 2 years. If Expected or Less Than Expected Average Mortality of Indiana bats is estimated for both years, and the Probability of Miss is less than 0.10 if no mortality is detected in one of those years, or less than 0.20 if no mortality is detected in either year, the Project would re-enter Implementation phase monitoring. If Greater Than Expected Average Mortality of Indiana bats is estimated in either year, Buckeye Wind could elect to either revert to previous cut-in speeds and re-enter Implementation phase monitoring, or proceed as stipulated in Section 5.5.3.3 - Greater Than Expected Mortality of Indiana bats in Year-1.

4) New techniques or new information are developed that can help reduce Indiana bat mortality (see Section 7.2.1.9 – Use of New Methods, Information, or Technical Advances): The wind industry is committing substantial resources toward identifying risk factors and possible minimization approaches to reduce impacts to Indiana bats along with all bat species. If new techniques are proven through the work of non-Project specific studies, Buckeye Wind and the USFWS will work together to determine if those new techniques can be incorporated while also

ensuring that the Biological Goal and Objectives 1, 3, and 4 are still met. Re-evaluation in this case would follow the same path as the Evaluation phase monitoring prescribed, beginning with Year 1 Evaluation phase PCM.

6.5.3.6 Special Cases

This feathering plan will be maintained as long as Expected or Less Than Expected mortality is documented, or until advancements in avoidance and minimization methods are developed that warrant Re-evaluation. New avoidance and minimization methods will be implemented within a Re-evaluation Phase with approval from the USFWS (see Section 7.2.1.9 – Use of New Methods, Information, or Technological Advances).

Based on documented mortality and estimated take levels, Buckeye Wind may, at its discretion, opt to increase cut-in speeds above those described above in order to ensure compliance with permitted take limits. Particular adaptive management measures may include:

- Increased cut-in speeds at turbines or turbine groups that appear to have particularly high mortality levels.
- Increased cut-in speeds above the increments indicated above, up to and including selective nightly shut downs.

No reduction in cut-in speeds will be initiated without meeting the conditions of the adaptive management plan outlined above and without coordination with the USFWS.

6.5.4 Monitoring for Mitigation

The second biological goal described in Section 1.2 – Biological Goals and Objectives of the HCP pertains to promoting the health and viability of Indiana bat populations both locally and in the Midwest RU. There is 1 biological objective which describes measureable targets needed to achieve this goal:

Objective 2: Mitigate for the impacts of the incidental taking of 130.0 Indiana bats over the 30-year ITP Term through the purchase or easement acquisition and subsequent restoration and/or enhancement (if necessary), with permanent preservation of 87.8 ha (217.0 ac) of suitable Indiana bat habitat within 11.2 km (7 mi) of a P2 Indiana bat hibernaculum in OH (see Section 6.3 – Mitigation Measures for more details).

Monitoring will document the location, quantity, and landcover of each mitigation site, and any restoration or enhancement actions that have occurred at the mitigation site to date. After acquisition of mitigation land or establishment of conservation easements on mitigation land, and enhancement or restoration of mitigation sites to meet the criteria described in Section 6.3.4 – Restoration and Enhancement has occurred, habitat assessment monitoring will be used to help determine if these biological goals and objectives are continually being met by assessing the condition of potential roost trees within the mitigation site, monitoring invasive species cover, monitoring survival of planted trees, ensuring compliance with the terms of the ITP, and evaluating the effectiveness of mitigation. Mitigation is planned to be completed in 2 phases (see section 6.3.3). Consequently, mitigation monitoring for each phase will be performed in Years 1 through 5 after the mitigation has occurred and every 5th year thereafter until the end of the ITP Term. If funding to an approved mitigation bank is used for any portion of the mitigation, and that mitigation bank has established a USFWS approved monitoring program, mitigation monitoring for that portion of mitigation may be deferred to the mitigation bank with USFWS and ODNR DOW approval (see Section 7.3.4 – Change in Mitigation Acres).

Monitoring will be completed by a third party contractor with knowledge of Indiana bat habitat requirements. Buckeye Wind will issue a Request for Proposals to select an appropriate contractor to perform the work. Upon selecting a preferred contractor based on costs and qualification, Buckeye Wind will provide the winning bid to the FWS and to ODNR DOW for approval.

Monitoring will generate a variety of data on existing and planted trees within the mitigation area. These data will be used to assess the density of potential roost trees per acre and the success of tree planting and girdling activities in order to inform the adaptive management plan discussed in the following section. Mitigation areas will be monitored by photographing the area, assessing the quality of roosting and foraging habitat by enumerating the number of suitable roost trees, documenting the state of understory vegetation (e.g., cluttered or open) and percent invasive non-native woody cover, and measuring survival and growth of planted riparian vegetation or trees. Potential roost trees, planted trees, and trees selected for girdling will be photographed and the following characteristics will be measured:

- dbh,
- Tree species;
- Tree height;
- Canopy class (e.g., emergent, dominant, midstory, suppressed);
- Decay stage (e.g., alive, declining, dead, loose bark, no bark, broken top);
- Percent exfoliating bark available for roosting;
- Type of roosts available (e.g., cavities, exfoliating bark, or splits); and
- Canopy closure at 4 cardinal directions as measured by a densiometer.

6.5.4.1 Adaptive Management for Mitigation

Based on the best scientific information available, Buckeye Wind expects this HCP to achieve the goals and objectives set forth in Section 1.2 – Biological Goals and Objectives of the HCP. Further, mitigation actions will be based on the outcome of actions during previous years. Therefore, implementation of mitigation actions will adopt an adaptive management approach that will begin 1 year after implementation of mitigation actions at each mitigation site. Adaptive management actions will be implemented if during any monitoring year, any mitigation site fails to meet 1 or more of the restoration and enhancement criteria described in Section 6.3.4 – Restoration and Enhancement.

Within areas to be preserved, it is expected that there will be existing forest which may contain snags. During any habitat assessment year, if there are less than 2 small snags, 5 medium snags, and 2 large snags per acre on average, then assessment results will be used to decide whether to girdle existing trees. If there are the appropriate numbers of living trees in each size class, and they are species found in Appendix L of the PEP Guidelines (USFWS 2009b), then these trees may be girdled to create snags. Success of tree girdling will be assessed in the following survey year. If there are the appropriate numbers of potential roost trees, but there are insufficient numbers of medium and large dbh trees, then potential roost trees will be identified and will be revisited for girdling once they are of sufficient dbh.

In unwooded corridors or where tree density is deficient, tree planting will be used to restore Indiana bat swarming, foraging, and roosting habitat. Assuming a 70% survival rate (Davis et al. 2010), approximately 430 stems/ac will be planted to achieve no less than an average of 300 stems/ac/PA. Following planting, Year 2 habitat assessments will determine whether an average of 300 stems/ac/PA have survived. If not, the ratio of surviving stems to total stems planted will be calculated to determine the stem survival rate. The actual survival rate will be used to determine the number of trees necessary to plant in Year 2 in order to achieve an average of 300 stems/ac/PA in Year 3. For example, if an average of 430 stems/ac/PA are planted in Year 1, and an average of 258 stems/ac/PA, survive to Year 2, the result is a success rate of

60%. In order to achieve an average of 300 stems/ac/PA, 42 (300 minus 258) additional stems/ac/PA need to survive. Since a 60% survival rate of trees planted in Year 1 was observed in Year 2, an additional 70 stems/ac/PA, on average (42 divided by 0.6), will be planted in Year 2 (see Section 6.3.4 – Restoration and Enhancement for more information).

Yearly habitat assessments will occur in Years 1 to 5, or until an average of 300 stems/ac/PA have survived. After Year 5, or after at least an average of 300 stems/ac/PA, have been established (whichever is greatest), habitat assessments will be conducted every 5 years to ensure continued survival of planted trees, and to enumerate the number of trees within each size class described above. If non-native woody invasive are preventing adequate survival of trees, the understory will be cleared, outside the active period, in order to allow adequate survival. .

Results of each habitat assessment will be analyzed to determine if woody invasive species cover remains below 5% at each mitigation site. If woody invasive species cover exceeds 5% at any mitigation site in any monitoring year, control methods including manual pulling and digging and herbicides will be used to reduce cover to below 5%.

6.5.5 Reporting

Buckeye Wind will implement this monitoring program in consultation with USFWS and ODNR DOW. An annual report describing methods and results of mortality and mitigation monitoring will be submitted to the ODNR DOW and USFWS by 31 December of each calendar year that monitoring is actively conducted. Buckeye Wind will also provide summaries of spring and summer Indiana bat mortality to the USFWS at the end of each of these seasons to inform potential adaptive management according to Section 6.5.3 – Adaptive Management for Minimization. Intermittent construction reports will also be submitted as new turbines are erected.

Intermittent Construction Reports will include:

- A written notification of the turbine number, location, and date placed in commercial operation for each turbine(s). This notification will be submitted at least 30 days prior to the turbine(s) being placed in commercial operation.
- A calculation of the extrapolated annual, 5-year, and total take allowance, as well as any annual trigger points, for the total Project including all turbines in commercial operation at that time (see Section 5.1.2.5.3 – Estimated Take with Feathering, under *Phasing Considerations for Take Allowance*). This report will be submitted within 30 days of the turbine(s) being placed in commercial operation.

Seasonal Reports will include:

- Quantity and species composition of observed bat mortality, including Indiana bat mortality during reporting period (bird mortality will also be reported);
- Review of adaptive management measures implemented, if any, in response to observed mortality.

Annual Reports will include:

- Quantity and species composition of observed bat mortality, including Indiana bat mortality during reporting period (bird mortality will also be reported);

- Estimates of total mortality of all bats, *Myotis* species, and Indiana bats using searcher efficiency trials, carcass persistence trials, and searchable area adjustments (estimated bird mortality will also be reported). All estimates will include 95% confidence intervals;
- An estimate of probability of detection and probability of miss if no Indiana bats are detected;
- Cumulative estimated Indiana bat mortality for entire ITP Term to date;
- Specific conditions, dates, locations, and circumstances of each observed Indiana bat mortality;
- Report on weather conditions monitored during nights preceding mortality searches and weather conditions during searches;
- Review of adaptive management measures implemented in response to observed and/or estimated mortality;
- Annual operating parameters (cut-in speeds at each turbine during each season) and compilation of mortality data as it relates to those parameters;
- Results of habitat assessment surveys at mitigation parcels, including vegetation management and mapping reports;
- Adaptive management measures implemented in response to results of habitat assessment surveys;
- Changed/unforeseen circumstances that have arisen;
- Raw carcass data of bat fatalities in Excel spreadsheet format (raw date for bird fatalities will also be provided);
- Fatality Reporting Forms;
- A calendar reflecting dates, times, and locations of searches;
- Injured bat reporting forms and rehabilitator reports (also provided for birds);
- A description of the subsequent year's monitoring efforts based on the monitoring phase and any adaptive management measures that will be implemented;
- A cost estimate of the subsequent year's monitoring, which will be reserved in a Surety to provide additional funding assurance (see Section 6.7 – Funding for the HCP). A Surety, sufficient to cover the subsequent year's monitoring costs will be established by 1 Mar of each year. Evidence of the Surety will be provided to the USFWS by 1 Mar. of each year.
- Conservation measures implemented during the report year and findings, and/or conservation measures to be implemented the following year.

Annual meetings will be held with the USFWS and ODNR DOW in January of each calendar year to review the results of the previous year's monitoring. Additional meetings may be called by either the USFWS or Buckeye Wind to discuss new information or research that may be relevant to the ongoing implementation of the monitoring plan. The primary objectives of annual meetings will be to:

- Review the results of the previous year's monitoring;
- Evaluate the effectiveness of the monitoring plan;
- Evaluate the efficacy of the feathering strategy;
- Determine whether changes to the feathering plan need to be made in the following year based on the adaptive management criteria laid out in the HCP; and
- Develop recommendations for additional avoidance, minimization, and monitoring techniques.

Annual meetings will also provide the opportunity to review:

- The population status of Indiana bats in the Midwest RU and the implications that any changes may have on the ongoing implementation of the monitoring plan;
- The listing status of other species that might be impacted by the Project;
- The status of mitigation including habitat protection, restoration/enhancement, and monitoring implemented by Buckeye Wind to offset permitted Indiana bat mortality; and

- The status of and results from research implemented as conservation measures under the HCP.

6.6 Issuance Criteria – Maximum Extent Practicable

Section 10 (a)(2)(B) and 50 CFR 17.22(b)(2) and 50 CFR 17.32 (b)(2) list 6 criteria that must be met in order for the USFWS to approve the HCP and issue an ITP (see Section 1.4.1 – Federal Endangered Species Act). In particular, 1 of the criteria is that minimization and mitigation measures must be to the maximum extent practicable.

The finding that an HCP has minimized and mitigated impacts of take to the maximum extent practicable requires consideration of 2 factors: adequacy of the minimization and mitigation program and whether it is the maximum that can be practically implemented by the Applicant. According to the Services' HCP Handbook (USFWS and NOAA 1996), "to the extent maximum that the minimization and mitigation program can be demonstrated to provide substantial benefits to the species, less emphasis can be placed on the second factor."

6.6.1 Adequacy of Minimization and Mitigation Program

To the extent that the biological goals and objectives help translate the statutory and regulatory criteria or standards into meaningful biological measures, specific to this particular HCP situation and in a manner that will facilitate monitoring (Section 1.2 – Biological Goals and Objectives of the HCP), the minimization and mitigation plan offers an adequate minimization program. The minimization plan proposed here is adequate for the following reasons:

- Operational feathering has been proven to reduce bat mortality in multiple different studies (Arnett et al. 2010, Baerwald et al. 2009, Good et al. 2011; see Section 5.1.2.5.3 – Estimated Take with Feathering).
- Buckeye Wind is proposing to implement operational feathering at turbines during the Indiana bat active period. The feathering plan will avoid and minimize Indiana bat mortality specifically from turbine operation, resulting in no more than 26 Indiana bats over any 5 consecutive year period (see Section 5.1.2.5.3 – Estimated Take with Feathering).
- Despite multiple post-construction surveys for wind power in the eastern and midwestern United States, Indiana bat mortality has been rarely documented.
- Because some uncertainties exist, mortality monitoring will document Indiana bat take levels during the ITP Term. The results of the monitoring will inform rigorous and detailed adaptive management actions that will ensure that the authorized take is not exceeded.
- Through implementation of the feathering plan, monitoring, and adaptive management, Buckeye Wind will strive to ensure the estimated average level of Indiana bat mortality will not be exceeded on an annual basis. As discussed in the Section 5.1.2.6 – Biological Significance of Incidental Take (Collision Mortality), the requested take for the Project will not preclude the Indiana bat population from expanding, both locally and within the Midwest RU.

Mitigation measures are designed to offset the impacts of the incidental take that does occur due to the Project operation. By protecting and enhancing important Indiana bat habitat, the mitigation plan will promote the health and viability of the species within the Midwest RU, as described in Objective 2. Permanent protection of areas around a P2 hibernaculum will ensure habitat for foraging and swarming and staging and therefore promote the overwinter survival and reproductive success of the species. The proposed mitigation program is therefore adequate to offset the proposed incidental take of Indiana bats.

By using the Biological goals and objectives to translate the statutory criteria into meaningful biological measures, the HCP presents an adequate minimization and mitigation plan. Benefit to the species is also demonstrated:

- Indiana bat mortality will be kept to a very low level that will not preclude the species from expanding or persisting on the Midwest RU level or within the Action Area as a result of the Project operations (Section 5.1.2.6 – Biological Significance of Incidental Take [Collision Mortality]).
- Mitigation will enhance and permanently protect suitable Indiana bat habitat in the Midwest RU during the ITP Term and beyond. Enhanced and protected habitat will improve the health and viability of the species, offsetting the impacts of the taking.
- Adaptive management will inform minimization measures that will further enhance understanding of the interaction between Indiana bats and wind turbines.
- Conservation Measures including research on Indiana bat and wind turbine interactions and/or research on fall migration behavior will enhance understanding of Indiana bat and wind turbine exposure potential during key seasonal periods during which risk is high or uncertain, which can be applied at wind facilities across the range of the Indiana bat.

6.6.2 Practical Implementation by Buckeye Wind

As the wind industry grows, projects must become more competitive in all aspects of design and operation. A wind project is not viable unless it can find an entity that will buy the electric power and the environmental attributes (renewable energy credits or RECs) for a price that allows the project investors to make an adequate return on their investments. Determination of the adequate return on investment depends on the investor’s own internal targets as well as the returns that can be realized by other projects in the industry. Costs associated with operation of a project are a key factor in evaluating the return on investment.

Costs of Minimization and Mitigation

The costs of implementing the minimization plan will negatively affect the viability of the Project. These costs result in a less competitive Project when compared to wind projects that do not have a feathering plan (cut-in speeds are equal to the manufacture’s cut-in speeds at all times during all seasons). Wind projects generate revenue based on how much energy is generated and the price of energy and RECs:

$$\text{Revenue} = \text{Energy Generated} * \text{Price of Energy} * \text{Price of RECs}$$

More restrictive operational cut-in speeds have an exponentially higher cost to the Project and can quickly begin to erode Project viability. The power in the wind that hits a wind turbine and turns the blades is given by the equation:

$$\text{Power} = \tfrac{1}{2} * \text{Rotor Swept Area} * \text{Air Density} * \text{Wind Speed}^3$$

In other words, the power hitting the turbine, and thus the power available to be converted into energy, increases by the wind speed cubed. This means that each increment of power lost at higher wind speed is exponentially larger than what is lost at lower wind speeds. Subsequently, since the Project produces revenue based on the amount of energy that is produced, the amount of lost revenue increases exponentially as the cut-in speed is increased.

Therefore, the estimated costs associated with implementation of minimization and mitigation measures proposed in this HCP can be calculated based on assumptions about Project operation (lost production due to feathering plan), price of energy and price of RECs (submitted as Confidential Business Information; CBI Report). The following estimated costs would be associated with implementation of the minimization and mitigation measures proposed in this HCP:

1) 2.50% less clean energy generated (lost production due to feathering);
2) $980,000 in lost annual revenues;
    - Lost production due to feathering * price of energy * price of RECs.
3) $24.5 million in lost revenues over the ITP Term.
    - Lost annual revenues multiplied by 25 years of operational life.
4) $1.6 million to implement the mitigation strategy presented in this HCP (see Section 6.7.2 – Mitigation).

Overall, minimization and mitigation for incidental take for Indiana bats will cost the Project approximately $26.1 million over the ITP Term as a result of the feathering plan and the mitigation plan.

If the maximally restrictive operations alternative was selected as the preferred method to reduce take of Indiana bats, the cost of minimization would be significantly greater. In the maximally restrictive operations alternative all 100 turbines would be non-operational from sunset to sunrise during the entire period over which Indiana bats are active (1 Apr to 31 Oct; Section 2.7.2.3 – Maximally Restrictive Operations Alternative). Again using base assumptions about Project operation (lost production due to maximally restrictive operating plan) and price of energy and price of RECs, this alternative would result in the following additional estimated costs to the Project:

1) 22.7% less clean energy generated as compared to the proposed feathering plan (total of 24.6% less energy generated compared to no feathering).
2) $8.65 million in lost annual revenues as compared to the proposed feathering plan (total of $9.63 million in lost annual revenue compared to no feathering).
3) $216.5 million in lost revenues over the ITP Term as compared to the proposed feathering plan ($241 million in lost revenues over the ITP Term compared to no feathering).

Buckeye Wind has proposed a minimization and mitigation plan that will provide adequate minimization and mitigation of impacts to the Indiana bat and will provide benefits to the species. Using the biological goals and objectives as a translation of the issuance criteria into meaningful biological measures, it is clear that the HCP does minimize and mitigate to the maximum extent practicable.

A minimization plan that incorporates more restrictive operational constraints would result in costs of up to $241 million over the ITP Term (a substantial increase in costs from the proposed minimization plan costs of $24.5 million). While a more restrictive operational cut-in speed may be more protective of the Indiana bat, that proposition is not certain and would place substantial additional financial burden on the Project. It is therefore not practicable to commit up to $8.65 million per year and $216.5 million over the ITP Term in additional costs, as compared to the proposed plan, for uncertain additional benefits to the species. Monitoring and adaptive management afford the opportunity for Buckeye Wind to alter the minimization plan if it proves to be inadequate. The minimization and mitigation plans proposed in Section 6.2 and Section 6.3, respectively, along with the monitoring and adaptive management approaches described in Section 6.5 represent minimization and mitigation to the maximum extent practicable.

6.7 Funding for the HCP

Under Section 10(a)(2)(A)(ii) and 10(a)(2)(B)(iii) of the ESA, an HCP submitted in support of an ITP must establish "the funding that will be available to implement such steps the applicant will take to monitor, minimize, and mitigate the impacts from the proposed taking" (50 C.F.R. § 17.22(b)(1)). The ITP approval could be denied and is subject to full or partial suspension, or revocation, should Buckeye Wind fail to ensure funding for mitigation and conservation measures outlined in this HCP.

Buckeye Wind will provide funding to implement the Conservation Program outlined in Chapter 6.0. Funding or implementation of specific portions of the Conservation Program will be provided prior to beginning Project operation, unless otherwise indicated, as provided in Table 6-6, and additional portions of funding will be provided as the Project progresses. Funding assurance will be provided in the form of a Surety acceptable to the USFWS (for example, an escrow account, cash, or bond). The Surety will be used to provide funding assurances for those portions of the Conservation Program that are not yet actually implemented. Buckeye Wind will provide funds required to implement mortality and mitigation monitoring to comply with its obligations under the HCP, ITP, and the Implementing Agreement. Buckeye Wind will be responsible for the continued implementation of the HCP through the ITP Term.

Buckeye Wind's history of funding costly wind power project development, including pre- and post-construction studies to minimize impacts to avian and bat resources, demonstrates Buckeye Wind's ability and commitment to continue such funding. By entering into an Implementing Agreement with the USFWS, Buckeye Wind provides assurances that funding will be available to implement actions that mitigate the impact of the proposed taking of Indiana bats. Unless otherwise noted, all amounts described in this section are based on 2012 dollars and will therefore need to be adjusted for inflation in the future.

6.7.1 Mortality Monitoring

Funding for mortality monitoring will be earmarked in the capital and annual operating budgets of the Project. Estimated amounts will be included in the financial projections used to close debt financing for the Project, and the Project loan documents will clearly state that actual ongoing HCP monitoring and mitigation costs will be included in operating costs that are to be paid out of wind generation revenues prior to debt service payments to the lenders. It is important to note that if the Project has insufficient funds for operations, the Project will not be operational and therefore would not pose risk to Indiana bats. Since mitigation measures will be funded prior to take occurring (see Table 6-6 and Section 6.3 – Mitigation Measures), all take associated with the Project would be mitigated if the Project suffered from insufficient funds. As a further assurance that funds will be in place to conduct monitoring, Buckeye Wind will establish a Surety sufficient to cover the costs of PCM required for the upcoming monitoring year. Any independent surety company providing bonding under this HCP shall have a Best's credit rating of not less than A minus. The Surety will be made payable to the independent consultant selected to conduct the PCM (see Section 6.5.2 – Methods for Minimization Monitoring). At the end of each survey year, the annual report will include a description of the PCM needed for the subsequent year, based on the results of the prior year's monitoring phase and any adaptive management. Buckeye Wind will also provide as part of its annual report a proposal from an independent consultant (see Section 6.5.2 – Methods for Minimization Monitoring) for the monitoring work described for the upcoming year. The Surety will be updated as necessary to reflect the amount set forth in the independent consultant's proposal, and evidence of the Surety will be provided to the USFWS by 1 March of each year during the ITP Term.

EverPower and its subsidiaries have conducted post-construction monitoring at other sites across the eastern US. Estimates for mortality monitoring are based on costs associated with those other projects, extrapolated for the level of effort associated with the monitoring plan described in this HCP. For example, 2 of EverPower's subsidiaries will conduct post-construction monitoring in 2012 (see Section 6.5.2 – Methods for Minimization Monitoring for a description of the monitoring methods):

- Project X in New York State: Six turbines will be searched each day for 2 years, from 15 April to 15 November, for a proposed cost of $121,500 per year.
  - By extrapolation, 33.3 turbines each day, as would be required to meet the objectives of this HCP, would cost $674,300 per year[44].

- Project Y in Pennsylvania: Ten Turbines will be searched each day for two years, from 15 April to 15 November, for a proposed cost of $230,000 per year
  - By extrapolation, 33.3 turbines each day, as would be required to meet the objectives of this HCP, would cost $765,000 per year[45].

While the level of effort for monitoring in this HCP is greater than in NY or PA (e.g., a search area of 2.0 times the blade length is significantly greater than other states), Buckeye Wind expects economies of scale to offset the resulting cost increases. The estimated annual costs are $700,000 per monitoring year. Combined with every other year or greater monitoring, average annual costs may be reduced to about $350,000 after the Evaluation Phase and include the following scope:

- Monitoring an average of 33.3 turbines each day according to the specification of this HCP[46].
- Performing searcher efficiency trial and carcass removal trials according to the specification of this HCP.
- Calculating the estimated mortality based on statistical analysis and the observed mortality.
- Producing a written report summarizing findings.

Note that while the amounts presented here are reasonable estimates based on actual proposals for similar monitoring efforts, the amount of the Surety each year (including year 1) will be based on a proposal from an independent consultant. The PCM plan outlined in the independent consultant's proposal must be adequate to meet the requirements of this HCP. The appropriate Surety will be established by 1 March of each year (see Section 6.5.5 – Reporting).

6.7.2 Mitigation

Mitigation funding will be provided based on the estimated cost of securing 87.8 ha (217.0 ac) of land within 11.2 km (7 mi) of a P2 hibernaculum in OH.

6.7.2.1 Costs Associated with Identification of Mitigation Property(ies)

Initial estimates for identifying mitigation property(ies) are based on a proposal provided by a nationally recognized organization capable of implementing and managing mitigation efforts. The cost proposal was approximately $250,000 (referred to herein as "Identification Costs"). Identification Costs are subject to adjustment for inflation in the future. Identification of mitigation property(ies) includes the following tasks:

- Identify and Prioritize Potential Mitigation Site. This task will be based on the criteria provided in the HCP;
- Research Mitigation Properties. This task will include contacting landowners, conducting field work (including title) and developing a long term management and monitoring strategy;

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[44] Additional costs may be incurred to meet ODNR recommendations (see Section 6.5.2.3 – Search Frequency).
[45] Additional costs may be incurred to meet ODNR recommendations (see Section 6.5.2.3 – Search Frequency).
[46] In order to meet ODNR post-construction monitoring recommendations, monitoring for the first year or two may include more than 33.3 turbines per day (See Section Section 6.5.2.3 – Search Frequency).

- Select and Approve Sites for Mitigation. This will occur with input and final approval of Buckeye Wind, USFWS, and ODNR DOW;
- Acquire land and/or purchase conservation easement. This will include all contract for sale or easement and all due diligence (including real estate engagement, ground verification, estimate of initial restoration or enhancement needs, preliminary title work, etc.);.

These tasks do not include the cost of purchasing the property or purchasing a conservation easement over the property.

A 3rd party conservation organization approved by FWS and ODNR DOW will be identified to hold the land or conservation easement in perpetuity. Memoranda of Agreement between Buckeye Wind and any agency or 3rd party restoration and enhancement partners will be executed.

Implementation of mitigation is proposed to occur in 2 stages. Stage 1 will include the first 10 years of operation. The first 10 years equate to 40% of the 25-year operational life of the Project. Thus, Buckeye Wind will obtain a Surety equal to 40% of the $250,000 Identification Costs, or $100,000 (subject to adjustment for inflation). The Surety will be obtained, and evidence of the Surety will be provided to USFWS, prior to the beginning of Project operation. The Surety will be made payable to a qualified firm experienced in acquiring mitigation and natural habitat for conservation and approved by the USFWS.

Stage 2 will include the remaining years of operation, beginning with operational Year 11. The remaining years equate to 60% of the 25-year operational life of the Project. Thus, Buckeye Wind will obtain a Surety equal to 60% of the $250,000 Identification Costs, or $150,000 (subject to adjustment for inflation). The Surety will be obtained, and evidence of the Surety will be provided to USFWS, prior to the 11th year of Project operation. The Surety will be made payable to a qualified firm experienced in acquiring mitigation and natural habitat for conservation and approved by the USFWS.

At any time during the ITP Term, Buckeye Wind may provide an estimate of Identification Costs actually remaining and adjust the Surety to contain an amount sufficient to cover those remaining Identification Costs. Such estimate will be provided by the firm selected to complete identification of mitigation properties.

6.7.2.2 Acquisition Costs

Initial research suggests that forested property in OH does not typically exceed $5,000 per ac. Therefore, Buckeye Wind estimates that it would cost about $1.1 million ("Acquisition Cost") to secure 87.8 ha (217.0 ac) of land for mitigation to offset the impacts of take of Indiana bats from the project. Buckeye Wind expects the cost of securing a permanent easement on a property to be no more than the full value of the land and therefore equal to purchasing the land. Acquisition Costs are subject to adjustment for inflation in the future.

Before the beginning of Project operation, Buckeye Wind will obtain a Surety in an amount adequate to cover mitigation acquisition costs associated with take during the first 10 years of Project operation (Stage 1). The first 10 years equate to 40% of the 25-year operational life of the Project. Thus, Buckeye Wind will obtain a Surety equal to 40% of the estimated $1.1 million of Acquisition Costs ($440,000 subject to adjustment for inflation), for purchase and/or protection of 35.1 ha (86.8 ac) of mitigation land that would be adequate to offset the impacts of take of 52 Indiana bats. The Surety will be made payable to a qualified firm experienced in acquiring mitigation and natural habitat for conservation and approved by the USFWS. Evidence of the Surety will be provided to the USFWS prior to Project operation.

If all or a portion of Stage 1 mitigation land is purchased prior to the beginning of project operation, the Surety will then be equal to the cost of the remaining acreage needed to achieve 35.1 ha (86.8 ac). For example, if 8.0 ha (20 ac) of mitigation land are purchased prior to the beginning of project operation, the Surety would be valued at $334,000 (86.8 ac – 20 ac = 66.8 ac x $5,000/ac = $334,000).

Stage 2 includes the remaining years of operation, beginning with operational Year 11. The remaining years equate to 60% of the 25-year operational life of the Project. Thus, Buckeye Wind will obtain a Surety equal to 60% of the estimated $1.1 million of Acquisition Costs ($660,000 subject to adjustment for inflation), for purchase and/or protection of 52.68 ha (130.2 ac) of mitigation land that would be adequate to offset the impacts of take of 78 Indiana bats. The Surety will be made payable to a qualified firm experienced in acquiring mitigation and natural habitat for conservation and approved by the USFWS. The Surety will be obtained and evidence of the Surety provided to the USFWS prior to the beginning of the 11th year of Project operation.

If all or a portion of Stage 2 mitigation land is purchased prior to the beginning of the 11th year of project operation, the Surety will then be equal to the cost of the remaining acreage needed to achieve 52.68 ha (130.2 ac). For example, if 8.0 ha (20 ac) of mitigation land are purchased prior to the beginning of the 11th year of project operation, the Surety would be valued at $551,000 (130.2 ac – 20 ac = 110.2 ac x $5,000/ac = $551,000).

All land acquisition and conservation easements will aim to be in place before the beginning of the respective stage, but in no case after the 1st year of the respective stage (by the end of the 1st and 11th year, respectively).

At any time during the ITP Term, Buckeye Wind may provide an estimate of Acquisition Costs actually remaining and adjust the Surety to contain an amount sufficient to cover those remaining Acquisition Costs. Such estimate will be provided by the firm selected to complete identification of mitigation properties.

6.7.2.3 Restoration/Enhancement, Maintenance, and Monitoring Costs

Buckeye Wind has received an estimate for restoration/enhancement, maintenance, and monitoring of the mitigation effort (referred to herein as "Management Costs"). That estimate includes an upfront cost of $66,500 for restoration/enhancement, which includes site preparation and any necessary tree planting, invasive species control, and tree girdling[47]. Annual maintenance would be approximately $135,000 total for the Years 1 through 5 and $7,500 for every year thereafter. Annual monitoring would be $8,500 per year. Therefore, Buckeye Wind will obtain a Surety, for the following amounts for Stage 1 Management Costs:

- $26,600 for up front restoration/enhancement ($66,500 x 40%);
- $66,000 for annual maintenance, based on a total of $165,000 (annual maintenance for Years 1 to 5, then in each of Years 10, 15, 20 and 25) multiplied by 40%[48]. Year 1 is the year after a conservation easement is placed on the land (whether purchased or not).

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[47] This amount was estimated using the assumption that 16.2 ha (40 ac) would need to be restored forest plots. Since mitigation for this HCP will be focused on enhancement and preservation of existing wooded areas, with limited restoration, the estimate is considered conservative.
[48] If more than 40% of the 87.8 ha (217 ac) is purchased before Stage 2 mitigation, the Surety will be adjusted on a pro-rated basis.

- $30,600 for annual monitoring, based on a total of $76,500 (annual monitoring for Years 1 to 5, then in each of Years 10, 15, 20 and 25) multiplied by 40%. Year 1 is the year after a conservation easement is placed on the land (whether purchased or not).

A Surety totaling $123,200 (subject to adjustment for inflation) will be obtained by Buckeye Wind prior to the beginning of Project operation in order to provide assurance that funds will be in place for Stage 1 Management Costs. The Surety will be made payable to the independent contractor or consultant selected to conduct the restoration/enhancement, maintenance, and monitoring.

Buckeye Wind will obtain a Surety in the following amounts for Stage 2 Management Costs:

- $39,900 for restoration/enhancement ($66,500 x 60%);
- $90,000 for maintenance based on a total of $150,000 (annual maintenance for Years 10 to 15, then in each of Years 20 and 25) multiplied by 60%.
- $35,700 for monitoring based on a total of $59,500 (annual monitoring for Years 10-15, then in each of Years 20 and 25) multiplied by 60%.

A Surety totaling $165,600, subject to adjustment for inflation, will be obtained by Buckeye Wind prior to the beginning of the 11th year of Project operation in order to provide assurance that funds will be in place for Stage 2 Management Costs. The Surety will be made payable to the independent contractor or consultant selected to conduct the restoration/enhancement, maintenance, and monitoring.

All mitigation funding amounts will be pro-rated according to the number of turbines actually erected. For example, if 52 turbines are placed in commercial operation before the additional 48, funding for at least $344,900 (or, 52% x [$100,000 + $440,000 + $123,200], covering Stage 1 Identification Costs, Acquisition Costs and Management Costs, respectively), subject to adjustment for inflation, will be assured by a Surety obtained by Buckeye Wind prior to the beginning of operation of those 52 turbines. When the remaining 48 turbines are placed into commercial operation, the remaining Stage 1 funding, $318,500 (or 48% x [$100,000 + $440,000 + $123,200], covering Stage 1 Identification Costs, Acquisition Costs, and Management Costs, respectively), subject to adjustment for inflation, will be assured by a Surety obtained by Buckeye Wind prior to the beginning of commercial operation of those 48 turbines. Funding for the Stage 2 Surety will be pro-rated in the same manner if the remaining 48 turbines are not operational at the beginning of the 11th year of Project operation.

At any time during the ITP Term, Buckeye Wind may provide an estimate of Management Costs actually remaining and adjust the Surety to contain an amount sufficient to cover those remaining Management Costs. Such estimate will be provided by the firm selected to conduct the restoration/enhancement, maintenance, and monitoring.

6.7.3 Conservation Measures

Funding for conservation measures will be made available from Project revenues to a qualified research program(s) after 1 year of Project operation has been completed. The funding will be assigned within 5 years of the beginning of Project operation and will be provided to appropriate private or academic institutions to conduct research on Indiana bat behavior relative to wind energy development (See Section 6.4 – Conservation Measures). Disbursement of funds will be decided in coordination with the FWS and ODNR DOW.

6.7.4 Other Expenses

6.7.4.1 Changed Circumstances Fund

Reasonably foreseeable circumstances described in Section 7.2.1 – Changed Circumstances could trigger the need to restore or enhance the mitigation lands. Due to the uncertainty surrounding future impacts from changed circumstances and effective measures to minimize or mitigate them, Buckeye Wind will obtain a Surety in order to provide assurance that funds will be in place for future restoration actions directly related to degradation of mitigation land from changed circumstances. In the case that a changed circumstance response is triggered, activities described in Section 7.2.1 – Changed Circumstances will be implemented to restore and enhance the effected mitigation lands.

Potential responses to changed circumstance include: girdling to create snags if there are less than 2 small diameter snags, 5 medium diameter snags, and 2 large diameter snags per acre on average; planting trees if there are less that 300 stems per acre on average; or controlling for woody invasive species if they occupy more than 5% cover in the understory. The most expensive of these potential responses per acre is replanting of trees. Therefore the restoration costs are based on the costs of replanting trees within the area of changed circumstances. Buckeye Wind considers it unlikely that a single changed circumstance event will deforest all 87.8 ha (217 ac) of mitigation land, as these events are rare in Ohio, and because mitigation land will likely be made up of disjunct parcels. Therefore, the changed circumstance Surety will contain funds sufficient for restoration, monitoring, and management for 44 ha (109 ac), to account for deforestation of half the mitigation lands by a single changed circumstance event. However, should a single event deforest the entire mitigation area (i.e., 87.8 ha [217 ac] of mitigation lands), Buckeye Wind will commit the appropriate funds necessary to restore, monitor, and manage the entire 87.8 ha (217 ac). The annual operating budget will be the funding source for these additional funds.

Buckeye Wind received an estimate for Management Costs from an environmental consulting firm with experience in habitat restoration for restoration of 16.2 ha (40 ac) of mitigation land. That estimate includes an upfront cost of $66,500 for restoration/enhancement, $11,300 per year for maintenance of that 16.2 ha (40 ac) plot, and approximately $8,500 per year for annual monitoring. These estimates were extrapolated to calculate Management Costs for restoration of 44 ha (109 ac) in response to a changed circumstance.

Monitoring after a changed circumstance will occur annually for the first 5 years. However, subsequent monitoring in 5-year intervals will be dependent upon the timing of the changed circumstance event in light of the 30-year ITP Term. For example, an event in Year 7 of operation will require annual monitoring during Years 8 to 12 of operation, then again in Year 17, and finally in Year 22. However, an event in Year 18 of operation will require annual monitoring during Years 19 to 23 of operation, in which case no further monitoring would occur. Therefore, estimated costs in response to a changed circumstance event assume monitoring will occur over 7 monitoring years (annually in Years 1 to 5 following the event, then in each of Years 10 and 15 following the event). This is likely a conservative estimate, as events occurring after Year 15 of operation will require less monitoring effort.

For Stage 1 (1st 10 years of operation), a Surety in the amount of $170,700 will be obtained by Buckeye Wind to cover Management Costs to restore, enhance, maintain, and monitor 44 ha (109 ac) of mitigation lands that have been affected by a changed circumstance event:

- $72,500 for up front restoration/enhancement ($66,500 x 109 ac/40 ac x 40%);
- $86,200 for annual maintenance ($11,300 x 109 ac/40 ac x 7 years [Years 1 to 5, then in each of Years 10 and 15], multiplied by 40%[49]). Here, Year 1 is the year after a changed circumstance event.
- $12,000 for annual monitoring ($8,500 x 109 ac/217 ac x 7 years [Years 1 to 5, then in each of Years 10 and 15], multiplied by 40%). Here, Year 1 is the year after a changed circumstance event.

Evidence of the Surety will be provided to the USFWS prior to the start of Project operation. For Stage 2 (remaining years of 25-year operational life of the Project), a Surety in the amount of an additional $255,900 ($427,500 total; subject to adjustment for inflation) will be obtained by Buckeye Wind to restore and enhance mitigation lands that have been affected by changed circumstances:

- $108,700 for up front restoration/enhancement ($66,500/ac x 109 ac/40 ac x 60%);
- $129,300 for annual maintenance ($11,300 x 109 ac/40 ac x 7 years [Years 1 to 5, then in each of Years 10 and 15] multiplied by 60%). Here, Year 1 is the year after a changed circumstance event.
- $17,900 for annual monitoring ($8,500 x 109 ac/217 ac x 7 years [Years 1 to 5, then in each of Years 10 and 15], multiplied by 60%). Here, Year 1 is the year after a changed circumstance event.

Evidence of the Surety will be provided to the USFWS prior to the beginning of the 11th year of Project operation. The Surety obtained by Buckeye Wind will provide assurance that the funds are in place to conduct any necessary restoration or enhancement on the mitigation lands that have been affected by changed circumstance as described in Section 7.2.1 – Changed Circumstances. The Surety will be made payable to the independent contractor or consultant selected to conduct the restoration/enhancement, maintenance, and monitoring associated with the Changed Circumstance.

Application of changed circumstances funds towards corrective measures will occur when a changed circumstances trigger, identified in Section 7.2.1 – Changed Circumstances, has been met. Because it is difficult to know exactly what the cost of covering changed circumstances could be, Buckeye Wind will obtain a contingency Surety in an amount equaling 10% of the total amount bonded for changed circumstances. This Surety will assure that there is a contingency fund available to cover any unexpected costs resulting from changed circumstances. Corrective measures that could be funded (in whole or in part) by the contingency fund are identified for each changed circumstance addressed in Section 7.2.1 – Changed Circumstances. Every 5 years, the changed circumstance Surety and the resulting changed circumstances contingency Surety will be re-evaluated to account for current land values and inflation. If a changed circumstance triggers a response and the Surety is depleted to fund the response, the Surety will be maintained or replenished to the appropriate value within 6 months of the Surety being depleted to fully fund any future changed circumstances events that may occur during the ITP Term. This amount is subject to adjustment for inflation.

[49] If more than 40% of the 217 ac is purchased and requires restoration before Stage 2 mitigation, the Surety will be adjusted on a pro-rated basis.

6.7.4.2 ITP Administration Costs

Aside from the costs identified in Section 6.7 – Funding for the HCP, there will be costs associated with the administration of the ITP. It is expected that a portion of the time for senior operations staff and environmental and permit compliance staff at Buckeye Wind will be dedicated to ITP administration. This will include maintaining lines of communication with the USFWS and ODNR DOW, managing consultants' work (monitoring, reports, etc.), attending annual meetings with USFWS and ODNR DOW, and other tasks necessary to ensure successful implementation of the ITP. It is expected that these costs will be absorbed within the annual salary of such managers and will consist of less than 5% of the total responsibilities for 2-3 appropriate managers.

6.7.4.3 Contingency Fund

The purpose of this contingency amount is to provide a reasonable "buffer" if costs estimated in this section are higher than anticipated. This total will change year to year as the assured funding is revised based on year-ahead monitoring estimates and mitigation lands actually purchased and conserved (thereby eliminating the need for funding assurance).

The Contingency Fund takes 5% of the base costs that will be placed in a Surety to provide funding assurance, including Year 1 monitoring ($700,000), Stage 1 Acquisition Costs ($440,000), Stage 1 Identification Costs ($100,000), Stage 1 Management Costs ($123,200) and Reporting Costs, for a total contingency base of $1.36 million. Five percent of $1.36 million equals $68,200. This total will change year to year as the assured funding is revised based on year-ahead monitoring estimates, mitigation lands actually purchased and conserved (thereby eliminating the need for funding assurance), adjustments for inflation and other factors. The purpose of this contingency amount is to provide a reasonable "buffer" if costs estimated for specific actions (i.e., monitoring, mitigation, changed circumstances and reporting) are higher than anticipated.

Table 6-6. Funding estimates and assurances for 100 turbines (based on 2012 dollars).

Conservation Strategy	Annual costs	Total over ITP Term	Funding Source	Timing of Strategy	Timing of Funding
Monitoring					
Evaluation Phase PCM[1]	$700,000	First 2 years, $1.4 M	Annual operating budget, with 1 year ahead Surety	Annual, during active period	1 Mar of every year during ITP Term
Implementation Phase PCM [1]	$350,000[2]	Dependent on results, estimate 23 years, $8.1 M	Annual operating budget, with 1 year ahead Surety	Every 2 years or every 3 years	1 Mar of every year during ITP Term
Mitigation Monitoring	Included in Management Costs below	Included in Management Costs below		Years 1-5, then every 5th year thereafter	Included in Management Costs below
Subtotal		*$9.5 M*			
Mitigation					
Acquisition Costs[3]	Stage 1, $440,000 Stage 2, $660,000[3]	$1.1 million	Demonstration of land actually purchased or protected, with the balance deposited to a Surety.	Stage 1 to be completed by the end of year 1 and Stage 2 completed by end of year 11.	Stage 1: prior to the beginning of Project operation. Stage 2: prior to the beginning of year 11.

Table 6-6. Funding estimates and assurances for 100 turbines (based on 2012 dollars).

Conservation Strategy	Annual costs	Total over ITP Term	Funding Source	Timing of Strategy	Timing of Funding
Identification Costs[4]	Stage 1, $100,000 Stage 2, $150,000	$250,000[4]	Demonstration of expenses paid or services rendered, with balance deposited in a Surety.	Stage 1 to be completed by the end of year 1 and Stage 2 completed by end of year 11.	Stage 1: prior to the beginning of Project operation. Stage 2: prior to the beginning of year 11.
Management Costs[5]	Stage 1, $123,200. Stage 2, $165,600	$288,800	Demonstration of expenses paid or services rendered, with balance deposited in a Surety.	Stage 1 to be completed by the end of year 1 and Stage 2 completed by end of year 11.	Stage 1: prior to the beginning of Project operation. Stage 2: prior to the beginning of year 11.
Subtotal	*Stage I, $663,200 Stage 2, $975,600*	*$1.6 M*			
Conservation Measures					
Research on Indiana bat behavior relative to wind energy projects		$200,000	Provided from operation revenue.		Available after 1 year of Project operation, assigned within 5 years of beginning of Project operation
Subtotal		*$200,000*			
Reporting					
Report Preparations			Included in mortality monitoring budget	By 1 Jan of each year during the ITP Term	
Agency Consultation and Meetings	$4,000	$120,000	Annual operating budget	By 1 Jan of each year during the ITP Term	
Subtotal		*$120,000*			
Other Expenses					
Changed Circumstances[6]	Stage 1, $170,700 Stage 2, $255,900	$426,600	Deposited in a Surety	Conditional on occurrence of Changed Circumstance	Stage 1: prior to the beginning of Project operation. Stage 2: prior to the beginning of year 11.
Adaptive Management[7]		Minimal		Ongoing	

Table 6-6. Funding estimates and assurances for 100 turbines (based on 2012 dollars).

Conservation Strategy	Annual costs	Total over ITP Term	Funding Source	Timing of Strategy	Timing of Funding
ITP Administration	5% of total annual time for 2-3 appropriate managers		Absorbed within annual salaries	Ongoing	
Subtotal		*$426,600*			
Total Non-Contingency					
Total		**$11.6 M**			
Contingency					
10% Contingency for Changed Circumstances	Stage 1, $17,100. Stage 2, $25,600.	$42,700	Deposited in a Surety	N/A	Stage 1: prior to the beginning of Project operation. Stage 2: prior to the beginning of year 11.
5% Contingency for non-Changed Circumstances[8]		$68,200	Deposited in a Surety	N/A	Stage 1 by beginning of operation. Stage 2 beginning of year 11.
Subtotal		*$110,900*			
Grand Total					
GRAND TOTAL		**$11.7 M**			

[1]Assumes 100-turbine layout searched.

[2]Average annual cost based on $700,000 for each year of monitoring, conducted every other year.

[3]Based on maximum funding needed to reach 87.8 ha (217 ac). In Stage 1, 35.1 ha (86.8 ac), or $440,000 less mitigation land already purchased. In Stage 2, 52.7 ha (130.2 ac), or $660,000 (to be adjusted for then current values), less mitigation land already purchased.

[4]These costs include initial land identification and real estate transaction costs.

[5]Value based on estimate for land management of 87.8 ha (217 ac), with 16.2 ha (40 ac) reforested, from a firm experienced in restoration/enhancement, maintenance, and monitoring.

[6]Value is funding for half of mitigation land. Buckeye Wind considers it unlikely that a single changed circumstance event will deforest all 87.8 ha (217 ac) of mitigation land. Should such an event occur, Buckeye Wind will provide funds as needed to restore, monitor, and manage up to 87.8 ha (217 ac). The source of this funding will be the annual operating budget.

[7]Most of the adaptive management measures are related to altering the operations of the wind farm. While this could have substantial costs related to lost revenue, there are no "out of pocket" expenses.

[8]Based on Year 1 monitoring ($700,000), Stage 1 Acquisition Costs ($440,000), Stage 1 Identification Costs ($100,000), and Stage 1 Management Costs ($123,200) for a total contingency base of $1.36 M. Five percent of $1.36 M equals $68,200. This total will change year to year as the assured funding is revised based on year-ahead monitoring estimates and mitigation lands actually purchased and conserved (thereby eliminating the need for funding assurance), adjustments for inflation and other factors. The purpose of this contingency amount is to provide a reasonable "buffer" if costs estimated for specific actions (i.e., monitoring, mitigation, changed circumstances and reporting) are higher than anticipated.

7.0 PLAN IMPLEMENTATION

7.1 HCP Administration

Buckeye Wind will implement the HCP upon approval of the HCP and issuance of the ITP. Buckeye Wind is actively developing plans for the Project's additional 48 proposed turbines and securing all state and local permits for construction and operation of the additional turbines. While the timing of construction of the additional 48 turbines relative to the original 52 turbines is uncertain, this HCP includes an assessment of impacts from the entire 100-turbine Project, with specific Conservation Measures and monitoring being applied as described in Chapter 6.0 – Conservation Measures.

Buckeye Wind will be solely responsible for meeting the terms and conditions of the ITP and will allocate sufficient personnel and resources to ensure effective implementation of the HCP. Buckeye Wind will implement this HCP in coordination with the USFWS and ODNR DOW. An HCP Coordinator, who will likely be a representative of Buckeye Wind, will be identified by Buckeye Wind in coordination with the USFWS. The HCP Coordinator will be responsible for overseeing the HCP implementation, planning, and coordination of all meetings and agenda items and delivery of all monitoring and other reports to the USFWS and ODNR DOW as specified in this HCP and as required in the ITP. Should the HCP Coordinator leave his or her position for any reason, the most appropriate replacement will be determined in coordination with the USFWS. Buckeye Wind expects that management of mitigation lands will be carried out by a conservation trust or other appropriate conservation organization. Monitoring is expected to be carried out by third party contractors with expertise in conducting avian and bat fatality studies at wind facilities (for post-construction mortality monitoring) and with knowledge of Indiana bat habitat requirements (for mitigation monitoring). Funding that Buckeye Wind will provide for research (i.e., conservation measures) will also be carried out by third party contractors, academic institutions, or non-governmental organizations with expertise in Indiana bat behavior as it relates to wind energy development.

Buckeye Wind will meet at least annually with USFWS and ODNR DOW throughout the ITP Term. The objective of annual meetings will be to review annual mortality and mitigation monitoring reports to determine the need for adjustments to minimization, monitoring, and mitigation in accordance with the adaptive management criteria identified in Section 6.5 – Monitoring and Adaptive Management. Additional objectives of annual meetings will be to evaluate the potential application of new scientific findings to the adaptive management of this HCP and to evaluate potential occurrence of changed or unforeseen circumstances. Additional meetings or conferences may be initiated by Buckeye Wind and/or USFWS to address other concerns, as necessary, including implementation and results of conservation measures.

7.2 Changed and Unforeseen Circumstances

Implementing regulations for Section 10 of the ESA recognized that revisions to the original HCP may be required as circumstances and information may change. 50 CFR 17.22(b)(1)(iii)(C) requires that "…any plan approved for a long term permit will contain a procedure by which the parties will deal with unforeseen circumstances." Circumstances that can be reasonably anticipated and planned for are considered "changed circumstances" and may include new ESA listing of a species or a natural catastrophe in areas prone to such an event (USFWS and NOAA 1996). "Unforeseen circumstances" are defined as changing circumstances that were not or could not be anticipated by HCP participants and the USFWS and that result in a substantial and adverse change in the status of the Covered Species (USFWS and NOAA 1996). During the 30-year ITP Term of the HCP, Buckeye Wind and USFWS recognize that both anticipated or "changed circumstances" and unanticipated or "unforeseen circumstances" may occur.

7.2.1 Changed Circumstances

7.2.1.1 Listing of New Species under ESA

As cited previously, winter bat census data from 2009-2010 in CT, MA, NY, and VT indicate that the species experiencing the most significant declines from WNS include the little brown bat and tri-colored bat populations (both estimated at 93% reduction) and northern long-eared bat populations (estimated at a 99% reduction) (Langwig et al. 2010). Similar to reductions reported by Langwig et al. (2010), little brown bat populations in NY declined 93% from 2006 to 2009 (BCI 2010b). Initial modeling of the dynamics of WNS-infected populations indicates that little brown bats are at risk of regional extinction as a result of WNS within the next 16 years (Frick et al. 2010). The little brown bat occurs in the Action Area and was captured during pre-construction mist-netting surveys (197 little brown bats, or 66% of all individuals captured in a 2008 survey [Stantec 2008a] and 2 little brown bats or 4% of all individuals captured in a 2009 survey [Jackson Environmental Consulting Services LLC, 2009]) and during swarming surveys (201 little brown bats, or 23% of all individuals captured [Stantec 2008a]).

Other bat species are experiencing similar mortality from WNS and may also be at risk of population collapse, most notably northern long-eared bats, eastern small-footed bats, and Indiana bats (USGS 2010). The CBD recently petitioned the Secretary of the Interior to list the eastern small-footed bat and northern long-eared bat as a federally threatened or endangered species under the ESA and to designate critical habitat for these species concurrent with listing (CBD 2010; filed 21 January 2010). On 29 June 2011, the USFWS announced that the eastern small-footed and northern long-eared bats may warrant Federal protection as threatened or endangered under the ESA pursuant to 16 U.S.C. § 1533(b)(3)(B) (76 Fed. Reg. 38095-38106). The USFWS has thus initiated a more thorough status review of these species. The USFWS is also collecting information on additional species susceptible to WNS (USFWS 2011b).

The CBD petition states that the eastern small-footed bat and the northern long-eared bat are threatened by 4 of the 5 factors identified by the ESA to warrant listing: the loss and curtailment of their habitat or range; disease (i.e., WNS); numerous natural and anthropogenic factors (e.g., environmental contaminants, climate change, wind energy development); and inadequacy of existing regulatory mechanisms. Although many bat species in the eastern U.S. are experiencing the threats discussed above, the CBD petition (2010) argues that the life histories, habitat associations, and current population statuses of the eastern small-footed bat and northern long-eared bat make these species especially vulnerable to severe population declines and local extinctions. These 2 species were added to the USFWS Region 3 federal list of Species of Concern, an informal term indicating species which Region 3 feels might be in need of conservation activities and all bats are listed as Species of Concern by ODNR DOW.

The eastern small-footed bat was not detected during bat surveys in the Action Area or initial study area, and no suitable habitat for the species exists within the Action Area. It is not anticipated that this Project would have an effect on this species. The northern long-eared bat does occur in the Action Area and individuals were captured during pre-construction mist-netting surveys (38 northern long-eared bats, or 13% of all individuals captured in a 2008 survey [Stantec 2008a] and 17 northern long-eared bats or 34% of all individuals captured in a 2009 survey [Jackson Environmental Consulting Services LLC, 2009]) and during swarming surveys (653 northern long-eared bats, or 74% of all individuals captured [Stantec 2008a]). While northern long-eared bats comprised a large proportion of the species documented in the Action Area, data from post-construction monitoring studies indicate that they are one of the species least susceptible to collision/barotrauma mortality at wind facilities. A total of 12 northern long-eared bat fatalities have been recorded in 59 monitoring studies conducted from 1998 to 2010 at wind energy facilities in the United States and Canada (refer to Table 4-10), which represents only 0.2% of the 7,144 total bat fatalities documented at these facilities.

In the event that the USFWS determines that the listing of the northern long-eared bat, little brown bat and/or other bat or bird species is warranted under 16 U.S.C § 1533(b)(3)(B)(ii) or (5)(A)(i), Buckeye Wind, in coordination with the USFWS, will evaluate the potential for the Project to result in incidental take of those species. The same coordination will occur for any other species for which the Service determines listing is warranted under 16 U.S.C § 1533(b)(3)(B)(ii) or (5)(A)(i), either through a petition action or through a status assessment absent a petition action, that is expected to occur within the Action Area. The evaluation will consider the known occurrence of the species and habitat within the Action Area and results of post-construction mortality monitoring in the Action Area and at other wind facilities. As previously stated, the avoidance, minimization, mitigation, and conservation measures that will be implemented for the Indiana bat as part of this HCP will result in similar minimization of impacts and benefits to the other bats that share similar life history characteristics, roosting and foraging behavior, and habitat with the Indiana bat. If incidental take is deemed to be likely, the ITP will be amended or other avenues for take coverage will be explored. In the case that the northern long-eared bat or little brown bat is listed before an amendment is obtained, Buckeye Wind will take the appropriate actions pursuant to the ESA to avoid take.

7.2.1.2 White Nose Syndrome

In addition to potentially causing new species to be federally listed, WNS is a changed circumstance in itself because the ultimate effects on the Indiana bat range wide population are yet unknown (see Section 4.1.1 – White Nose Syndrome and Section 4.5.3 – Disease and Parasites). The 2007 Draft Recovery Plan does not address Indiana bat population decreases that have occurred as a result of WNS. However, it is a condition already present throughout much of the Indiana bat's range, including OH, and therefore WNS was included in the analysis of the biological significance of incidental take (see Section 5.1.2.6.3 – Population Declines from White Nose Syndrome).

Buckeye Wind is required to minimize and mitigate the impacts of the taking to the maximum extent practicable. Therefore, Buckeye Wind, in coordination with the USFWS, will review the biennial winter census results compiled by the USFWS Indiana Bat Recovery Team and if the population of Indiana bats in the Midwest RU is reduced by 50% or more from 2011 pre-WNS mortality levels (305,297 Indiana bats), Buckeye Wind will commit to reducing requested 5-year take limits by 50% (see Section 5.1.2.6.4 – Take Reductions as a Result of WNS). In this event, the 5-year take limit would be 13.0 Indiana bats (or average of 2.6 Indiana bats per year). For the purposes of Adaptive Management for minimization, Less than Expected take would be defined as less than 2.6 Indiana bats per year. Expected take would be 2.6 Indiana bats per year, and Greater than Expected take would be greater than 2.6 Indiana bats per year. These reductions in take would be expected as a result of fewer Indiana bats exposed because of overall population declines. Project operations under reduced take would continue to be subject to adaptive management decisions as outlined in Section 6.5 – Monitoring and Adaptive Management.

If the 5-year take limits are reduced, the mitigation acres will be recalculated to adjust for the reduced mortality expected for the project. For example, if the reduction in take limits occurs in the 10^{th} year, take limits for the remaining 15 years will consider an average of 2.6 Indiana bats per year. The take limit for the ITP Term would then be 5.2 x 10 years + 2.6 x 15 years, or 91 Indiana bats. Therefore, the mitigation acres needed to offset the effects of take would necessarily be reduced. As offsetting the effects of take of 130 Indiana bats would require 81.3 ha (206.3 ac; see Section 6.3.1 – Acres of Mitigation Calculation), offsetting the take of 91 bats would require 56.9 ha (144.4 ac). Since mitigation for 91.2 ac will have already been dedicated, Stage 2 mitigation would cover the additional 53.2 ac, plus 16.1 ac for tree clearing during construction, or a total of 69.3 ac for the remaining 15 years of the ITP Term.

In addition, the trigger point for immediate adaptive management would also change. In this case, if 2 Indiana bat mortalities are documented at the site before the fall season, cut-in speeds will be increased by 1.0 m/s at all turbines for the remainder of the active period (Figure 7-1). Any additional documented Indiana bat mortality will result in all turbines being operated with a cut-in speed of 7.0 m/s. After the cut-in speeds are increased to 7.0 m/s, if additional Indiana bat mortality is documented all turbines will be turned off from 1 hour before sunset to 1 hour after sunrise for the remainder of the active period.

In addition, if 1 Indiana bat mortality is documented before the fall season, 1 Indiana bat mortality in the fall season will trigger immediate adaptive management. If no Indiana bat mortalities are documented before the fall season and 2 Indiana bat mortalities are documented at the site during the fall season, immediate adaptive management will be triggered. In either scenario cut-in speeds will be increased by 1.0 m/s for the remainder of the active period. Any additional documented Indiana bat mortality will result in all turbines being operated with a cut-in speed of 7.0 m/s. If additional Indiana bat mortality is documented, all turbines will be turned off from 1 hour before sunset to 1 hour after sunrise for the remainder of the active period.

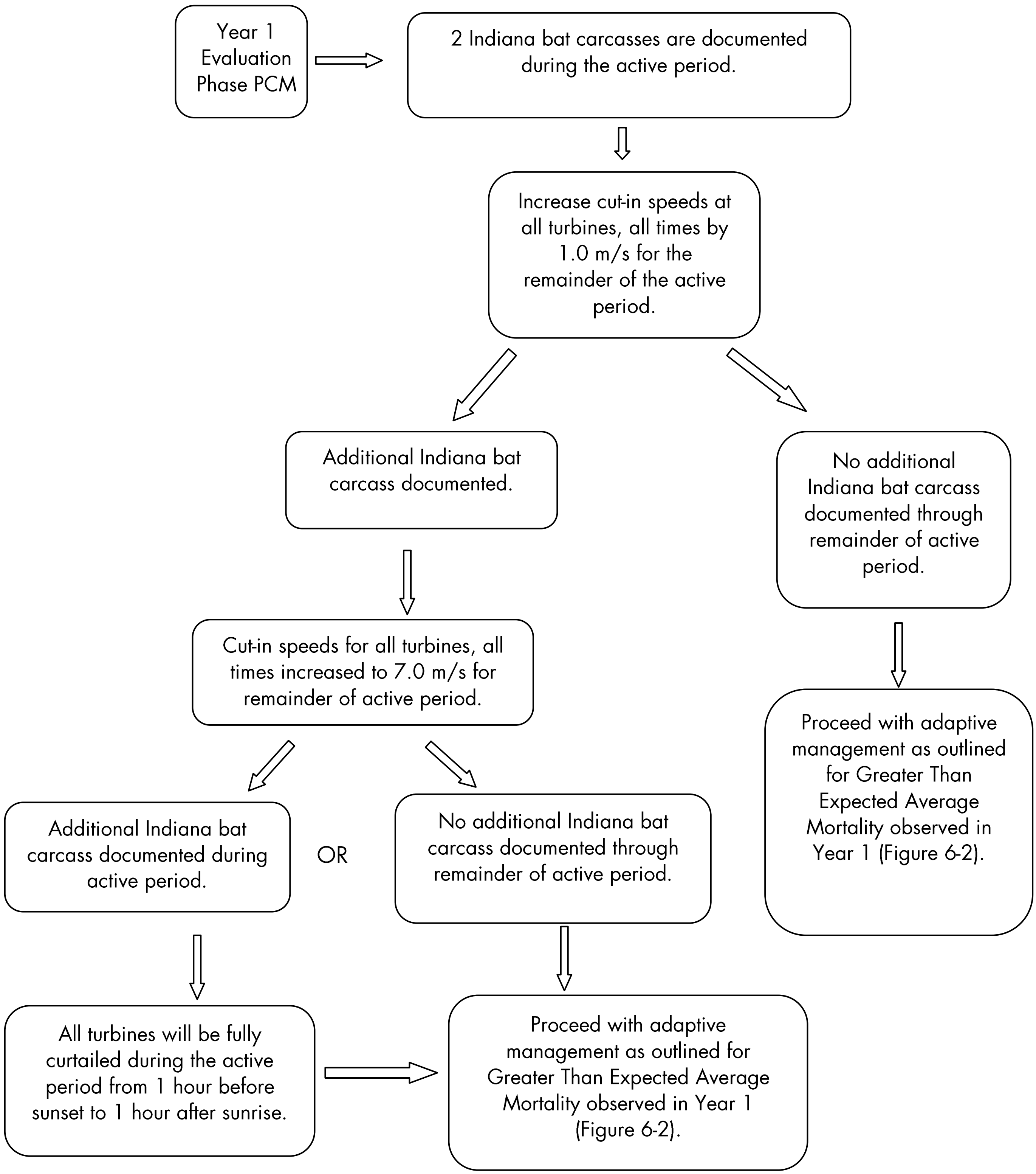

Figure 7-1. Within-season Trigger Points for adaptive management with Indiana bat populations decreased by 50% due to WNS.

7.2.1.3 Drought

Drought is defined as a period of time (generally months or years) when actual moisture supply is below the "climatically expected or climatically appropriate moisture supply" (Palmer 1965). Average annual precipitation in Ohio ranges from 32 in to 42 in across the state from north to south; minimum annual precipitation occurred in the drought year of 1930 (26.59 in; National Climatic Data Center [NCDC] no date). In OH, drought is most common in the spring and summer months and occurs an average of 2 times per decade, and periods of drought tend to cluster together in time (NCDC n.d., Rogers 1993). Periods of drought in OH commonly persist for 2 to 5 years and are linked to unusually high summer temperatures through increased evapotranspiration (Rogers 1993).

Climate change may increase the frequency and intensity of drought conditions in the summer months. Warmer temperatures are expected to leave OH's soils drier for more of the year. Despite an increase in overall precipitation, average summer rain in OH could decrease by 20% or more, increasing the risk of drought (Kling et al. 2003, as cited in Gomberg 2008). Warmer temperatures will lead to an increase in evaporation, and combined with a decrease in summer precipitation will cause increased soil moisture deficit, lower lake and river levels, and more drought-like conditions (IPCC 2007). Increased drought also has the potential to increase the frequency and magnitude of forest fires, which have the potential to eliminate areas of Indiana bat roosting and foraging habitat, depending on fire intensity (see Section 7.2.1.5 – Fire).

OH is characterized by short-term and long-term variation in water supply (Rogers 1993). The NCDC (n.d.) suggests that an average of 2 droughts per decade can be expected. Historic data in OH indicate that between 1895 and 1992 (i.e., over 97 years) there were approximately 13 periods in which drought occurred (Rogers 1993). However, there were 17 12-month periods during the same span of years (where 12-month periods were not tied to calendar years) that had the lowest precipitation. Drought severity is also variable. The Palmer Hydrological Drought Index (PHDI) is a measure of drought intensity. Historic OH data collected during the same time frame (i.e., between 1895 and 1992, or over 97 years) indicate that there were 17 years in which the PHDI reached a minimum during the growing season (i.e., April to September; Rogers 1993): 2 years were considered to have had mild drought conditions (PHDI values from -1.00 to -1.99); 11 years had moderate drought conditions (PHDI values from -2.00 to -2.99); 2 years had severe drought conditions (PHDI values from -3.00 to -3.99); and 2 years had extreme drought conditions (PHDI values below -4.00; Rogers 1993).

Drought has the potential to negatively affect Indiana bats because water is important as a drinking source and is important to the insect populations found in and near water sources, both necessary elements in meeting the energetic demands of pregnant and nursing females with dependent young (Kurta 2001). Insectivorous bats typically obtain 20% to 26% of their daily water from drinking (Kurta et al. 1989, 1990, 2001). Summer precipitation has also been shown to be related to adult female and juvenile survival in the closely related little brown bat. Based on 16 years (1993-2008) of mark-recapture data to estimate age-specific survival and breeding probabilities of the little brown bat in southern New Hampshire, Frick et al. (2009) found that adult female survival was highest in wet years with high cumulative summer precipitation. Given that this species exhibits low fecundity and high longevity, a substantial decline in the survival rate of reproductive females is expected to reduce population growth of little brown bats (Frick et al. 2009), as well as other bat species that share their life history characteristics, such as the Indiana bat.

As part of this HCP, mitigation will consist of permanent preservation, enhancement, and restoration of land surrounding a P2 hibernaculum in OH in conjunction with a third party conservation organization. Land cover within the mitigation area consists mostly of cultivated crops and developed areas, interspersed with fragmented parcels of forest (which are the focus of the mitigation measures) and limited areas of pasture and grassland. Mitigation actions are intended to offset the impacts of Project-related take, and therefore measureable thresholds set out in Section 6.3 – Mitigation Measures will be used to ensure that effective mitigation is maintained. On preserved land with existing forest stands, annual monitoring in Year 1 through Year 5, followed by subsequent monitoring every 5 years, will occur.

Drought will constitute a changed circumstance if monitoring determines that there are less than 2 small diameter snags, 5 medium diameter snags, and 2 large diameter snags per acre on average; if there are less that 300 stems per acre on average; or if woody invasive species occupy more than 5% cover in the understory. It is anticipated that, at a minimum, the response to changed circumstances due to drought would include 1 or more of the following activities, as described more fully in Section 6.3.4 – Restoration and Enhancement:

- Tree planting where tree mortality has reduced tree density to below an average of 300 stems/ac/PA;
- Tree girdling to return snag densities to the stated target; and
- Non-native woody invasive species control such that woody invasive species do not exceed 5%. Methods for clearing invasive species will include brush cutting (using bushhogs, mowers, or other similar equipment), hand cutting, and the use of herbicides if necessary.

However, drought is also one of a suite of natural disturbance events that can result in increased tree mortality and therefore increases in snag density (Wisdom and Bate 2008). While this effect is beneficial in that it would result in increased roosting opportunities, severe or extreme drought lasting over a long period of time has the potential to result in extreme tree mortality.

Once drought triggers a changed circumstance, and within 1 year of the drought ending, Buckeye Wind will begin restoration activities in accordance with the approach described in Section 6.3.4 – Restoration and Enhancement. Tree planting in response to severe tree mortality resulting from extended drought cannot be effectively implemented until after the drought is over. Prolonged drought lasting beyond the 30-year ITP Term will constitute an unforeseen circumstance. Actions will be implemented as described in Section 6.3 – Mitigation Measaures, will be consistent with ITP obligations, and will be funded (in whole or in part) by the Changed Circumstances fund (see Section 6.7 – Funding for the HCP).

7.2.1.4 Flooding

Floods in OH generally occur in the winter and early spring as a result of high precipitation during times of saturated ground (NCDC n.d.). Flooding can become severe in spring when these factors combine with melting snow. In summer, localized flooding in hilly terrain can result from repeated thunderstorms in the same area. Average annual precipitation in OH ranges from 32 in to 42 in across the state from north to south, with a state-wide average of 38 in (NCDC n.d.). The NCDC Storm Events database (http://www.ncdc.noaa.gov/stormevents/) lists 42 flood events that occurred in Preble County between 1993 and 30 April 2011; damages ranged from no property damage to half a million dollars' worth, but most flood events caused very little damage. None caused injuries, deaths, or crop damage. Similarly, Montgomery County has 6 reported flood events, with property damages ranging from $1,000 to $5,000 and no injuries, deaths, or crop damage; Darke County has 10 reported flood events with property damages ranging from $1,000 to $5,000 and no injuries, deaths, or crop damage. While summers may become drier as a result of global climate change, winters and springs in OH are expected to be wetter, making flooding events more likely. Winters could become 20% to 30% wetter when compared with the 1960-1990 average (Kling et al. 2003, as cited in Gomberg 2008). OH has already seen a 43% increase in the state's extreme precipitation events since 1948 (Madsen and Figdor 2007, as cited in Gomberg 2008). Storms with as much rain and snow as those that occur only once every 20 years now, are predicted to occur every 4 years to every 6 years by 2100 (Madsen and Figdor 2007, as cited in Gomberg 2008).

It is difficult to predict flood events since flooding depends on stream capacity, runoff potential, and rainfall patterns across a wide area. A 100-year flood, as defined by the Federal Emergency Management Agency (FEMA), has a 1% chance of occurring in any given year. Over long periods of time, this type of flood would occur on average once every 100 years, but in the short term its frequency could be more than once in a single year or once in more than 100 years. Similarly, a 1-year flood has a 100% chance of occurring each year, on average. However, in the short term, flooding does not necessarily occur every year. Land cover within the mitigation area consists mostly of cultivated crops and developed areas, interspersed with fragmented parcels of forest (which are the focus of the mitigation measures) and limited areas of pasture and grassland. USGS 1:24,000 topographic maps indicate a number of intermittent and perennial streams within the mitigation area; FEMA flood maps show that the 100-year flood hazard areas are limited to the immediate proximity of the streams. Because of issues with predicting flood intensity and frequency, a specific number of flood events expected over the 30-year ITP has not been developed for this HCP.

Flooding events could threaten the stability of Indiana bat hibernacula that are vulnerable to flooding; the result could be direct mortality of Indiana bats or unfavorable hibernating conditions due to changes in cave microclimate. However, flooding could also have a positive effect on Indiana bats if frequent water inundation resulted in senescence of deciduous trees, which would create conditions favorable to roosting, such as sloughing bark.

As part of this HCP, mitigation will consist of preservation, enhancement, and restoration of land surrounding a P2 hibernaculum in OH. Mitigation actions are intended to offset the impacts of Project-related take, and therefore measureable thresholds set out in Section 6.3 – Mitigation Measures will be used to ensure that mitigation is effective. On preserved land with existing forest stands, annual monitoring in Year 1 through Year 5, followed by subsequent monitoring every 5 years, will determine whether there are at least 2 small diameter snags, 5 medium diameter snags, and 2 large diameter snags per acre on averageGirdling may occur if the number of snags on average is below this ratio. If no trees are present on preserved land, then restoration in the form of tree planting will occur. Monitoring will ensure a 70% survival rate for seedlings during the first 5 years, and subsequent monitoring years will determine when trees are large enough to be girdled in order to create potential roosts.

Flooding will constitute a changed circumstance if a severe flood (i.e., a 50-year flood as defined by FEMA) occurs during the Project term and monitoring determines that there are less than 2 small diameter snags, 5 medium diameter snags, and 2 large diameter snags per acre on average, if there are less than 300 stems per acre on average, or if woody invasive species occupy more than 5% cover in the understory. It is anticipated that, at a minimum, the response to changed circumstances due to flooding would include 1 or more of the following activities, as described more fully in Section 6.3.4 – Restoration and Enhancement:

- Tree planting where tree mortality has reduced tree density to below an average of 300 stems/ac/PA;
- Tree girdling to return snag densities to the stated target; and
- Non-native woody invasive species control such that woody invasive species do not exceed 5%. Methods for clearing invasive species will include brush cutting (using bushhogs, mowers, or other similar equipment), hand cutting, and the use of herbicides if necessary.

Although FEMA maps show areas bordering creeks in the mitigation area and adjacent low-lying areas, which are more likely to experience flooding under high-water conditions, the extent of flooding and damages will depend on water levels, the rate at which water levels rise, soil conditions, specific topography, and many other factors. Once flood triggers a changed circumstance, and within 1 year of the flooding ending, Buckeye Wind will begin restoration activities in accordance with the approach described in Section 6.3.4 – Restoration and Enhancement. Tree planting in response to severe tree mortality resulting from extensive flooding cannot be effectively implemented until after the inundated soil has drained. Actions will be implemented as described in Section 6.3 – Mitigation Measures, will be consistent with ITP obligations, and will be funded (in whole or in part) by the Changed Circumstances fund (see Section 6.7 – Funding for the HCP).

7.2.1.5 Fire

Fire is a natural part of many ecosystems. In OH, small, frequent fires occurred naturally in pre-settlement times, but widespread fire suppression through the 1980s degraded ecosystems, reduced biodiversity, reduced the occurrence of open natural communities such as prairies, and allowed fuel to build up in forested areas (Snyder 2004). Currently, prescribed burns are conducted on federal, state, and private lands to manage forests, and small frequent fires elsewhere in the state occur. Prescribed burns are not contemplated to be used for conservation programs as part of this HCP.

Land cover types that have low fuel loads or high moisture content, including cropland, wetland, and developed cover types, are not prone to fire. In contrast, fire could propagate through forest, pasture, and grassland cover types. Land cover within the mitigation area consists mostly of cultivated crops and developed areas, interspersed with fragmented parcels of forest (which are the focus of the mitigation measures) and limited areas of pasture and grassland. Of those land cover types that could support fire in the mitigation area, the majority are classified as Class II: these areas have natural fire regimes that include predominantly high-severity fires occurring once every 35 years, on average (Fire Regime Condition Class [FRCC] 2010). The remaining fire-prone land cover types have been identified as Class III areas having natural fire regimes which include predominantly mixed-severity fires occurring once every 35 to 200 years (FRCC 2010). No forest fire events for Preble, Montgomery, or Darke counties have been reported to the NCDC Storm Events database (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms). Climate change may cause an increase in the frequency and severity of wildfires in Ohio, as warmer temperatures and decreased summer rainfall are expected to leave soils drier for more of the year and increase the frequency and intensity of drought conditions in the summer months (Kling et al. 2003, as cited in Gomberg 2008) (See Section 7.2.1.3 – Drought).

Forest fire has the ability to affect Indiana bat habitat in the mitigation land located outside a P2 hibernaculum in OH. Fire may be beneficial to Indiana bats: it can remove understory clutter, producing semi-open forest stands preferred by Indiana bats (see Section 4.4.4.2 – Foraging and Traveling Behavior). It can create potential roost trees by creating standing snags (see Section 4.4.4.1 – Maternity Roosts). And it can create canopy gaps, which in turn can result in increased insect diversity and increased solar exposure to any nearby roost trees (see Section 4.4.4.2 – Foraging and Traveling Behavior). However, large, intense, or frequent fires could have a negative impact on Indiana bat or fall swarming/spring emergence and roosting habitat in mitigation lands surrounding a hibernaculum. Destruction of large swaths of forest could reduce roost tree availability or sufficient canopy closure or it could allow woody invasives an opportunity to infiltrate the area.

As part of this HCP, mitigation will consist of preservation, enhancement, and restoration of land surrounding a P2 hibernaculum in OH. Mitigation actions are intended to offset the impacts of Project-related take, and therefore measureable thresholds set out in Section 6.3 – Mitigation Measures will be used to ensure that mitigation is effective.

Fire will constitute a changed circumstance if a single mixed-severity fire, defined as a fire replacing 25% to 75% of the dominant overstory vegetation, or if a single high-severity fire, defined as a fire replacing greater than 75% of the dominant overstory vegetation (FRCC 2010), occurs during the Project term and monitoring determines that there are less than 2 small diameter snags, 5 medium diameter snags, and 2 large diameter snags per acre on average, if there are less that 300 stems per acre on average, or if woody invasive species occupy more than 5% cover in the understory. It is anticipated that, at a minimum, the response to changed circumstances due to fire would include 1 or more of the following activities, as described more fully in Section 6.3.4 – Restoration and Enhancement:

- Tree planting where tree mortality has reduced tree density to below an average of 300 stems/ac/PA;
- Tree girdling to return snag densities to the stated target; and
- Non-native woody invasive species control such that woody invasive species do not exceed 5%. Methods for clearing invasive species will include brush cutting (using bushhogs, mowers, or other similar equipment), hand cutting, and the use of herbicides if necessary.

Fire is 1 of a suite of natural disturbance events that can result in increased tree mortality and therefore increases in snag density (Wisdom and Bate 2008). While this effect is beneficial in that it would result in increasing roosting opportunities within preserved areas, severe crown fires have the potential to result in extreme tree mortality. Indiana bat roost trees have been documented in stands with canopy closure ranging from less than 20% to 80% for females and from 49% to 80% for males (Kurta 2005). Although roost trees can therefore be located in areas of open canopy, it is likely that large areas of high snag density, resulting in an open canopy, would be unsuitable for roosting.

Once fire triggers a changed circumstance, and within 1 year of the fire event, Buckeye Wind will begin restoration activities in accordance with the approach described in Section 6.3.4 – Restoration and Enhancement. Tree planting in response to extreme tree mortality resulting from severe fire cannot be effectively implemented until after soils have cooled and adequate water content has been reestablished. Actions will be implemented as described in Section 6.3 – Mitigation Measures, will be consistent with ITP obligations, and will be funded (in whole or in part) by the Changed Circumstances fund (see Section 6.7 – Funding for the HCP).

7.2.1.6 Tornadoes

A tornado is defined as violently rotating column of air extending from a cumuliform cloud, such as a thunderstorm, to the ground. The United States experiences more tornadoes than any other country (NOAA 2010). Tornadoes may occur at any time during the year, but are most frequent in the late spring and summer months. Based on Disaster Center data, OH experienced a total of 656 recorded individual tornadoes from 1950 to 1995 and averages approximately 14 individual tornadoes per year[50]. FEMA tornado maps indicate that most areas in OH experience F3 (136-165 mph), F4 (166-200 mph), and F5 (>200 mph) tornadoes with moderate to high frequency compared to other states in the United States[51].

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[50] http://www.disastercenter.com/ohio/tornado.html

[51] http://www.fema.gov/plan/prevent/saferoom/tsfs02_torn_activity.shtm

Eleven tornado events in Preble County were reported to the NCDC Storm Events database[52] between 1950 and 30 April 2011; most were of magnitudes F0 (65-85 mph) or F1 (86-110 mph), but there was 1 tornado each of magnitudes F3 and F4. One tornado event was reported to the NCDC Storm Events database for Montgomery County (FO) and 3 were reported for Darke County (2 were FO, 1 was F1). Property damages ranged from a couple thousand to 25 million dollars. Tornadoes may increase in frequency and magnitude in OH and elsewhere as climate change results in more frequent and more severe thunderstorms, hurricanes, and extreme weather patterns (Dutzik and Willcox 2010).

A tornado has the potential to destroy Indiana bat roosting habitat through the destruction and removal of both live trees and snags. Tornadoes occurring during the active season for Indiana bats have the potential to cause direct mortality of both adults and juveniles. The scale of damage from a tornado will depend on the magnitude of the tornado and the duration and linear speed of the tornado, which may range from a localized area of touch-down to a wide path extending tens or hundreds of miles. Tornadoes are not expected to create or enhance habitat for Indiana bats, as most trees killed by a tornado are unlikely to remain standing.

As part of this HCP, mitigation will consist of preservation, enhancement, and restoration of land surrounding a P2 hibernaculum in OH. Mitigation actions are intended to offset the impacts of Project-related take, and therefore measureable thresholds set out in Section 6.3 – Mitigation Measures will be used to ensure that mitigation is effective.

A tornado that moves through forested habitat is likely to cause tree damage and destruction, especially to standing snags. A tornado will constitute a changed circumstance if a tornado of magnitude F4 or less is documented to occur within the mitigation area by the National Weather Service during the Project term and monitoring determines that there are less than 2 small diameter snags, 5 medium diameter snags, and 2 large diameter snags per acre on average, if there are less that 300 stems per acre on average, or if woody invasive species occupy more than 5% cover in the understory. It is anticipated that, at a minimum, the response to changed circumstances due to tornado would include 1 or more of the following activities, as described more fully in Section 6.3.4 – Restoration and Enhancement:

- Tree planting where tree mortality has reduced tree density to below an average of 300 stems/ac/PA;
- Tree girdling to return snag densities to the stated target; and
- Non-native woody invasive species control such that woody invasive species do not exceed 5%. Methods for clearing invasive species will include brush cutting (using bushhogs, mowers, or other similar equipment), hand cutting, and the use of herbicides if necessary.

Tornadoes occurring within forested parts of the mitigation area have the potential to result in extreme tree mortality, depending on tornado magnitude and path size. Although a tornado may cause only patchy destruction, leaving areas of standing trees, it is likely that habitat with large areas of open canopy would be unsuitable for roosting.

Once a tornado triggers a changed circumstance, and within 1 year of the tornado event, Buckeye Wind will begin restoration activities in accordance with the approach described in Section 6.3.4 – Restoration and Enhancement. Actions will be implemented as described in Section 6.3 – Mitigation Measures, will be

[52] http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

consistent with ITP obligations, and will be funded (in whole or in part) by the Changed Circumstances fund (see Section 6.7 – Funding for the HCP).

7.2.1.7 Invasive Species and Vegetation Disease

Both invasive species and vegetation disease can threaten the health and productivity of forest ecosystems. Outbreaks of these 2 conditions may occur separately or vegetation disease may result from an invasive species. Trees within the mitigation area may be subject to a variety of diseases caused by parasitic fungi, bacteria, viruses, nematodes, and other non-invasive or invasive organisms (Asselin 2010). In addition to disease-causing invasive species, herbivorous or parasitic invasive species may destroy deciduous trees through over-consumption of leaves or bark or disruption of metabolic processes within the tree, and vegetative invasive species may out-compete deciduous trees for resources such as sunlight or water.

Diseases currently threatening OH's deciduous trees include Bacterial leaf scorch, caused by the bacterium *Xylella fastidiosa;* oak wilt, caused by the fungus *Ceratocystis fagacearum;* Sudden Oak Death, caused by the fungus *Phytophthora ramorum;* and Thousand Cankers Disease, caused by the walnut twig beetle (*Pityophthorus juglandis*); and the fungus *Geosmithis morbida* (ODNR Division of Forestry [DOF] 2011). Gypsy moth (*Lymantria dispar*), emerald ash borer (*Agrilus planipennis*), and jumping oak gall (caused by the *Neuroterus saltatorius* wasp) have affected many forests across OH in recent decades. The Asian longhorned beetle (*Anoplophora glabripennis*) was recently documented in Clermont County, OH, and ODNR is concerned that it and the hemlock woolly adelgid (*Adelges tsugae*) may soon spread to Ohio's forests. Tree-of-heaven (*Ailanthus altissima*), bush honeysuckle (*Lonicera* spp.), multiflora rose (*Rosa multiflora*), autumn olive (*Elaeagnus umbellata)*, Japanese honeysuckle (*Lonicera japonica*), glossy buckthorn (*Frangula alnus)*, and *Paulownia* spp. are harmful woody invasive plants common in OH.

It is not possible to predict with any certainty the frequency, extent, or severity of disease outbreaks or invasive species. However, climate change may influence the effects of disease and invasive species on tree species. In general, diseases tend to be more prevalent in warmer climates, and vegetation stressed by increased temperatures or more drastic weather patterns may be more susceptible to disease or may be out-competed by invasive species. Climate change may allow certain invasive species or pathogens to expand their range, impacting forests that are not adapted to sustain the impacts from these organisms (Battles et al. 2006). Drought-stressed forests within the mitigation area may experience an increase in the occurrence of diseases and invasive species, and new diseases and invasive species may arrive with increased temperatures.

Invasive species and vegetation disease may improve habitat for Indiana bats by increasing tree mortality, thereby creating standing snags and, potentially, openings in the forest canopy. However, invasive insect species may replace suitable prey species for Indiana bats or destroy herbaceous vegetation that supports prey species. Invasive woody species may replace the deciduous tree species that provide suitable roosting habitat. Additionally, disease and invasive species both have the potential to cause extensive tree mortality, which may result in unsuitable Indiana bat habitat.

As part of this HCP, mitigation will consist of preservation, enhancement, and restoration of land surrounding a P2 hibernaculum in OH. Mitigation actions are intended to offset the impacts of Project-related take, and therefore measureable thresholds set out in Section 6.3 – Mitigation Measures will be used to ensure that mitigation is effective. Although the mechanisms by which invasive plants, disease, and invasive animals affect the forest stand, the triggers for each are the same.

An invasive species or a vegetation disease will constitute a changed circumstance if documented evidence from recognized experts confirms the presence of an invasive species or a disease and monitoring determines that the invasion or disease has resulted in less than 2 small diameter snags, 5 medium diameter snags, and 2 large diameter snags per acre on average, less that 300 stems per acre on average, or woody invasive species that occupy more than 5% cover in the understory. It is anticipated that, at a minimum, the response to changed circumstances due to invasive species or vegetative disease would include 1 or more of the following activities, as described more fully in Section 6.3.4 – Restoration and Enhancement:

- Tree planting where tree mortality has reduced tree density to below an average of 300 stems/ac/PA;
- Tree girdling to return snag densities to the stated target; and
- Non-native woody invasive species control such that woody invasive species do not exceed 5%. Methods for clearing invasive species will include brush cutting (using bushhogs, mowers, or other similar equipment), hand cutting, and the use of herbicides if necessary.

Outbreaks of disease and invasive species are likely to result in increased tree mortality and therefore increased snag density. While this effect is beneficial in that it would result in increasing roosting opportunities within preserved areas, severe epidemics have the potential to result in extreme tree mortality, loss of forest canopy, and degradation of quality of Indiana bat habitat. Indiana bat roost trees have been documented in stands with canopy closure ranging from less than 20% to 80% for females and from 49% to 80% for males (Kurta 2005). Although roost trees can therefore be located in areas of open canopy, it is likely that large areas of high snag density, resulting in an open canopy, would be unsuitable for roosting.

Because it is not possible to predict at this time the outbreak, extent, or location of land that may be negatively affected by disease or invasive species, implementation of the restoration will occur within 1 year of the outbreak or invasion being controlled and will be tailored to specific impact(s) of the outbreak or invasion on individual mitigation parcels. For example, if the invasive species is the emerald ash borer, then ash trees will not be used to replant the mitigation parcel. Actions will be implemented as described in Section 6.3 – Mitigation Measures, will be consistent with ITP obligations, and will be funded (in whole or in part) by the Changed Circumstances fund (see Section 6.7 – Funding for the HCP).

7.2.1.8 Climate Change

Climate change is defined as an increase in global average temperature, due to observed increase in greenhouse gas concentrations as a result of human activity (IPCC 2007). Global average temperatures have increased by approximately 1.3°F (0.74°C) between 1900 and 2000 and are predicted to increase by as much as 11.5°F (11.4°C) by 2100 (IPCC 2007). In the Midwest, average summer temperatures are predicted to be 3°F to 4°F (1.5°C to 2°C) above current averages by 2025 – 2035 (Kling et al. 2003). By the end of the century, models predict that winter temperatures could increase up to 14°F (8°C) above current averages and summer temperatures could increase up to 16°F (9°C) above current averages, under high-emission (worst-case) scenarios (Kling et al. 2003).

As described in the preceding sections, climate change may affect the effectiveness of mitigation by increasing the frequency and magnitude of natural disasters and epidemics above historic patterns. Climate change is expected to increase the frequency and intensity of drought conditions in the summer months, thereby potentially increasing the frequency and severity of forest fires (Kling et al. 2003 as cited in Gomberg 2008). Winters and springs in OH are expected to be wetter, making flooding events more likely (Kling et al. 2003 as cited in Gomberg 2008). Tornadoes may increase in frequency and magnitude in OH and elsewhere as climate change results in more frequent and more severe thunderstorms, hurricanes, and extreme weather patterns (Dutzik and Willcox 2010). Due to increasing drought stress in forests, occurrence of diseases and invasive species may increase, and new diseases and invasive species may arrive with increased temperatures (Battles et al. 2006).

Climate change represents a reasonably foreseeable circumstance that may negatively impact Indiana bat populations. However, impacts are expected to be complex and widely varied, which makes it extremely difficult to plan for measures that can effectively minimize or mitigate such effects (Hall 2008, Myers 2008). For example, increased drought, forest fires, flooding, and intense storm events are predicted for OH in the coming decades (see previous sections). The extent to which the increased frequency and intensity of these events could impact Indiana bats within the 30-year ITP Term is not possible to know. The impacts of natural disaster and epidemic events on Indiana bats, discussed in detail in each of the circumstance-specific sections above, may be magnified as climate change increases the frequency or magnitude at which such impacts occur.. The triggers for taking responsive action due to changed circumstances for each of the sections above are primarily based on the effects of the changed circumstance (in terms of tree and snag density) rather than frequency or severity, and will therefore allow for more frequent events resulting from climate change effects. The threshold that would define these events as unforeseen circumstances are conservative and exceed historic record of occurrence (see Section 7.2.2 – Unforeseen Circumstances and "No Surprise." As a result, reasonable effects of climate change are adequately covered in this HCP.

Additionally, by generating clean energy that will help offset or replace carbon-emitting energy sources, such as coal and oil, the Project is helping to mitigate the effects of climate change. Refer to Section 1.3 – Purpose and Need for the Project and Section 5.4 – Potential Beneficial Effects of Wind Energy on Indiana Bats for additional information on the Project's contribution to minimizing climate change and the associated beneficial impacts on Indiana bats.

7.2.1.9 Use of New Methods, Information, or Technological Advances

Over the course of the ITP Term, new information on Indiana bats and wind power interactions may become available, new methods for monitoring mortality may be developed, or technological advances may be developed to minimize bat mortality at wind turbines. Buckeye Wind may wish to apply 1 or more of these new developments into the operations and/or monitoring plan outlined in the HCP. For example, the use of dogs to assist searchers has been studied and may become a viable method of monitoring. Dogs have been shown to increase searcher efficiency (Arnett 2005), although dogs will not be used for the first 2 years of monitoring per ODNR Protocol.

Use of chemicals to control vegetation around turbines is another monitoring method that may be employed. Chemical control may become the preferred method to improve searcher efficiency through vegetation removal. For example, it may not be feasible to mow all the required areas as outlined in this HCP. In this case, a chemical regime may be started in order to achieve the monitoring vegetative control requirements in this HCP.

Finally, there may be new information, methods, or procedures for monitoring or operation that may become available during the course of the ITP Term (see Section 6.5.3.6 – Special Cases). It is expected that over time, results of post-construction mortality monitoring, findings from research conducted as part of the conservation measures implemented under this HCP, and results from research and evaluation related to the wind industry made elsewhere will be used to inform changes to the operation and monitoring plans. The following results of post-construction monitoring and research comparing Indiana bat activity and interaction with wind turbines may help inform management actions, including adjusting the feathering regime when higher or lower feathering cut-in speeds are appropriate to avoid or minimize Indiana bat mortality:

- Results with respect to monitored weather conditions could identify factors that result in more or less risk to Indiana bats.
- Studies that look at nightly timing of foraging activity could inform the best times to feather turbines to limit Indiana bat mortality.
- Attraction studies could influence additional minimization and avoidance measures that could be taken to make turbines less attractive to Indiana bats.
- Studies that examine spatial use patterns with respect to turbines may provide evidence that establish trends in Indiana bats movement around turbines, which could be used to inform the feathering plans for the Project.
- If Indiana bats exhibited patterns of use that indicated avoidance of certain turbines, then these turbines could be feathered at the lower cut-in speed due to predicted lower risk and vice versa.
- Migration studies could help demonstrate if and what habitat features Indiana bats follow while migrating, and if they avoid landscape features such as wind farms.
- Enhanced understanding of migration characteristics such as flight height, speed, and distance could inform how effective and necessary feathering would be during migration periods depending on the flight height, turbine avoidance, and migratory pattern data.
- If studies are done to better understand habitat use and features preferred by Indiana bats, the mitigation measures may change to create a more attractive habitat enhancement as part of the mitigation measures for the HCP.
- Acoustic deterrent techniques or other deterrents may be developed and shown to significantly reduce Indiana bat interactions at turbines.
- New methods for estimating total fatality may be developed, including new methods for conducting trials to estimate bias, or new formulas to make more precise or accurate estimates.

Ideally, the results of these studies can be compared and merged to add strength to changes to the feathering and monitoring plans. Other, non-Project-related advancements in scientific understanding of Indiana bat biology and behavior may be used to inform changes to the avoidance, minimization, mitigation, and conservation measures. Any changes to the minimization measures would result in 2 years of Evaluation Phase monitoring to confirm the results.

Buckeye Wind may choose to utilize any alternative monitoring methods should they be demonstrated, based on the best available science, to be as or more effective than the methods described in this HCP, as approved by USFWS and ODNR DOW. Similarly, other technological advances or new techniques and information may become available during the course of the ITP Term that Buckeye Wind may want to use to more effectively implement other areas of the HCP such as adaptive management. Potential new techniques and/or information are described further in Section 6.5.3.6 – Special Cases. Buckeye Wind will work with USFWS to ensure that any new information or techniques that are planned to be used are compatible with the biological goals and objectives of the HCP.

Any new method, information or technology will only be considered if it has been demonstrated in an acceptable scientific study, has been approved by the USFWS as the best available science and will not require an increase in the take authorization for the Project.

7.2.2 Unforeseen Circumstances and "No Surprises"

Unforeseen circumstances include changes in circumstances that could not reasonably have been anticipated, and that result in a substantial and adverse change in the status of the Indiana bat. In addition to WNS, it is possible that other previously undetected diseases could impact Indiana bats in the future. Emergent infectious diseases represent circumstances that could impact Indiana bats in the future, but are unforeseen. There has been an increase in mass population declines and species extinction caused indirectly or directly by emerging infectious diseases in the past 20 years (Daszak et al. 2000, Daszak and Cunningham 2003) and emerging infectious diseases in wildlife populations are currently recognized as a major threat to global biodiversity (Cunningham 1996, Scott 1988, Daszak et al. 2000, Dobson and Foufopoulos 2001, Daszak and Cunningham 2003). The effects of emerging diseases can be exacerbated in populations that are stressed due to habitat loss, overexploitation, climate change, and pollution (Daszak et al. 2000, Harvell et al. 2002). This puts already threatened and endangered wildlife most at risk (Dobson and Foufopoulos 2001).

The increase in emergent diseases has been linked to a multitude of factors including antibiotic resistant microbes, centralization of the food processing industry, human encroachment into wildlife habitat, and globalization of human movement and trade (Aguirre and Tabor 2008, Daszak and Cunningham 2003, Cunningham et al. 2003, Karesh et al. 2005). Because the specific diseases or the mechanism by which they could affect Indiana bats is currently unknown and there is not sufficient information to currently predict this, impacts to Indiana bats from future emergent infectious diseases represent an unforeseen circumstance, excepting WNS, which is discussed in detail in Section 7.2.1.2 – White Nose Syndrome and assessed as part of this HCP.

Natural disasters or epidemics of unusual severity or frequency will be considered unforeseen circumstances and will not be considered for restoration or additional mitigation funding or actions. Unforeseen circumstances include, but by their unforeseen nature are not limited to, the following criteria:

- During the 30-year ITP Term, more than 6 periods of moderate drought, more than 1 period of severe drought, or 1 period of extreme drought [PHDI index value less than -4.00] will be considered an unforeseen circumstance and will not be considered for funding.
- During the 30-year ITP Term, more than 1 50-year flood or the occurrence of a 100-year flood will be considered an unforeseen circumstance and will not be considered for funding.
- During the 30-year ITP Term, more than 1 fire event (either mixed-severity or high-severity) will be considered an unforeseen circumstance and will not be considered for funding.
- During the 30-year ITP Term, unforeseen circumstances specific to tornadoes will include: more than 5 category F1 or F2 tornados; more than 1 F3 or F4 tornado; or any F5 tornado.
- During the 30-year ITP Term, more than 2 confirmed detrimental outbreak of vegetation disease or invasive species will be considered unforeseen. (A detrimental outbreak will reduce snag densities or stem densities, or increase woody invasive cover, beyond the thresholds described in Section 6.3.4 – Restoration and Enhancement.)

Should Buckeye Wind become aware of an unforeseen circumstance that has the potential to impact Indiana bats in the Action Area, Buckeye Wind shall notify USFWS within 30 days. Demonstrating that unforeseen circumstances exist is the burden of the USFWS and will be based on the best scientific and commercial data available. Consistent with the "No Surprises" policy [50 CFR 17.22 (b)(5)], established by the Department of the Interior and the Department of Commerce, if additional mitigation measures are deemed necessary to provide for the conservation of the Indiana bat that was otherwise adequately covered under the terms of the properly functioning HCP, the obligation for such measures shall not rest with Buckeye Wind. The "No Surprises" policy states, in part (50 CFR 17.22(b)(5):

> (ii) *Changed circumstances not provided for in the plan.* If additional conservation and mitigation measures are deemed necessary to respond to changed circumstances and such measures were not provided for in the plan's operating conservation program, the Director will not require any conservation and mitigation measures in addition to those provided for

in the plan without the consent of the permittee, provided the plan is being properly implemented.

(iii) *Unforeseen circumstances.*
(A) In negotiating unforeseen circumstances, the Director will not require the commitment of additional land, water, or financial compensation or additional restrictions on the use of land, water, or other natural resources beyond the level otherwise agreed upon for the species covered by the conservation plan without the consent of the permittee.
(B) If additional conservation and mitigation measures are deemed necessary to respond to unforeseen circumstances, the Director may require additional measures of the permittee where the conservation plan is being properly implemented, but only if such measures are limited to modifications within conserved habitat areas, if any, or to the conservation plan's operating conservation program for the affected species, and maintain the original terms of the conservation plan to the maximum extent possible. Additional conservation and mitigation measures will not involve the commitment of additional land, water or financial compensation or additional restrictions on the use of land, water, or other natural resources otherwise available for development or use under the original terms of the conservation plan without the consent of the permittee.

7.3 HCP Amendments

7.3.1 Minor Amendments

The USFWS or Buckeye Wind may propose minor modifications to the HCP by providing notice to the other party. Such notice shall include a statement of the reason for the proposed modification and an analysis of its environmental effects, including its effects on operations under the HCP and on Covered Species. The USFWS and Buckeye Wind will use reasonable efforts to respond to proposed modifications within sixty (60) days of receipt of such notice. Proposed modifications will become effective upon written approval of the USFWS and Buckeye Wind. If for any reason the USFWS or Buckeye Wind objects to a proposed modification, the modification must be processed as an amendment of the ITP in accordance with Section 7.3.2 – Amendment of the ITP. The USFWS will not propose or approve minor modifications to the HCP if the USFWS determines that such modifications would result in operations under the HCP that are significantly different from those analyzed in connection with this HCP, adverse effects on the environment that are new or significantly different from those analyzed in this HCP, or additional take not analyzed in this HCP.

Minor modifications to the HCP processed pursuant to this subsection may include but are not limited to the following:

- corrections of typographic, grammatical, and similar editing errors that do not change the intended meaning;
- corrections of any maps or exhibits to correct minor errors in mapping or to reflect previously approved changes in the ITP or HCP; and
- minor changes to survey, monitoring or reporting protocols.

Any other modifications to the HCP will be processed as amendments of the ITP in accordance with Section 7.3.2 – Amendment of the ITP below.

7.3.2 Amendment of the ITP

The ITP may be amended in accordance with all applicable legal requirements, including but not limited to the ESA, NEPA, and USFWS' regulations. The USFWS or Buckeye Wind may propose an amendment and will provide a statement of the reasons for the amendment and an analysis of its environmental effects, including its effects on operations under the HCP and on Covered Species.

7.3.3 Renewal of the ITP

Upon agreement of the USFWS and Buckeye Wind and compliance with all applicable laws and regulations, including but not limited to 50 C.F.R. § 13.22, the ITP Term may be extended beyond its initial term in accordance with USFWS regulations in force on the date of the renewal. If Buckeye Wind desires to renew the ITP Term, it will notify USFWS at least one hundred eighty (180) days before the then-current term is scheduled to expire. Extension of the ITP Term constitutes extension of the HCP for the same amount of time, subject to any modifications that the USFWS may require at the time of renewal.

8.0 REFERENCES CITED

Abraxas Energy Consulting, LLC. 2009. Emissions Calculator. <http://www.abraxasenergy.com/emissions/>. Accessed 21 January 2009.

Adam, M. D., M. J. Lacki, and T. G. Barnes. 1994. Foraging areas and habitat use of the Virginia big-eared bat in Kentucky. Journal of Wildlife Management 58:462-469.

Aguirre, A. A., and G. M. Tabor. 2008. Global factors driving emerging infectious diseases. Animal Biodiversity and Emerging Diseases 1149:1-3.

Ahlén, I. 2003. Wind turbines and bats: a pilot study. Final Report Dnr 5210P-2002- 00473, Swedish National Energy Commission, Eskilstuna, Sweden

Aldridge, H. D. J. N., and I. L. Rautenbach. 1987. Morphology, echolocation and resource partitioning in insectivorous bats. Journal of Animal Ecology 56:763-778.

Allen, G. M. 1939. Bats. Dover Publications, Inc., New York, USA.

Anonymous. 1961. Large bird kills at TV towers. Bluebird 28:9.

Anthony, E. L. 1988. Age determination. Pages 47-57 *in* T. H. Kunz, editor. Ecological and behavioral methods for the study of bats. Smithsonian Institution Press, Washington, D.C., USA.

Anthony, E. L. P., M. J. Stack, and T. H. Kunz. 1981. Night roosting and nocturnal time budget of the little brown bat, *Myotis lucifugus*: effects of reproductive status, prey density, and environmental conditions. Oecologia 51:151–156.

Arnett, E. B., technical editor. 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. A final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas.

Arnett, E. B., W. K. Brown, W. P. Erickson, J. K. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. J. O'Connell, M. D. Piorkowski, and R. D. Takersley Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72:61-78.

Arnett, E. B., M. R. Schirmacher, M. M. P. Huso, and J. P. Hayes. 2009. Patterns of bat fatality at the Casselman Wind Project in south-central Pennsylvania. An annual report submitted to the Bats and Wind Energy Cooperative and the Pennsylvania Game Commission. Bat Conservation International. Austin, Texas.

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

Arnett, E. B., M. Schirmacher, M. M. P. Huso, and J. P. Hayes. 2011. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment 9:209-214.

Asselin, A. 2011. Plant Disease. The Canadian Encyclopedia. Historical Foundation of Canada. <http://www.thecanadianencyclopedia.com/index.cfm?PgNm=TCE&Params=A1ARTA0006329> Accessed 14 October 2011.

Avery, M. I. 1985. Winter activity of pipistrelle bats. Journal of Animal Ecology 54:721–738.

Avery, M., and T. Clement. 1972. Bird mortality at four towers in eastern North Dakota: Fall 1972. Prairie Naturalist 4:87-95.

Avian Power Line Interaction Committee [APLIC]. 2006. Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006. Edison Electric Institute, APLIC, and the California Energy Commission. Washington, DC and Sacramento, CA.

Backlund, P., A. Janetos, and D. Schimel. 2008. The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States: Synthesis and Assessment Product 4.3. U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Washington, D. C., USA.

Baerwald, E.F. 2008a. Variation in the activity and fatality of migratory bats at wind energy facilities in southern Alberta: causes and consequences. Master's thesis, University of Calgary, Calgary, Alberta, Canada.

Baerwald, E. F., G. H. D'Amours, B. J. Klug, and R. M. R. Barclay. 2008b. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18. <http://www.wbwg.org/conservation/papers/BaerwaldetalCurrentBiology2008.pdf>. Accessed 6 April 2010.

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 73:1077-1081.

Barber, J. R., K. Crooks, and K. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. Trends in Ecology and Evolution. 25(3):180-189.

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

Barclay, R. M. R. 1985. Long- versus short-range foraging strategies of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats and the consequences for prey selection. Canadian Journal of Zoology 63:2507-2515.

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

Barclay, R. M. R., and L. D. Harder. 2003. Life histories of bats: life in the slow lane. Pages 209–253 *in* T. H. Kunz and M. B. Fenton, editors. Bat ecology. University of Chicago Press, Chicago, Illinois, USA.

Barclay, R. M. R., and A. Kurta. 2007. Ecology and behavior of bats roosting in tree cavities and under bark. Pages 17-59 *in* J. Lacki, J. P. Hayes, and A. Kurta, editors. Bats in forests: conservation and management. John Hopkins University Press, Baltimore, USA.

Barclay, R. M. R., J. Ulmer, C. J. A. MacKenzie, M. S. Thompson, L. Olson, J. McCool, E. Cropley, and G. Poll. 2004. Variation in reproductive rate of bats. Canadian Journal of Zoology 82:688-693.

Bat Conservation International [BCI]. 2010a. WNS fungus hits endangered gray bats. <http://www.batcon.org/pdfs/whitenose/WNSGrayBat%205-17-2010%20(2).pdf> Accessed 1 June 2010.

Bat Conservation International [BCI]. 2010b. WNS Briefing. February 16, 2010.

Battles, J.J., T. Robards, A. Das, K. Waring, J.K. Gilless, F. Schurr, J. LBlanc, G. Biging, and C. Simon. 2006. Climate Change Impact on Forest Resources. A Report from: California Climate Change Center. White Paper. March 2006. CEC-500-2005-193-SF. 28 pp.

Batulevicius D., N. Pauziene, and D. H. Pauza. 2001. Dental incremental lines in some small species of the European vespertilionid bats. Acta Theriologica 46:33-42.

Belwood, J. J. 1979. Feeding ecology of an Indiana bat community with emphasis on the endangered Indiana bat, *Myotis sodalis*. Thesis, University of Florida, Gainesville, USA.

Belwood, J. J. 2002. Endangered bats in suburbia: observations and concerns for the future. Pages 193-198 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

BHE Environmental, Inc., 2010. Post-construction bird and bat mortality study Cedar Ridge Wind Farm Fond Du Lac County, Wisconsin. An interim report prepared for Wisconsin Power and Light, Madison, Wisconsin. BHE Environmental, Inc., Cincinnati, Ohio.

Blehert D. S., A. C. Hicks, M. Behr, C. U. Meteyer, B. M. Berlowski-Zier, E. L. Buckles, J. T. H. Coleman, S. R. Darling, A. Gargas, R. Niver, J. C. Okoniewski, R. J. Rudd, and W. B. Stone. 2009. Bat white-nose syndrome: an emerging fungal pathogen? Science 323:227.

Bolker, E. D., J. J. Hatch, and Catalin Zara. 2006. Modeling bird passage through a windfarm. <http://www.cs.umb.edu/~eb/windfarm> Accessed January 2010.

Bowles, J. B. 1981. Final report, 1980–1981, ecological studies on the Indiana bat in Iowa. Unpublished report, Iowa Conservation Commission, Des Moines, Iowa.

Boyles, J. G., B. L. Walters, J. O. Whitaker, and J. B. Cope. 2007. A reanalysis of apparent survival rates of Indiana myotis (*Myotis sodalis*). Acta Chiropterologica 9:127-132.

Brack, V., Jr. 1983. The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, *Myotis sodalis*. Dissertation, Purdue University, West Lafayette, USA.

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

Brack, V., Jr., S. Johnson, and C. Stihler. 2005. Winter hibernacula temperatures used by Indiana bats in: (1) caves in Indiana; (2) a mine in Preble County, Ohio; (3) caves in West Virginia; and (4) caves in Bland County, Virginia. Report prepared for the Indiana Bat Risk Assessment Workshop, Shepherdstown, West Virginia, USA.

Brack, V., Jr., and R. K. LaVal. 1985. Food habits of the Indiana bat in Missouri. Journal of Mammalogy 66:308-315.

Brack, V., Jr., C. W. Stihler, R. J. Reynolds, C. M. Butchkoski, and C. S. Hobson. 2002. Effect of climate and elevation on distribution and abundance in the mideastern United States. Pages 21-28 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Bradshaw, P. A. 1996. The physical nature of vertical forest habitat and its importance in shaping bat species assemblages. Pages 199–212 *in* R. M. Barclay and R. M. Brigham, editors. Bats and forests symposium, Victoria, Canada.

Brinkman, R. 2006. Survey of possible operational impacts on bats by wind facilities in southern Germany. Report for Administrative District of Freiburg Department 56, Conservation and Landscape Management. Ecological Consultancy, Gundelfingen, Germany.

Britzke, E. R. 2003. Spring roosting ecology of female Indiana bats (*Myotis sodalis*) in the Northeastern United States. U.S. Fish and Wildlife Service, Concord, New Hampshire, USA.

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

Britzke, E. R., A. C. Hicks, S. L. von Oettingen, and S. R. Darling. 2006. Description of spring roost trees used by female Indiana Bats (*Myotis sodalis*) in the Lake Champlain Valley of Vermont and New York. American Midland Naturalist 155:181-187.

Brown, W. K., and B. L. Hamilton. 2002. Draft report: bird and bat interactions with wind turbines Castle River Wind Farm, Alberta. Report prepared for VisionQuest Windelectric, Inc., Calgary, Alberta, Canada.

Brown, W. K. and B. L. Hamilton. 2004. Bird and bat mortality at the McBride Lake Wind Farm, Alberta 2003-2004. Prepared for Vision Quest Windelectric Inc., Calgary, Alberta, Canada. <http://www.batsandwind.org/pdf/McBride%20Alberta%20Canada.pdf>. Accessed 24 February 2011.

Brown, W.K. and B.L. Hamilton. 2006a. Bird and bat interactions with wind turbines Castle River Wind Facility, Alberta, 2001-2002. Report for Vision Quest Windelectric, Inc., Calgary, Alberta, Canada. <http://www.batsandwind.org/pdf/Castle%20River%20Alberta%20Canada.pdf>. Accessed 24 February 2011.

Brown, W.K. and B.L. Hamilton. 2006b. Monitoring of bird and bat collisions with wind turbines at the Summerview Wind Power Project, Alberta: 2005-2006. Prepared for Vision Quest Windelectric, Calgary, Alberta by TEAM Ltd., Calgary, Alberta, and BLH Environmental Services, Pincher Creek, Alberta. <http://www.batsandwind.org/pdf/Brown2006.pdf>. Accessed 23 February 2011.

Brumm, H., and H. Slabbekoorn. 2005. Acoustic communication in noise. Advanced Studies in Behavior 35:151–209.

Buchler, E. R., and S. B. Childs. 1981. Orientation to distant sounds by foraging big brown bats (*Eptesicus fuscus*). Animal Behaviour 29:428-432.

Burger, J., D. Graves, P. Angel, V. Davis, and C. Zipper. 2005. The Forestry Reclamation Approach. Forest Reclamation Advisory No. 2. U.S. Office of Surface Mining. < http://arri.osmre.gov/>. Accessed 1 October 2010.

Burgman, M. A., and Fox J. C. 2003. Bias in species range estimates from minimum convex polygons: implications for conservation and options for improved planning. Animal Conservation 6:19-28.

Butchkoski C. 2009. Indiana Bat (*Myotis sodalis*) Summer Roost Investigations. Annual job report. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

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

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

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

Butchkoski, C. M., and G. Turner. 2008. Indiana bat (*Myotis sodalis*) summer roost investigations. Annual job report. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

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

Callahan, E. V. 1993. Indiana bat summer habitat requirements. Thesis, University of Missouri, Columbia, USA.

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

Canham, C. D., Cole, J. J., Lauenroth, W. K. eds. 2003. Models in EcoSystem Science. Princeton University Press. Princeton, New Jersey. 420 pp.

Carter, T. C. 2003. Summer habitat use of roost trees by the endangered Indiana bat (*Myotis sodalis*) in the Shawnee National Forest of southern Illinois. Dissertation, Southern Illinois University, Carbondale, USA.

Carter, T. C., G. Feldhamer, and J. Kath. 2001. Notes on summer roosting of Indiana bats. Bat Research News 42:197-198.

Center for Biological Diversity [CBD]. 2010. Petition to list the eastern small-footed bat (*Myotis leibii)* and northern long-eared bat (*Myotis septentrionalis)* as threatened or endangered under the Endangered Species Act. Tucson, USA.

Charnov, E. L. 1993. Life History Invariants: Some Explorations of Symmetry in Evolutionary Ecology. Oxford University Press, Oxford, United Kingdom.

Chenger, J. 2003. Iowa Army Ammunition Plant 2003 Indiana bat investigations. Unpublished report. Iowa Army Ammunition Plant, Middletown, Iowa, USA.

Chenger, J. 2006. 2006 Mt. Hope – Hibernia Indiana bat migration study. Prepared for Picatinny Arsenal Environmental Affairs Office, Dover, NJ, 1 November 2006.

Clawson, R. L. 1986. An investigation of the summer distribution and status of Indiana bats in Missouri. U.S. Fish and Wildlife Service. Federal Aid Project W-13-R-40, Washington, D.C., USA.

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, USA.

Clawson, R. L., R. K. LaVal, M. L. LaVal, and W. Caire. 1980. Clustering behavior of hibernating *Myotis sodalis* in Missouri. Journal of Mammalogy 61:245-253.

Cooke, W. W. 1915. Bird migration. U.S. Department of Agriculture Bulletin 185:1-47.

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

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

Crawford, R. L., and W. W. Baker. 1981. Bats killed at north Florida television tower: a 25-year record. Journal of Mammalogy 62:651-652.

Crome, F. J. H., and G. C. Richards. 1988. Bats and gaps: microchiropteran community structure in a Queensland rain forest. Ecology 69:1960-1969.

Cryan, P. M. 2003. Migration and thermoregulation strategies of hoary bats (*Lasiurus cinereus*) in North America. Dissertation, University of New Mexico, Albuquerque, USA.

Cryan, P. M., M. A. Bogan, R. O. Rye, G. P. Landis, and C. L. Kester. 2004. Stable hydrogen isotope analysis of bat hair as evidence for seasonal molt and long-distance migration. Journal of Mammalogy 85:995–1001.

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

Cryan, P. M., and J. P. Veilleux. 2007. Migration and the use of autumn, winter, and spring roosts by tree bats. Pages 153-175 *in* M.J. Lacki, J.P. Hayes, and A. Kurta, editors. Bats in forests: Conservation and Management. The Johns Hopkins University Press, Baltimore, USA.

Cryan, P. M., C. U. Meteyer, J. G. Boyles, and d. S. Blehert. 2010. Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology. BMC Biology 8:135-142.

Cunningham, A. A. 1996. Disease risk of wildlife translocations. Conservation Biology 10:349-353.

Cunningham, A. A., P. Daszak, and J. P. Rodrıguez. 2003. Pathogen pollution: defining a parasitological threat to biodiversity conservation. Journal of Parasitology 89:S78–S83.

Currie, R. R. 2002. Response to gates at hibernacula. Pages 86-99 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Daszak, P, and A. A. Cunningham. 2003. Anthropogenic change, biodiversity loss, and a new agenda for emerging diseases. Journal of Parasitology 89:S37-S41.

Daszak, P., A. A. Cunningham, and A. D. Hyatt. 2000. Emerging infectious diseases of wildlife—threats to biodiversity and human health. Science 287:443–449.

Daszak, P., A. A. Cunningham, and A. D. Hyatt. 2003. Infectious disease and amphibian population declines. Diversity and Distributions 9:141-150.

Davis, V., J. Franklin, C. Zipper, and P. Angel. 2010. Planting hardwood tree seedlings on reclaimed mine land in Appalachia. The Appalachian Regional Reforestation Initiative (ARRI) Forest Reclamation Advisory No. 7, February, 2010.

Dedon, M., S. Byrne, J. Aycrigg, and P. Hartman. 1989. Bird mortality in relation to the Mare Island 115-kV transmission line: progress report 1988/1989. Department of the Navy, Western Division, Naval Facilities Engineering Command, Office of Environmental Management, San Bruno, California, USA.

De Jong, J., and I. Ahlén. 1991. Factors affecting the distribution pattern of bats in the Uppland, central Sweden. Holarctic Ecology 14:92-96.

Derby, C., A. Dahl, W. Erickson, K. Bay, and J. Hoban, 2007. Post-construction monitoring report for avian and bat mortality at the NPPD Ainsworth Wind Farm. Prepared for Nebraska Public Power District, Columbus, Nebraska. Western EcoSystems Technology, Inc., Cheyenne, Wyoming.

Dobson, A and J. Foufopoulos. 2001. Emerging infectious pathogens in wildlife. Philosophical Transactions of the Royal Society of Biological Sciences 356:1001-1012.

Drake, D., J. Garvin, S. Grodsky, and M. Watt. 2010. Post-construction bird and bat monitoring at the Forward Energy Center. Report prepared for Forward Energy, LCC., Chicago, USA.

Drobney, R. D., and R. L. Clawson. 1995. Indiana bats. Pages 97-98 *in* E.T. LaRoe, G. S. Farris, C. E. Puckett, P. D. Doran, and M. J. Mac, editors. Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. U.S. Department of the Interior, National Biological Service. <http://biology.usgs.gov/s+t/noframe/c164.htm>. Accessed 18 May 2010.

Ducks Unlimited [DU]. 2009. Updating the National Wetlands Inventory (NWI) for Ohio Final Report Submitted to: Ohio Department of Natural Resources. Great Lakes/ Atlantic Regional Office. Ann Arbor, Michigan. USA. <http://www.ducks.org/Conservation/GLARO/3822/GISNWIData.html#oh>. Accessed 1 June 2010.

Durr, T., and L. Bach. 2004. Bat deaths and wind turbines: a review of current knowledge, and of the information available in the database for Germany. Bremer Beitrage fur Naturkunde und Naturschutz 7:253–264.

Dutzik, T. and N. Willcox. 2010. Global Warming and Extreme Weather: The Science, the Forecast, and the Impacts on America. Environment Ohio Research and Policy Center. September 2010. 48 pp.

Elder, W. H., and J. Hansen.1967. Bird mortality at KOMU-TV tower, Columbia, Missouri, fall 1965 and 1966. The Bluebird 34:3–6.

Elliott, W. R. 2008. Gray and Indiana Bat population trends in Missouri. Pages 46-61 *in* W. R. Elliott, editor. Proceedings of the 18th National Cave and Karst Management Symposium, St. Louis, USA.

Elliott, W. R., and R. L. Clawson. 2001. Temperature data logging in Missouri bat caves. Pages 52–57 *in* G.T. Rea, editor. Proceedings of the 1999 National Cave and Karst Management Symposium, Chattanooga, Tennessee, USA.

Enk, T., K. Bay, M. Sonnenberg, J. Baker, M. Kesterke, J. Boehrs, and A. Palochak. 2010. Biglow Canyon Wind Farm Phase I post-construction avian and bat monitoring second annual report, Sherman County, Oregon. Prepared for Portland General Electric Company, Portland, Oregon. Prepared by Western EcoSystems Technology, Inc.(WEST) Cheyenne, Wyoming, and Walla Walla, Washington. <http://www.oregon.gov/ENERGY/SITING/docs/BCW_2009MonitoringReport.pdf?ga=t>. Accessed 24 2011.

Environmental Design and Research [EDR]. 2009. Application to the Ohio Power Siting Board for a Certificate of Environmental Compatibility & Public Need for the Buckeye Wind Project. Buckeye Wind, LLC., Syracuse, USA.

Environmental Solutions and Innovations [ESI], Inc. 2009. A 2009 Winter Census of Bats of the Lewisburg Limestone Mine Preble County, Ohio. Ohio Division of Wildlife, Ohio Department of Natural Resources, Columbus, USA.

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000. Avian and bat mortality associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 Study Year. Technical report prepared by WEST, Inc. for Umatilla County Department of Resource Services and Development, Pendleton. <http://west-inc.com/reports/vansyclereportnet.pdf>. Accessed 23 February 2011.

Erickson, W. P., J. Jeffrey, K. Kronner, and K. Bay. 2003a. Stateline Wind Project Wildlife Monitoring Annual Report, Results for the Period July 2001 December 2002. FPL Energy, the Oregon Office of Energy, and the Stateline Technical Advisory Committee, Salem, USA.

Erickson, W.P., K. Kronner, and B. Gritski. 2003b. Nine Canyon Wind Power Project avian and bat monitoring report. September 2002 – August 2003. Prepared for the Nine Canyon Technical Advisory Committee and Energy Northwest by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Northwest Wildlife Consultants (NWC), Pendleton, Oregon. <http://www.west-inc.com/reports/nine_canyon_monitoring_final.pdf>. Accessed 23 February 2011.

Erickson, W.P., J. Jeffrey, K. Kronner, and K. Bay. 2004. Stateline Wind Project wildlife monitoring final report: July 2001 - December 2003. Technical report for and peer-reviewed by FPL Energy, Stateline Technical Advisory Committee, and the Oregon Energy Facility Siting Council, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Walla Walla, Washington, and Northwest Wildlife Consultants (NWC), Pendleton, Oregon. <http://www.west-inc.com/reports/swp_final_dec04.pdf>. Accessed 23 February 2011.

Erickson, W.P., J. Jeffrey, and V.K. Poulton. 2008. Puget Sound Energy Wild Horse Wind Facility post-construction avian and bat monitoring first annual report. Prepared for Puget Sound Energy, Ellensburg, Washington, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. <http://www.efsec.wa.gov/wildhorse/Supplemental%20EIS/DSEIS/WILDHORSE%20Wind%20Project%20_%20First%20Annual%20Monitoring%20Report_012808.pdf>. Accessed 23 February 2011.

Erickson, W., G. Johnson, D. Young, D. Strickland, R. Good, M. Bourassa, K. Bay and K. Sernka. 2002. Synthesis and comparison of baseline avian and bat use, raptor nesting and mortality information from proposed and existing wind developments: Final Report for Bonneville Power Administration. West, Inc., Cheyenne, Wyoming, USA.

Erkert, H. G. 1982. Ecological aspects of bat activity rhythms. Pages 201-242 *in* T.H. Kunz, editor. Ecology of Bats. Plenum Press, New York, USA.

Farney, J., and E. D. Fleharty. 1969. Aspect ratio, loading, wing span, and membrane areas of bats. Journal of Mammalogy 50:362-367.

Federal Aviation Administration [FAA]. 2007. Obstruction marking and lighting. Advisory Circular AC 70/7460-1K, U.S. Department of Transportation. Washington, D.C., USA.

Fenton, M. B. 1997. Science and the Conservation of Bats. Journal of Mammalogy 78:1-14.

Fenton, M. B. 2001. Bats, Revised Edition. Checkmark Books, New York, USA.

Fiedler, J. K. 2004. Assessment of bat mortality and activity at Buffalo Mountain Windfarm, eastern Tennessee. Thesis, University of Tennessee, Knoxville, USA.

Fiedler, J. K., T. H. Henry, R. D. Tankersley, and C. P. Nicholson. 2007. Results of bat and bird monitoring at the expanded Buffalo Mountain Windfarm, 2005. Tennessee Valley Authority. <http://www.tva.gov/environment/bmw_report/results.pdf>. Accessed 12 April 2010.

Findley, J. S., and C. Jones. 1964. Seasonal distribution of the hoary bat. Journal of Mammalogy 45:461-470.

Fire Regime Condition Class [FRCC]. 2010. FRCC Guidebook Version 3.0, September 2010. <http://frames.nbii.gov/portal/server.pt?open=512&objID=309&&PageID=1397&mode=2&in_hi_userid=2&cached=true>> Accessed July 2011.

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.

Ford, W. M., J. M. Menzel, M. A. Mensel, and J. W. Edwards. 2002. Summer roost-tree selection by a male Indiana bat on the Fernow Experimental Forest. U.S. Department of Agriculture, U.S. Forest Service. Research Note NE-378. Newton Square, Pennsylvania, USA.

Frick, W. F., Pollock, J. F., Hicks, A. C., Langwig, K. E., Reynolds, D. S., Turner, G. G., Butchkoski, C. M., and T. H. Kunz. 2010. An emerging disease causes regional population collapse of a common North American bat species. Science 329:679-682.

Frick, W. F., D. S. Reynolds, and T. H. Kunz. 2009. Influence of climate and reproductive timing on demography of little brown myotis *Myotis lucifugus*. Journal of Animal Ecology 79:128-136.

Furlonger, C. L., H. J. Dewar, and M. B. Fenton. 1987. Habitat use by foraging bats. Canadian Journal of Zoology 65:284–288.

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

Ganier, A. F. 1962. Bird casualties at a Nashville TV tower. Migrant 33:58-60.

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.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1989. A portable mist-netting system for capturing bats with emphasis on *Myotis sodalis* (Indiana bat). Bat Research News 30:1-8.

Gardner, J. E., J. D. Garner, and J. E. Hoffman. 1991a. Summer roost selection and roosting behavior of *Myotis sodalis* (Indiana bat) in Illinois. Illinois Natural History Survey, Bloomington, Illinois.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991b. Summary of *Myotis sodalis* summer habitat studies in Illinois: with recommendations for impact assessment. Indiana/Gray bat Recovery Team Meeting, Columbia, USA.

Gardner, J.E., J.E. Hofmann, and J. D. Garner. 1996. Summer distribution of the Federally endangered Indiana bat (*Myotis sodalis*) in Illinois. Transactions of the Illinois State Academy of Science 89:187-196.

Garner, J. D., and J. E. Gardner. 1992. Determination of summer distribution and habitat utilization of the Indiana bat (*Myotis sodalis)* in Illinois. Project E-3, Illinois Department of Conservation, Springfield, USA. Gollop, M. A. 1965. Bird migration collision casualties at Saskatoon. Blue Jay 23:15-17.

Good, R. E., W. 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. Western EcoSystems Technology, Inc., Cheyenne, Wyoming.

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 1 – October 31, 2011. Prepared for Fowler Ridge Wind Farm, Fowler, Indiana. Prepared by Western EcoSystems Technology, Inc. Bloomington, Indiana.

Gomberg, A. 2008. What's at Stake: How Global Warming Threatens the Buckeye State. Environment Ohio Research and Policy Center, Timothy Telleen-Lawton, Frontier Group. <http://www.environmentohio.org/reports/global-warming/global-warming/whats-at-stake-how-global-warming-threatens-the-buckeye-state> Accessed 15 December 2010.

Great Lakes Regional Assessment Group. 2000. Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change: Great Lakes Overview. < http://www.gcrio.org/NationalAssessment/greatlakes/greatlakes.pdf >. Accessed 1 October 2010.

Greenhall, A. 1973. Indiana bat: a cave-dweller in trouble. National Parks Conservation Magazine 47:14-17.

Griffin, D. R. 1970. Migrations and homing of bats. Pages 233-264 *in* W. A. Wimsatt, editor. Biology of bats. Academic Press, New York, USA.

Gruver, J. C., M. Sonnenberg, K. Bay, and W.P. Erickson. 2009. Results of a Post-Construction Bat and Bird Fatality Study at Blue Sky Green Field Wind Energy Center, Fond du Lac County, Wisconsin, July 2008 May 2009. Final report prepared for We Energies, Milwaukee, WI. Prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming, USA.

Gumbert, M. W. 2001. Seasonal roost tree use by Indiana bats in the Somerset Ranger District of the Daniel Boone National Forest, Kentucky. Thesis. Eastern Kentucky University, Richmond, USA.

Gumbert, M. W., J. M. O'Keefe, and J. R. MacGregor. 2002. Roost fidelity in Kentucky. Pages 143-152 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species Bat Conservation International, Austin, USA.

Hall, H. D. 2008. Expectations for consultations on actions that would emit greenhouse gases. Memorandum from H. Dale Hall, FWS Director, to Regional Directors of FWS, May 14, 2008. <http://www.fws.gov/policy/m0331.pdf>. Accessed December 2011.

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

Handwerk, B. 2008. Wind Turbines Give Bats the "Bends," Study Finds. National Geographic News. August 25, 2008. <http://news.nationalgeographic.com/news/pf/61204214.html>. Accessed January 2010.

Harvell, C. D., K. Kim, J. M. Burkholder, R. R. Colwell, P. R. Epstein, D. J. Grimes, E. E. Hofmann, E. K. Lipp, A. D. M. E. Osterhaus, R. M. Overstreet, J. W. Porter, G. W. Smith, and G. R. Vasta. 2002. Emerging marine diseases-climate links and anthropogenic factors. Science 285:1505-1510.

Harvey, M. J. 2002. Status and ecology in the southern United States. Pages 29-34 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Texas, USA.

Hawkins, J.A., J. Jaskula, A. Mann, and V. Brack, Jr. 2005. Habitat Conservation Plan: 2004 telemetry study of autumn swarming behavior of the Indiana bat (Myotis sodalis). Report prepared for the Indiana Department of Natural Resources, Indianapolis, IN. 25 pp. plus appendices.

Hayes, J. P. 1997. Temporal variation in activity of bats and the design of echolocation monitoring studies. Journal of Mammalogy 78:1-524.

Hayes, J. P., and J. C. Gruver. 2000. Vertical stratification of activity of bats in an old-growth forest in western Washington. Northwest Science 74:102-108.

Henshaw, R. E. 1965. Physiology of hibernation and acclimatization in two species of bats (*Myotis lucifugus* and *Myotis sodalis*). Dissertation, University of Iowa, Iowa City, USA.

Herzog, C. and R. Reynolds. 2012. Epicenter Regional Update. Proceedings from the 5th Annual White-Nose Syndrome Symposium, June 4-7, 2012, Madison, Wisconson.

Hessler Associates, Inc. 2009. Environmental sound survey and noise impact assessment, Buckeye Wind Project. Prepared for EverPower Wind Holdings, Inc. Hessler Associates, Inc. Haymarket, Virginia, USA.

Hicks, A., E. Britzke, C. Herzog, J. Coleman, D. Redell, A. Kurta, J. Kath, J. Dickson, R. Reynolds, S. Darling, M. Valent, G. Turner, and C. Dobony. 2012. Banding begins to determine if WNS survivors occur in the Northeast. Proceedings from the 5th Annual White-Nose Syndrome Symposium, June 4-7, 2012, Madison, Wisconson.

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>. Accessed May 2010.

Hicks, A. C., and P. G. Novak. 2002. History, status, and behavior of hibernating populations in the northeast. Pages 35-47 in A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Homer, C. C. Huang, L. Yang, B. Wylie, and M. Coan. 2004. Development of a 2001 National Landcover Database for the United States. Photogrammetric Engineering and Remote Sensing 70:829-840.

Horn, J. W., E. B. Arnett, and T. H. Kunz. 2008. Behavioral Responses of Bats to Operating Wind Turbines. Journal of Wildlife Management 72:123-132.

Howe, R. W., W. Evans, and A. T. Wolf. 2002. Effects of wind turbines on birds and bats in northeastern Wisconsin. Wisconsin Public Service Corporation, Green Bay, USA.

Hull and Associates, Inc [Hull]. 2009. Surface Waters, Ecological Communities, and Threatened and Endangered Species. Buckeye Wind, LLC., New York, USA.

Hull and Associates, Inc [Hull]. 2010. Draft Surface Water Delineation Report. EverPower Wind Holdings, New York, USA.

Humphrey, S. R. 1978. Status, winter habitat, and management of the endangered Indiana bat, *Myotis sodalis*. Florida Scientist 41:65-76.

Humphrey, S. R. 1992. Indiana bat *Myotis sodalis*, family *Vespertilionidae*, order *Chiroptera*. Pages 54-62 *in* S. Humphrey, editor. Volume 1: Rare and endangered biota of Florida. University Press of Florida, Tallahassee, USA.

Humphrey, S. R., and J. B. Cope. 1977. Survival rates of the endangered Indiana bat, *Myotis sodalis*. Journal of Mammalogy 58:32-36.

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

Humphries, M. M., D. W. Thomas, and D. L. Kramer. 2003. The role of energy availability in mammalian hibernation: a cost-benefit approach. Physiological and Biochemical Zoology 76:165-179.

Humphries, M. M., D. W. Thomas, and J. R. Speakman. 2002. Climate-mediated energetic constraints on the distribution of hibernating mammals. Nature 418:313–316.

Huso, M. M. P. 2010. An estimator of wildlife fatality from observed carcasses. Environmetrics 22:318-329.

Indiana Department of Natural Resources. 2001. Resource Management Strategy for Indiana Bat on Indiana State Forests (Revised April 2008). http://www.in.gov/dnr/files/I-H-1_Strategy_for_Indiana_Bat.pdf. Accessed November 2011.

Intergovernmental Panel on Climate Change [IPCC]. 2007. Climate Change 2007: The Physical Science Basis. S. Solomon, D. Qin, and M. Manning, editors. Contribution of Working Group to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Paris, France.

Jackson Environmental Consulting Services, LLC. 2009. Bat species inventory of Champaign County wind turbine project. Champaign County, Ohio.

Jacobson, D., and C. High. 2008. Wind Energy and Air Emission Reduction Benefits: A Primer. U.S. Department of Energy, National Renewable Energy Laboratory, Office of Energy Efficiency and Renewable Energy. <http://www.windpoweringamerica.gov/pdfs/policy/wind_air_emissions.pdf>. Accessed 10 March 2010.

Jacques Whitford Stantec Limited, 2009. Ripley Wind Power project post-construction monitoring report. Submitted to Suncor Energy Products Inc. and Acciona Energy Products Inc., Calgary, Alberta, Canada. Jacques Whitford Stantec Ltd., Markham, Ontario, Canada.

Jackson Environmental Consulting Services, LLC. 2009. Bat species inventory of Champaign County wind turbine project. Champaign County, Ohio. 34 pp. + Appendices.

Jain, A. A. 2005. Bird and bat behavior and mortality at a northern Iowa wind farm. Thesis, Iowa State University, Ames, USA.Jain, A. A, P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study–2006. Annual report prepared for PPM Energy and Horizon Energy. Curry and Kerlinger LLC., McLean, Virginia, USA.

Jain, A. A, P. Kerlinger, R. Curry, and L. Slobodnik. 2007. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study–2006. Annual report prepared for PPM Energy and Horizon Energy. Curry and Kerlinger LLC., McLean, Virginia.

Jain, A. A, P. Kerlinger, R. Curry, and L. Slobodnik. 2009a. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study–2007. Annual report prepared for PPM Energy and Horizon Energy. Curry and Kerlinger LLC., McLean, Virginia.

Jain, A. A, P. Kerlinger, R. Curry, L. Slobodnik, and M. Lehman. 2009b. Annual report for the Maple Ridge wind power project post-construction bird and bat fatality study–2008. Annual report prepared for Iberdrola Renewables, Inc. and Horizon Energy. Curry and Kerlinger LLC., McLean, Virginia.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, J. Quant, and D. Pursell, 2009c. Annual report for the Noble Bliss Windpark, LLC postconstruction bird and bat fatality study 2008. Curry and Kerlinger, LLC, Syracuse, New York.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, A. Fuerst and C. Hansen, 2009d. Annual report for the Noble Ellenburg Windpark, LLC postconstruction bird and bat fatality study 2008. Curry and Kerlinger, LLC, Syracuse, New York.

Jain, A., P. Kerlinger, R. Curry, L. Slobodnik, J. Histed and J. Meacham, 2009e. Annual report for the Noble Clinton Windpark, LLC postconstruction bird and bat fatality study 2008. Curry and Kerlinger, LLC, Syracuse, New York.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, A. Fuerst, and A. Harte. 2010a. Annual report for the Noble Bliss Windpark, LLC postconstruction bird and bat fatality study 2009. Curry and Kerlinger, LLC, Cape May, New Jersey.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, and K. Russell. 2010b. Annual report for the Noble Clinton Windpark, LLC postconstruction bird and bat fatality study 2009. Curry and Kerlinger, LLC, Cape May, New Jersey.

Jain, A., P. Kerlinger, L. Slobodnik, R. Curry, and K. Russell. 2010c. Annual report for the Noble Ellenburg Windpark, LLC postconstruction bird and bat fatality study 2009. Curry and Kerlinger, LLC, Cape May, New Jersey.

Jeffrey, J.D., K. Bay, W.P. Erickson, M. Sonneberg, J. Baker, M. Kesterke, J. Boehrs, and A. Palochak. 2009. Portland General Electric Biglow Canyon Wind Farm Phase I post-construction avian and bat monitoring first annual report, Sherman County, Oregon. Technical report prepared for Portland General Electric Company, Portland, Oregon. Prepared by Western EcoSystems Technology (WEST) Inc., Cheyenne, Wyoming, and Walla Walla, Washington. <http://www.oregon.gov/ENERGY/SITING/docs/BCW_2008MonitoringReport.pdf?ga=t>. Accessed 24 February 2011.

Johnson, G. 2004. A review of bat impacts at wind farms in the United States. Proceedings of the wind energy and birds/bats workshop: understanding and resolving bird and bat impacts, May 18-19, 2004, Washington, D.C., USA.

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

Johnson, S. A., V. Brack, and R. K. Dunlap. 2002. Management of hibernacula in the State of Indiana. Pages 100-109 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepherd, D. A. Shepherd, and S. A. Sarappo. 2003*a*. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. American Midland Naturalist 150:332-342.

Johnson, G.D., W.P. Erickson, and J. White. 2003b. Avian and bat mortality during the first year of operation at the Klondike Phase I Wind Project, Sherman County, Oregon. Technical report prepared for Northwestern Wind Power, Goldendale, Washington, by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. <http://www.west-inc.com/reports/klondike_final_mortality.pdf>. Accessed 23 February 2011.

Johnson, G. D., M. K. Perlik, W. P. Erickson, M. D. Strickland, D. A. Shepherd, and P. Sutherland, Jr. 2003*c*. Bat interactions with wind turbines at the Buffalo Ridge, Minnesota WindResource Area: An assessment of bat activity, species composition, and collision mortality. Electric Power Research Institute, Palo Alto, USA and Xcel Energy, Minneapolis, USA.

Johnson, G. D., M. K. Perlik, W. P. Erickson, and M. D. Strickland. 2004. Bat activity, composition, and collision mortality at a large wind plant in Minnesota. Wildlife Society Bulletin 32:1278-1288.

Johnson, G. D. and M. D. Strickland. 2003. Biological assessment for the federally endangered bat (Myotis sodalis) and Virginia big-eared bat (*Corynorhinus townsendii virginianus*). NedPower Mount Storm LLC, Chantilly, Virginia, USA.

Johnson, G. D., D. P. Young, Jr., W. P. Erickson, M. D. Strickland, R. E. Good, and P. Becker. 2000. Avian and bat mortality associated with the initial phase of the Foote Creek Rim Wind power Project, Carbon County, Wyoming: November 3, 1998 October 31, 1999. SeaWest Energy Corporation, Livermore, California, USA and U.S. Bureau of Land Management, Cheyenne, USA.

Jonasson, K. A. and C. K. R. Willis. 2011. Changes in body condition of hibernating bats support the thrifty female hypothesis and predict consequences for populations with White-Nose Syndrome. PLoS ONE 6:e21061.

Jones, K. E., A. Purvis, and J. L. Gittleman. 2003. Biological correlates of extinction risk in bats. The American Naturalist 161:601–614.

Kalcounis, M. C., Hobson, K. A., Brigham, R. M., and K. R. Hecker.1999. Bat activity in the boreal forest: importance of stand type and vertical strata. Journal of Mammalogy 80:673–682.

Karesh, W. B., R. A. Cook, E. L. Bennett, and J. Newcomb. 2005. Wildlife trade and global disease emergence. Emerging Infectious Diseases 11: 1000-1002.

Kerlinger, P., R. Curry, L. Culp, A. Jain, C. Wilkerson, B. Fischer, and A. Hasch. 2006. Post-construction avian and bat fatality monitoring for the High Winds Wind Power Project, Solano County, California: two year report. Prepared for High Winds LLC, FPL Energy by Curry and Kerlinger, LLC. <http://www.co.solano.ca.us/civica/filebank/blobdload.asp?BlobID=8915>. Accessed 23 February 2011.

Kerlinger, P., R. Curry, L. Culp, B. Fischer, A. Hasch, and C. Wilkerson. 2007. Post-construction avian monitoring study for the Shiloh I Wind Power Project Solano County, California year one final report. Curry and Kerlinger, L.L.C., McLean, Virginia.

Kerlinger, P., R. Curry, L. Culp, B. Fischer, A. Hasch, A. Jain, and C. Wilkerson. 2008. Post-construction avian monitoring study for the Shiloh I Wind Power Project Solano County, California year two final report. Curry and Kerlinger, L.L.C., McLean, Virginia.

Kerlinger, P., R. Curry, L. Culp, A. Hasch, and A. Jain. 2009. Post-construction avian monitoring study for the Shiloh I Wind Power Project Solano County, California, final report. Prepared for Iberdrola Renewables by Curry & Kerlinger, LLC. McLean, Virginia. <http://www.co.solano.ca.us/civica/filebank/blobdload.asp?BlobID=8914>. Accessed 24 February 2011.

Kerns, J, and P. Kerlinger. 2004. A study of bird and bat collision fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia. Curry and Kerlinger, LLC, McLean, Virginia, USA.

Kerns, J., W. P. Erickson, and E. B. Arnett. 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia. Pages 24–95 *in* E. B. Arnett, editor. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. Bats and Wind Energy Cooperative. Bat Conservation International, Austin, USA.

Kerth, G. and Melber, M. 2009. Species-specific barrier effects of a motorway on the habitat use of two threatened forest-living species. Biol. Conserv. 142, 270–279

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

Kiser, J. D., J. R. MacGregor, H. D. Bryan, and A. Howard. 2002. Use of concrete bridges as nightroosts. Pages 208-215 i*n* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Kling, G., K. Hayhoe, L. Johnson, R. Lindroth, J. J. Magnuson, S. Moser, S. Polasky, S. Robinson, B. Shuter, M. Wander, M. Wilson, D. Wuebbles, and D. Zak. 2003. Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems. The Union of Concerned Scientists and the Ecological Society of America. Cambridge, Massachusetts, USA.

Kozlowski, J., and R. G. Wiegert. 1986. Optimal allocation of energy to growth and reproduction. Theoretical Population Biology 29:16-37.

Krusac, D. L., and S. R. Mighton. 2002. Conservation of the Indiana bat in national forests: where we have been and where we should be going. Pages 55-65 *in* A. Kurta and J. Kennedy editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewezak. 2007*a*. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. Journal of Wildlife Management 71:2449-2486.

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

Kunz, T. H., J. A. Wrazen, and C. D. Burnett. 1998. Changes in body mass and fat reserves in pre-hibernating little brown bats (*Myotis lucifugus*). Ecoscience 5:8-17.

Kurta, A. 1980. Status of the Indiana bat, *Myotis sodalis*, in Michigan. Michigan Academician13:31-36.

Kurta, A. 2000. The bat community in northwestern Lower Michigan, with emphasis on the Indiana bat and eastern pipistrelle. U.S. Forest Service, Huron-Manistee National Forests, Cadillac, Michigan, USA.

Kurta, A. 2005. Roosting ecology and behavior of Indiana bats (*Myotis sodalis*) in summer. Pages 29-42 *in* K.C. Vories and A. Harrington, editors. Proceedings of the Indiana bat and coal mining: a technical interactive forum. Office of Surface Mining, U.S. Department of the Interior, <http://www.mcrcc.osmre.gov/PDF/Forums/Bat%20Indiana/TOC.pdf>. Accessed 17 October 2006.

Kurta, A., G. P. Bell, K. A. Nagy, and T. H. Kunz. 1989 Energetics of pregnancy and lactation in free-ranging little brown bats (*Myotis lucifugus*). Physiological Zoology 62:804-818.

Kurta, A., J. Caryl, and T. Lipps. 1997. Bats and Tippy Dam: species composition, seasonal use, and environmental parameters. Michigan Academician 24:473-490.

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., T. H. Kunz, and K. A. Nagy. 1990 Energetics and water flux of free-ranging big brown bats (*Eptesicus fuscus*) during pregnancy and lactation. Journal of Mammalogy 71:59-65.

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

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

Kurta, A., and H. Rice. 2002. Ecology and management of the Indiana bat in Michigan. Michigan Academician 33:361–376.

Kurta, A., and J. A. Teramino. 1994. A novel hibernaculum and noteworthy records of the Indiana bat and eastern pipistrelle (*Chiroptera: Vespertilionidae*). American Midland Naturalist 132:410-413.

Kurta, A., and J. O. Whitaker, Jr. 1998. Diet of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 140:280-286.

Kurta, A., K. J. Williams, and R. Miles. 1996. Ecological, behavioural, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis*). Pages 102-117 *in* R. M. R. Barclay and R. M. Brigham, editors. Bats and Forests Symposium, British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

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

Lacki, M. J., S. K. Amelon, and M. D. Baker. 2007. Foraging ecology of bats in forests. Pages 83-127 *in* M. J. Lacki, J. P. Hayes, and A. Kurta, editors. Bats in forests: conservation and management. Johns Hopkins University Press, Baltimore, USA.

Lance, R. F., B. Bollich, C. L. Callahan, and P. L. Leberg. 1996. Surveying forests-bat communities with Anabat detectors. Pages 175-184 *in* R. M. R. Barclay and R. M. Brigham, editors. Bats and Forests Symposium, Victoria, British Columbia, Canada.

Langwig, K.E., S.R. Darling, W.F. Frick, C.J. Herzog, A.C. Hicks, C.J. Kocer, T.H. Kunz, R.B. Smith, and R.I. von Linden. 2010. Declines of six hibernating bat species from white-nose syndrome in the northeastern United States. Abstracts of Presented Papers and Posters for 2010 White-nose Syndrome Symposium, May 25-27, Pittsburgh, Pennsylvania.

LaVal, R., and M. L. LaVal. 1980. Ecological studies and management of Missouri bats, with emphasis on cave-dwelling species. Terrestrial Report 8. Missouri Department of Conservation, Jefferson City, USA.

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

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

Leonardo Academy, Inc. 2008. Emission Factors and Energy Prices for Leonardo Academy's Cleaner and Greener® Program. Multiple Pollutant Emission Reduction Reporting System <http://www.cleanerandgreener.org/download/Emission%20Factors%20and%20Energy%20Prices%20-%20revised%20March%202008.pdf>. Accessed 15 May 2010.

Lincoln, F. C. 1950. Migration of birds. U.S. Fish and Wildlife Service, No. 16, Washington, D.C., USA.

Linnell, M. A., M. R. Conover, and T. J. Ohashi. 1999. Biases in bird strike statistics based on pilot reports. Journal of Wildlife Management 63:997-1003.

Lorch, J. M., C. U. Meteyer, M. J. Behr, J. G. Boyles, P. M. Cryan, A. C. Hicks, A. E. Ballmann, J. T. H. Coleman, D. N. Redell, D. M. Reeder, and D. S. Blehert. 2011. Experimental infection of bats with *Geomyces destructans* causes white-nose syndrome. Nature 480:376-378.

Luensmann, P.S. 2005. Myotis sodalis. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). <http://www.fs.fed.us/database/feis/> Accessed 12 October2011.

MacGregor, J. 1993. Responses of winter populations of the Federal endangered Indiana bat (*Myotis sodalis*) to cave gating in Kentucky. Pages 364-370 *in* D. L. Foster, editor. 1991 National Cave Management Symposium Proceedings. Bowling Green, Kentucky, USA.

MacGregor J., J. Kiser, M. Gumbert, and T. Reed. 1999. Autumn roosting habitat of male Indiana bats (*Myotis sodalis*) in a managed forest setting in Kentucky. Pages 169-170 *in* J. Stringer and D. Loftis, editors. Proceedings of 12th central hardwood forest conference, U.S. Forest Service, Asheville, North Carolina, USA.

Madsen, T., and E. Figdor. 2007. When It Rains, It Pours: Global Warming and the Rising Frequency of Extreme Precipitation in the United States. Environment America Research & Policy Center. Washington, D.C., USA.

Maier, C. 1992. Activity patterns of pipistrelle bats (*Pipistrellus pipistrellus*) in Oxfordshire. Journal of Zoolgy 228:69-80.

Manly, B. F. J. 2007. Randomization, Bootstrap and Monte Carlo Methods in Biology, third edition. Chapman & Hall/CRC, Boca Raton, FL.

Martin, K. W., R. F. Lance, and C. H. Bucciantini. 2005. Collisions with aircraft and use of culverts under runways by bats at U.S. Naval Air Station Meridian, Meridian, Mississippi. Bat Research News 46:51-54.

McCracken, G. F., Y. Lee, J. K. Westbrook, B. B. Balsley, and M. L. Jensen. 1997. High altitude foraging by Mexican free-tailed bats: vertical profiling using kites and hot air balloons. Bat Research News 38:117.

McCracken, G. F., Y. F. Lee, J. K. Westbrook, B. B. Balsley, and M. L. Jensen. 1997. High altitude foraging by Mexican free-tailed bats: vertical profiling using kites and hot air balloons. Bat Research News 38:117.

McKinney, M. L. 1997. Extinction vulnerability and selectivity; combining ecological and paleontological views. Annual Review Ecological Systems 28:495-516.

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

Meinke, C. W., S. T. Knick, and D. A. Pyke. 2009. A spatial model to prioritize sagebrush landscapes in the Intermountain West (USA) for restoration. Restoration Ecology 17:652–659.

Menzel, M. A., W. M. Ford, B. R. Chapman, and J. Ozier. 2000. Summer roost tree selection by eastern red bats, seminole bats, and evening bats in the upper coast plain of South Carolina. Proceedings of Annual Conference of Southeast Fish and Wildlife Agencies 54:304-313.

Menzel, M. A., J. M. Menzel, T. C. Carter, W. M. Ford, and J. W. Edwards. 2001. Review of the forest habitat relationships of the Indiana bat (*Myotis sodalis*). General Technical Report NE-284:1-21. U.S. Forest Service, Northeastern Research Station, Newton Square, Pennsylvania, USA.

Menzel, J. A., W. M. Ford, M. A. Menzel, T. C. Carter, J. E Gardner, J. D. Garner, and J. E. Hofmann. 2005. Summer habitat use and home-range analysis of the endangered Indiana bat. Journal of Wildlife Management 69:430-436.

Meretsky, V. J., V. Brack, Jr., T. C. Carter, R. Clawson, R. R. Currie, T. A. Hemberger, C. J. Herzog, A. C. Hicks, J. A. Kath, J. R. MacGregor, R. A. King, and D. H. Good. 2010. Digital photography improves consistency and accuracy of bat counts in hibernacula. Journal of Wildlife Management 74:166-173.

Meteyer, C. U., E. L. Buckles, D. S. Blehert, A. C. Hicks, D. E. Green, V. Shearn-Bochsler, N. J. Thomas, A. Gargas, M. J. Behr. 2009. Histopathologic criteria to confirm white-nose syndrome in bats. Journal of Veterinary Diagnostic Investigation 21:411-414.

Miller, G. S. Jr., and G. M. Allen. 1928. The American bats of the genera *Myotis* and *Pizonyx*. Bulletin of the U.S. National Museum 144:1-218.

Missouri Department of Conservation. 2009. The Indiana Bat: How to manage Missouri Department of Conservation forests for an endangered species (updated October 29, 2009). <http://mdc4.mdc.mo.gov/Documents/21008.pdf> Accessed June 2011.

Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. American Midland Naturalist 37:223-249.

Mohr, C. E. 1972. The status of threatened species of cave-dwelling bats. Bulletin of the National Speleological Society 34:33-37.

Mueller, H. C. 1968. The role of vision in vespertilionid bats. American Midland Naturalist 79:524-525.

Mumford, R. E., and L. L. Calvert. 1960. *Myotis sodalis* evidently breeding in Indiana. Journal of Mammalogy 41:512.

Munson, M. A., K. Webb, D. Sheldon, D. Fink, W. M. Hochachka, M. Iliff, M. Riedewald, D. Sorokina, B. Sullivan, C. Wood, and S. Kelling. 2011. The eBird Reference Dataset, Version 3.0. Cornell Lab of Ornithology and National Audubon Society, Ithaca, NY, December 2011.

Murray, S. W., and A. Kurta. 2002. Spatial and Temporal Variation in Diet. Pages 182-192 in A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

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

Myers, M. D. 2008. The challenges of linking carbon emissions, atmospheric greenhouse gas concentrations, global warming, and consequential impacts. Memorandum from Mark. D. Myers, USGS Director, to the FWS Director and Solicitor, May 14, 2008. < http://www.fws.gov/home/feature/2008/polarbear012308/pdf/Memo_to_FWS-Polar_Bears.PDF>. Accessed December 2011.

Myers, R. F. 1964. Ecology of three species of myotine bats in the Ozark Plateau. Dissertation, University of Missouri, Columbia, USA.

National Climatic Data Center [NCDC]. n.d. Climate of Ohio. <http://www.geography.osu.edu/faculty/rogers/OOC.pdf> Accessed July 2011>.

National Oceanic and Atmospheric Administration [NOAA] National Weather Service. 2010. Thunderstorms, Tornadoes, Lightning…Nature's Most Violent Storms. A Preparedness Guide, Including Tornado Safety Information for Schools. NOAA/PA 201051. 18 pp.

National Research Council [NRC]. 2007. Environmental Impacts of Wind-Energy Projects Committee on Environmental Impacts of Wind Energy Projects, National Research Council ISBN: 0-309-10835-7. < http://www.nap.edu/catalog/11935.html>. Accessed 14 June 2010.

National Wildlife Federation [NWF]. 2008. Fact Sheet: Global Warming and Ohio. <http://www.nwf.org/Global-Warming/~/media/PDFs/Global%20Warming/Global%20Warming%20State%20Fact%20Sheets/Ohio.ashx>. Accessed 1 October 2010.

National Wind Coordinating Collaborative [NWCC]. 2010. Fact Sheet: Wind Turbine Interactions with Birds, Bats, and their Habitats: A summary of Research Results and Priority Questions. <

https://www.nationalwind.org/assets/publications/Birds_and_Bats_Fact_Sheet_.pdf> Accessed September 1, 2010.

Negraeff, O. E., and R. M. Brigham. 1995. The influence of moonlight on the activity of little brown bats. Zeitschrift fur Saugertierkunde 60:330–336.

Neuweiler, G. 1989. Foraging ecology and audition in echolocating bats. Trends Ecology and Evolution 4:160-166.

Nicholson, C. P. 2001. Buffalo Mountain Windfarm bird and bat mortality monitoring report: October 2000 September 2001. Tennessee Valley Authority, Knoxville, USA.

Nicholson, C. P. 2003. Buffalo Mountain Wind farm bird and bat mortality monitoring report: October 2001–September 2002. Tennessee Valley Authority, Knoxville, USA.

Nicholson, C. P., R. D. Tankersley, Jr., J. K. Fiedler, and N. S. Nicholas. 2005. Assessment and prediction of bird and bat mortality at wind energy facilities in the southeastern United States. Tennessee Valley Authority, Knoxville, USA.

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

Normandeau Associates, Inc., 2010. Stetson Mountain II Wind Projects year 1 post-construction avian and bat mortality monitoring study. Prepared for First Wind LLC, Portland, Maine. Normandeau Associates, Falmouth, Maine.

Ohio Department of Natural Resources Division of Forestry [ODNR]. 2009. On-Shore Bird and Bar Pre- and Post-Construction Monitoring Protocol for Commercial Wind Energy Facilities in Ohio. An Addendum to the Ohio Department of Natural Resource's Voluntary Cooperative Agreement. 2009. Available: http://www.dnr.state.oh.us/LinkClick.aspx?fileticket=S24B8hy2Iu4%3D&tabid=21467

Ohio Department of Natural Resources Division of Forestry [ODNR DOF]. 2011. Educational Downloads: A Guide to the Management of Ohio's State Forests, Asian Longhorned Beetle Poster, Ohio Woodland Journal Articles-Articles written by Division of Forestry staff. Available: http://www.dnr.state.oh.us/tabid/5320/Default.aspx

Ohio Department of Natural Resources Division of Wildlife [ODNR DOW]). 2011. Forest wildlife overview. <http://www.dnr.state.oh.us/Home/wild_resourcessubhomepage/ResearchandSurveys/WildlifePopulationStatusLandingPage/ForestWildlifeOverview/tabid/19354/Default.aspx>. Accessed February 2011.

Ohio Department of Natural Resources Division of Wildlife [ODNR DOW]. n.d. Ohio Division of Wildlife Life History Notes: Indiana bat. Publication 370(399). <http://www.dnr.state.oh.us/Portals/9/pdf/pub370.pdf> Accessed 6 January 2012.

Obama for America. 2008. Barack Obama and Joe Biden: New Energy for America <http://www.barackobama.com/pdf/factsheet_energy_speech_080308.pdf>. Accessed 15 May 2010.

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

Ontario Ministry of Natural Resources [OMNR]. 2010. White nose syndrome detected in Ontario bats. <http://www.mnr.gov.on.ca/en/Newsroom/LatestNews/289824.html>. Accessed 19 March 2010.

Ormsbee, P. C., J. D. Kiser, and S. I. Perlmeter. 2007. Importance of night roosts to the ecology of bats. Pages 129-151 *in* M. L Lacki, J. P. Hayes, and A. Kurta, editors. Bats in forests: conservation and management. Johns Hopkins University Press, Baltimore, USA.

Overing, R. 1936. The 1935 fall migration at the Washington Monument. Wilson Bulletin 48:222–224.

Palmer, W. C. 1965. Meteorological drought. Research Paper No. 45, U.S. Department of Commerce – Weather Bureau, Washington, D.C.

Palmer, M. A., E. S. Bernhardt, W. H. Schlesinger, K. N. Eshleman, E. Foufoula-Georgiou, M. S. Hendryx, A. D. Lemly, G. E. Likens, O. L. Loucks, M. E. Power, P. S. White, and P. R. Wilcock. 2010. Mountaintop Mining Consequences. Science 327:148-149.

Parmesan, C., and G. Yohe. 2003. A Globally Coherent Fingerprint of Climate Change Impacts Across Natural Systems. Nature 421:37-42.

Patricelli, G. L., and J. L. Blickley. 2006. Avian communication in urban noise: causes and consequences of vocal adjustment. Auk 123:639-649.

Patterson, A. P., and J. W. Hardin.1969. Flight speeds of five species of Vespertilionid bats. Journal of Mammalogy 50:152-153.

Peurach, S. C. 2003. High-altitude collision between an airplane and a hoary bat, *Lasiurus cinereus*. Bat Research News 44(1):2-3.

Capouillez, W.A., Librandi Mumma, T.M. 2008. Pennsylvania Game Commission Wind Energy Voluntary Cooperative Agreement Second Annual Report. April 18, 2007 – September 30, 2008. Pennsylvania Game Commission. Harrisburg, Pennsylvania, USA. http://www.pgc.state.pa.us

Peurach, S. C., C. J. Dove, and L. Stepko. 2009. A decade of U.S. Air Force bat strikes. Human-Wildlife Conflicts 3:199–207.

Pianka, E.R. 1970. On r and K selection. American Naturalist 104:592–597.

Piorkowski, M.D. 2006. Breeding bird habitat use and turbine collisions of birds and bats located at a wind farm in Oklahoma mixed-grass prairie. Submitted to Faculty of the Graduate College of Oklahoma State University, Stillwater, Oklahoma. <http://digital.library.okstate.edu/etd/umi-okstate-1860.pdf>. Accessed 25 February 2011.

Piorkowski, M.D. and T.J. O'Connell. 2010. Spatial pattern of summer bat mortality from collisions with wind turbines in mixed-grass prairie. The American Midland Naturalist 164:260-269.

Public Utilities Commission of Ohio [PUCO]. 2008. Where Does Ohio's Electricity Come From?. <http://www.puco.ohio.gov/PUCO/Consumer/Information.cfm?id=7650>. Accessed 14 January 2009.

Puechmaille, S. J., P. Verdeyroux, H. Fuller, A. G. M. Behaert M., and E. C. Teeling. 2010. White-nose syndrome fungus (*Geomyces destructans*) in bat, France. Emerging Infectious Diseases. <http://www.cdc.gov/eid/content/16/2/pdfs/09-1391.pdf>. Accessed 15 April 2010.

Purvis, A., J. L. Gittleman, G. Cowlishaw, and G. M. Mace. 2000. Predicting extinction risk in declining species. Proceedings of the Royal Society of London Series B 267:1947-1952.

Rabin, L. A., R. G. Coss, and D. H. Owings. 2006. The effects of wind turbines on antipredator behavior in California ground squirrels (*Spermophilus beecheyi*). Biological Conservation 131:410-420.

Racey, P. A. 1982. Ecology of bat reproduction. Pages 57-104 *in* T.H. Kunz, editor. Ecology of bats. Plenum Press, New York, USA.

Racey, P. A., and S. M. Swift. 1985. Feeding ecology of *Pipistrellus pipistrellus* (*Chiroptera: Vespertilionidae*) during pregnancy and lactation. Journal of Animal Ecology 54:205–215.

Racey, P. A., and A. C. Entwistle. 2000. Life history and reproductive strategies of bats. Pages 363-414 *in* E. G. Crichton and P. H. Krutzsch, editors. Reproductive biology of bats. Academic Press, London, UK.

Reynolds, D. S. 2006. Monitoring the potential impact of a wind development site on bats in the northeast. Journal of Wildlife Management 70:1219–1227.

Richardson, W. J. 1974. Spring migration over Puerto Rico and the western Atlantic: a radarstudy. Ibis 116:172-193.

Richardson, W. J. 1976. Autumn migration over Puerto Rico and the western Atlantic: a radarstudy. Ibis 118:309-332.

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

Ritzi, C. M., B. L. Everson, and J. O. Whitaker, Jr. 2005. Use of bat boxes by a maternity colony of Indiana *Myotis* (*Myotis sodalis*). Northeastern Naturalist 12:217-220.

Rodrigue, J. L. 2004. Biological Assessment: Fernow Experimental Forest. Final Report, USDA Forest Service Northeastern Research Station, Parsons, WV. 105 pp.

Rogers, J. C. 1993. Climatological Aspects of Drought in Ohio. Ohio Journal of Science 93:51-59.

Romme´, R. C., A. B. Henry, R. A. King, T. Glueck, and K. Tyrell. 2002. Home range near hibernacula in spring and autumn. Pages 153-158 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species Bat Conservation International, Austin, USA.

Russell, A. L., C. M. Butchkoski, L. Saidak, and G. F. McCracken. 2008. Road-killed bats, highway design and the commuting ecology of bats. Endangered Species Research. DOI: 10.3354/esr00121. <http://amyrussell.net/docs/RussellEtAl2008ESR.pdf>. Accessed 10 June 2010.

Russo, D., and G. Jones. 2003. Use of foraging habitats by bats in a Mediterranean area determined by acoustic surveys: conservation implications. Ecography 26:197–209

Rydell, J. 1991. Seasonal use of illuminated areas by foraging northern bats *Eptesicus nilssoni*. Holarctic Ecology 14:203–207.

Sanders, C., and J. Chenger. 2000. South Penn Tunnel *Myotis sodalis* Study. Pennsylvania Turnpike Commission, Harrisburg, Pennsylvania, USA.

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

Saunders, W. B. 1930. Bats in migration. Journal of Mammalogy 11:225.

Saunders, W. B., and R. M. R. Barclay. 1992. Ecomorphology of insectivorous bats: a test of predictions using two morphologically similar species. Ecology 73:1335-1345.

Schaub, A., J. Ostwald, and B. M. Siemers. 2008. Foraging bats avoid noise. Journal of Experimental Biology 211:3174–3180.

Shoenfeld, P. 2004. Suggestions regarding avian mortality extrapolation. Technical memo provided to FPL Energy. West Virginia Highlands Conservancy, HC70, Box 553. Davis, West Virginia. 26260. <http://www.wvhighlands.org/Pages/WinPow.html>. Accessed 1 October 2010.

Scott, M. E. 1988. The impact of infection and disease on animal populations: Implications for conservation biology. Conservation Biology 2:40-56.

Shiel, C. B., and J. S. Fairley. 1998. Activity of Leisler's bat, *Nyctalus leisleri,* in the field in south-east County Wexford, as revealed by a bat-detector. Biology and Environment 98:105-112.

Slabbekoorn, H., and E. A. Ripmeester. 2008. Birdsong and anthropogenic noise: implications and applications for conservation. Molecular Ecology 17:72–83.

Snyder, T. A. 2004. The Historical Role of Fire in Ohio. <http://www.dnr.state.oh.us/Portals/18/fire/pdf/firehistory04.pdf>. Accessed July 2011.

Sparks, D. W. 2003. How does urbanization impact bats? Dissertation, Indiana State University, Terre Haute, USA.

Sparks, D. W., C. M. Ritzi, J. E. Duchamp, and J. O. Whitaker, Jr. 2005a. Foraging habitat of the Indiana bat, (*Myotis sodalis*) at an urban-rural interface. Journal of Mammalogy 86:713- 718.

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

Sparks, D.W., J.O. Whitaker, Jr., and C.M. Ritzi. 2005b. Foraging ecology of the endangered Indiana bat. Pages 15-27 *in* K.C. Vories and A. Harrington, editors. The Proceedings of the Indiana bat and coal mining: a technical interactive forum Office of Surface Mining, U.S. Department of the Interior, Alton, Illinois, USA. <http://www.mcrcc.osmre.gov/PDF/Forums/Bat%20Indiana/TOC.pdf>. Accessed 17 October 2006.

Speakman, J. R., and D. W. Thomas. 2003. Physiological ecology and energetics of bats. Pages 430-490 *in* T. H. Kunz and M.B. Fenton, editors. Bat Ecology. University of Chicago Press, Chicago, USA.

Sonnenberg, M. and W. Erickson. 2010. Fatality Study Simulations Results. Draft report prepared for Horizon Wind Energy, Iberdrola Renewables, and Invenergy. Prepared by Western EcoSystems Technology, Inc., Cheyenne, Wyoming.

Stantec Consulting [Stantec]. 2008a. Fall 2007 bird and bat migration survey report: Visual, radar, and acoustic bat surveys for the Buckeye Wind Power Project in Champaign and Logan Counties, Ohio. Everpower Wind Holdings, Inc., New York, USA.

Stantec Consulting [Stantec]. 2008b. Summer 2008 bat mist-netting report for the Buckeye Wind Power Project in Champaign and Logan Counties, Ohio. Everpower Wind Holdings Inc., New York, USA.

Stantec Consulting [Stantec]. 2008c. 2007 Spring, summer, and fall post-construction bird and bat mortality study at the Mars Hill Wind Farm, Maine. Prepared for UPC Wind Management, LLC, Cumberland, Maine. Stantec Consulting, Topsham, Maine.

Stantec Consulting [Stantec]. 2009a. Spring, summer, and fall 2008 bird and bat survey report for the Buckeye Wind Power Project in Champaign and Logan Counties, Ohio. Prepared for Everpower Wind Holdings, Inc., New York, USA.

Stantec Consulting [Stantec]. 2009b. Post-construction monitoring at the Mars Hill Wind Farm, Maine Year 2, 2008. Prepared for First Wind Management, LLC, Portland, Maine. Stantec Consulting, Topsham, Maine.

Stantec Consulting [Stantec]. 2009c. Post-construction monitoring at the Munnsville Wind Farm, New York 2008. Prepared for E. ON Climate and Renewables, Austin, Texas. Stantec Consulting, Topsham, Maine.

Stantec Consulting [Stantec]. 2010a. Cohocton and Dutch Hill Wind Farms Year 1 Post-Construction Monitoring Report, 2009 for the Cohocton and Dutch Hill Wind Farms In Cohocton, New York. Prepared for Canandaigua Power Partners, LLC and Canandaigua Power Partners II, LLC.

Stantec Consulting [Stantec]. 2010b. Stetson I Mountain Wind Project Year 1 Post-Construction Monitoring Report, 2009 for the Stetson Mountain Wind Project In Penobscot and Washington Counties, Maine Prepared for First Wind Management, LLC.

Stantec Consulting [Stantec]. 2010c. Wolfe Island EcoPower Centre post-construction follow-up plan bird and bat resources monitoring report no. 2 July-December 2009. Prepared for TransAlta

Corporation's wholly owned subsidiary Canadian Renewable Energy Corporation. Stantec Consulting Ltd., Guelph, Ontario, Canada.

Stantec Consulting [Stantec]. 2011a. Draft Avian and Bat Protection Plan for the Buckeye Wind Power Project, Champaign County, Ohio. Prepared for EverPower Wind Holdings, Inc., New York, USA.

Stantec Consulting [Stantec]. 2011b. Cohocton and Dutch Hill Wind Farms Year 2 Post-Construction monitoring Report, 2010 for the Cohocton and Dutch Hill Wind Farms in Cohocton, New York. Prepared for Canandaigua Power Partners, LLC and Canandaigua Power Partners II, LLC.

Stihler, C. 2005. Hellhole Cave, Pendleton County, West Virginia: results of the winter bat survey conducted on 26 February 2005. Unpublished report. West Virginia Division of Natural Resources, Wildlife Resources Section, Wildlife Diversity Program. South Charleston, USA.

Swift, S. M. 1980. Activity patterns of pipistrelle bats. Journal of Zoolgy190:285-295.

Szewczak, J. M., and E. B. Arnett. 2006. Preliminary Field Test Results of an Acoustic Deterrent with the Potential to Reduce Bat Mortality from Wind Turbines. A report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, USA. <http://www.batsandwind.org/pdf/detfield2006.pdf> Accessed 1 July 2010.

Terres, J. K. 1956. Migration records of the red bat, *Lasiurus borealis*. Journal of Mammalogy 37:442.

Tidhar, D., W. Tidhar, and M. Sonnenberg, 2010. Post-construction fatality surveys for Lempster wind project Iberdrola Renewables. Prepared for Lempster Wind, LLC. Western EcoSystems Technology, Inc., Waterbury, Vermont.

Thogmartin, W. E., R. A. King, P. C. McKann, J. A. Szymanski, and L. Pruitt. 2012. Population-level impact of white-nose syndrome on the endangered Indiana bat. Journal of Mammalogy 93:1086-1098.

Thomas, D. W., M. Dorais, and J. M. Bergeron. 1990. Winter energy budgets and cost of arousals for hibernating little brown bats, *Myotis lucifugus*. Journal of Mammalogy 71:475-479.

Thomson, C. E. 1982. *Myotis sodalis*. The American Society of Mammalogists. Mammalian Species 162:1-5.

Tierney, R. 2009. Buffalo Gap 2 Wind Farm avian mortality study July 2007-December 2008 final survey report. Prepared for Buffalo Gap Wind Farm, LLC. TRC, Albuquerque, New Mexico.

Timm, R. M. 1989. Migration and molt patterns of red bats, *Lasiurus borealis* (*Chiroptera: Vespertilionidae),* in Illinois. *Bulletin of the Chicago Academy of Sciences* 14:1-7.

TRC Environmental Corporation. 2008. Post-construction avian and bat fatality monitoring and grassland bird displacement surveys at the Judith Gap Wind Energy Project, Wheatland County, Montana. Prepared for Judith Gap Energy, LLC, Chicago, Illinois. TRC Environmental Corporation, Laramie, Wyoming. <http://www.newwest.net/pdfs/AvianBatFatalityMonitoring.pdf>. Accessed 23 February 2011.

Turner, G. G. 2006. Bat Migratory Behaviors and Routes in Pennsylvania and Maryland. Proceedings NWCC Wildlife Workgroup Research Planning Meeting VI, San Antonio, Texas, USA. November 14-15, 2006. <http://www.nationalwind.org/assets/blog/WindWildlife_Research_Mtg_VI_Proceedings_FINAL.pdf> Accessed 1 July 2010

Turner, G. G., and D. M. Reeder. 2009. Update of White Nose Syndrome, September 2009. Bat Research News 50:47-54.

Tuttle, M. D., and J. Kennedy. 2002. Thermal requirements during hibernation. Pages 68–77 *in A.* Kurta and J. Kennedy, editors. The Indiana Bat: Biology and Management of an Endangered Species. Bat Conservation International, Austin, USA.

Tuttle, M. D. and D. Stevenson. 1978. Variation in the cave environment and its biological implications. Pages 108-121 *in* R. Zuber, J. Chester, S. Gilbert, and D. Rhodes, editors. 1977 National Cave Management Symposium Proceedings. Adobe Press, Albuquerque, USA.

U.S. Army Corps of Engineers [USACE]. 2007. Summary Table of 2007 Nationwide Permits. http://www.usace.army.mil/cecw/pages/nw_permits.aspx. Accessed 1 June 2011.

U.S. Department of Agriculture, Soil Conservation Service [USDA-SCS]. 1971. Soil survey of Champaign County, Ohio. Ohio Department of Natural Resources, Division of Lands and Soil and Ohio Agricultural Research and Development Center. Washington, D.C., USA.

U.S. Department of Agriculture [USDA], National Agriculture Imagery Program. 2010. National Agricultural Imagery Program. <http://www.fsa.usda.gov/FSA/apfoapp?area=home&subject=prog&topic=nai>. Accessed 1 May 2010.

U.S. Department of Energy, Energy Information Administration [DOE EIA]. 2007. Electric Power Annual 2006. U.S. Department of Energy, Office of Coal, Nuclear, Electric, and Alternate Fuels. DOE/EIA-0348. <http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html>. Accessed 15 November 2007.

U.S. Environmental Protection Agency [EPA]. 2000. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1998, 236-R-00-01, Washington, D.C., USA. <http://www.epa.gov/globalwarming>. Accessed 14 March 2010.

U.S. Environmental Protection Agency [EPA]. 2003. Mountaintop mining/valley fills in Appalachia: draft programmatic environmental impact statement. Appendix A-D, EPA 9-03-R- 00013. Philadelphia, USA.

U.S. Environmental Protection Agency [EPA]. 2009a. Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2007. U.S. Environmental Protection Agency, Washington, D.C. April 15, 2009. EPA 430-R-09-004.

U.S. Environmental Protection Agency [EPA]. 2009b. Climate Change: Science, State of Knowledge. <http://www.epa.gov/climatechange/science/stateofknowledge.html>. Accessed 14 January 2010).

U.S. Fish and Wildlife Service [USFWS]. 1983. Recovery Plan for the Indiana Bat. Washington, D.C., USA.

U.S. Fish and Wildlife Service [USFWS]. 1999. Agency Draft Indiana Bat (*Myotis sodalis*) Revised Recovery Plan. Fort Snelling, Minnesota, USA.

U.S. Fish and Wildlife Service [USFWS]. 2004. Biological opinion on the impacts of the Laxare East & Black Castle contour coal mining projects on the Indiana Bat; February, 2005. West Virginia Field Office, Elkins, West Virginia, USA.

U.S. Fish and Wildlife Service [USFWS]. 2005a. Biological Opinion on the construction, operation, and maintenance of the U.S. 24 New Haven, Indiana to Defiance, Ohio project for the federally-listed endangered Indiana bat (*Myotis sodalis*) submitted to the Federal Highway Administration; September, 2005. Ohio Ecological Services Field Office, Reynoldsburg, USA.

U.S. Fish and Wildlife Service [USFWS]. 2005b. Biological Opinion on the construction, operation, and maintenance of the U.S. 33 Nelsonville Bypass for the federally-listed endangered Indiana bat (*Myotis sodalis*) submitted to the Federal Highway Administration; September, 2005. Ohio Ecological Services Field Office, Reynoldsburg, Ohio, USA.

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

U.S. Fish and Wildlife Service [USFWS]. 2008a. BFO Forest Management Guidelines for Informal Section 7 Consultations on Indiana bats (*Myotis sodalis*) within the State of Indiana. Bloomington Field Office, Bloomington, IN, 14 February 2008.

U.S. Fish and Wildlife Service [USFWS]. 2008b. New Jersey Field Office Forest Management Recommendations for Indiana Bats. New Jersey Field Office, October 2008.

U.S. Fish and Wildlife Service [USFWS]. 2009a. Indiana Bat: Five-Year review: summary and evaluation. Bloomington, Indiana, USA.

U.S. Fish and Wildlife Service [USFWS]. 2009b. Range-wide Indiana Bat Protection and Enhancement Plan Guidelines. Developed in collaboration with the Office of Surface Mining Reclamation and Enforcement (OSM) and the Interstate Mining Compact Commission (IMCC). <http://www.osmre.gov/guidance/docs/INBATPEPGuidelines.pdf>. Accessed 1 October 2010.

U.S. Fish and Wildlife Service [USFWS]. 2009c. Post-delisting monitoring plan for the bald eagle (Haliaeetus leucocephalus) in the contiguous 48 States. U.S. Fish and Wildlife Service, Divisions of Endangered Species and Migratory Birds and State Programs, Midwest Regional Office, Twin Cities, Minnesota, USA.

U.S. Fish and Wildlife Service [USFWS]. 2010*a*. Preamble to the committee recommendations, committee policy recommendations, and committee recommended guidelines. Submitted to the Secretary of the Interior by the Wind Turbines Guidelines Advisory Committee.

U.S. Fish and Wildlife Service [USFWS]. 2010b. Endangered and Threatened Wildlife and Plants; Listing the Rayed Bean and Snuffbox as Endangered; Proposed Rule. Federal Register 75: 67552-67583.

U.S. Fish and Wildlife Service [USFWS]. 2011a. Questions and Answers Pertaining to Effects Analyses for Indiana bats and Wind Energy Projects, Revised 22 August 2011. <http://www.fws.gov/midwest/Endangered/mammals/inba/pdf/IndianaBatWindGuidance22AuAugu2011.pdf> Accessed September 2011.

U.S. Fish and Wildlife Service [USFWS]. 2011b. Review finds endangered species protection may be warranted for two bat species. < http://us.vocuspr.com/Newsroom/Query.aspx?SiteName=fws&Entity=PRAsset&SF_PRAsset_PRAssetID_EQ=127578&XSL=PressRelease&Cache=True> Accessed 18 October 2011.

U.S. Fish and Wildlife Service [USFWS]. 2011c. Draft U.S. Fish and Wildlife Service land-based wind energy guidelines, September 13, 2011. < http://www.fws.gov/windenergy/docs/WEG_September_13_2011.pdf> Accessed November 2011.

U.S. Fish and Wildlife Service [USFWS]. 2012a. North American bat death toll exceeds 5.5 million from white-nose syndrome. Press Release. January 17, 2012.

U.S. Fish and Wildlife Service [USFWS]. 2012b. U.S. Fish and Wildlife Service Lists Two Freshwater Mussels as Endangered Species; Press Release. February 14, 2012.

U.S. Fish and Wildlife Service [USFWS]. 2012c. 2011 Rangewide Population Estimate for the Indiana Bat (*Myotis sodalis*) by USFWS Region. http://www.fws.gov/midwest/Endangered/mammals/inba/. Revised 1 January 2012.

U.S. Fish and Wildlife Service [USFWS] and National Marine Fisheries Service [NMFS]. 1998. Endangered Species Consultation Handbook. Procedures for Conducting Section 7 Consultations and Conferences. March 1998 Final.

U.S. Fish and Wildlife Service [USFWS] and National Oceanic and Atmospheric Administration [NOAA]. 1996. Habitat conservation planning and incidental take permit processing handbook. <http://www.nmfs.noaa.gov/pr/pdfs/laws/hcp_handbook.pdf> Accessed 10 March 2010.

U.S. Fish and Wildlife Service [USFWS] and National Oceanic and Atmospheric Administration [NOAA]. 2000. Notice of Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process, Final Rule. Federal Register 65:35241-35257.

U.S. Geological Survey [USGS]. 2003. National Water-Quality Assessment Program: Great and Little Miami River Basins FS-117_97. Columbus, Ohio, USA. <http://oh.water.usgs.gov/miam/Background.html>. Accessed 7 October 2009.

U.S. Geological Survey [USGS]. 2010. White-Nose Syndrome threatens the survival of Hibernating bats in North America. <http://www.fort.usgs.gov/WNS/>. Accessed 18 October 2010.

Van Gelder, R. G. 1956. Echo-location failure in migratory bats. Transactions of the Kansas Academy of Science 59:220-222.

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

Vermont Fish and Wildlife Department. 2008. Forest Management Guidelines for Indiana Bat Habitat, September 2008. <http://www.gwriters.com/saf/Draft_Indiana_Bat_Forest_Management_Guidelines1.pdf.pdf> Accessed June 2011.

Viele, D. P., A. Kurta, and J. Kath. 2002. Timing of nightly emergence. Pages 199-207 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Villa, R. B., and E. L. Cockrum. 1962. Migration in the guana bat, *Tadarida brasiliensis mexicana*. Journal of Mammalogy 43:43-64.

Walley. H. D. 1971. Movements of *Myotis lucifugus* from a colony in LaSalle County, Illinois. Transactions of Illinois State Academy of Science 63:409-414.

Warren, P.S., K. Madhusudan, M. Ermann, and A. Brazel. 2006. Urban bioacoustics: it's not just noise. Animal Behavior 71:491–502.

Warren-Hicks, W. J. 1999. Formal Methods for Risk-Based Decision-Making. HERA 5(2):225-229.

Warren-Hicks, W. J., and Hart, A. eds., 2010. Application of Uncertainty Analysis to Ecological Risks of Pesticides. Taylor & Francis, New York, New York.

Warren-Hicks, W. and J., D. Moore, eds. 1998. Uncertainty Analysis in Ecological Risk Assessment: Pellston '95. SETAC Press, Florida.

Watrous, K. S., T. M. Donovan, R. M. Mickey, S. R. Darling, A. C. Hicks, and S. L. Von Oettingen. 2006. Predicting minimum habitat landscape: patterns at the landscape and microhabitat scale. Ecological Applications 13:939–950.

Wear, D. N., and J. G. Greis. 2002. Southern forest resource assessment. U.S. Department of Agriculture, Forest Service, Southern Research Station, General Technical Report SRS-53, Asheville, USA.

Whitaker, J. O., Jr., and V. Brack, Jr. 2002. Distribution and summer ecology in Indiana. Pages 48-54 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, Texas, USA.

Whitaker, J., and W. Hamilton. 1998. Mammals of the Eastern United States. Cornell University Press, Ithaca, New York, USA.

Whitaker, J.O., Jr. and D.W. Sparks. 2003. 2002 Monitoring program for the Indiana Myotis (*Myotis sodalis*) near the site of the future Six Points interchange in Hendricks and Marion Counties, Indiana as required under the Six Points Interchange Habitat Conservation Plan.

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

Wibbelt G., A. Kurth, D. Hellmann, M. Weishaar, A. Barlow, M. Veith, J. Prüger, T. Görföl, L. Grosche, F. Bontadina, U. Zöphel, H.Seidl, P. M. Cryan, and D. S. Blehert. 2010. White-nose syndrome fungus (*Geomyces destructans*) in bats, Europe. Emergent Infectious Diseases. DOI: 10.3201/eid1608.100002.

Wilhere, G. F. 2002. Adaptive management in habitat conservation plans. Conservation Biology 16:20-29.

Wilkins, K. T. 1987. *Lasiurus seminolus*. Mammalian Species 280:1–5.

Williams, T. C., and J. M. Williams. 1967. Bat collisions with high performance aircraft, a preliminary field investigation conducted at Randolph Air Force Base, Texas, 19–25 October, 1967, Office of Scientific Research Report 67-2510, U.S. Air Force, Arlington, Virginia, USA.

Williams, T. C, L. C. Ireland, and J. M. Williams. 1973. High altitude flights of the free-tailed bat, *Tadarida brasiliensis,* observed with radar. Journal of Mammalogy, 54:807-821.

Williams, T. C., and J. M. Williams. 1970. Radio tracking of homing and feeding flights of a neotropical bat. Animal Behavior 18:302-309.

Willis, C. K. R., and R. M. Brigham. 2004. Roost Switching, roost sharing and social cohesion: forest-dwelling big brown bats, *Eptesicus fuscus*, conform to the fission-fusion model. Animal Behaviour 68: 495-505.

Wind Turbine Guidelines Federal Advisory Committee [FAC}. 2010. Preamble to the Committee Recommendations Committee Policy Recommendations Committee Recommended Guidelines. Submitted to the Secretary of the Interior by the Wind Turbines Guidelines Advisory Committee.

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

Winhold, L., E. Hough, and A. Kurta. 2005. Long-term fidelity by tree-roosting bats to a home area. Bat Research News 46:9-10.

Wisdom, M. J. and L. J. Bate. 2008. Snag density varies with intensity of timber harvest and human access. Forest Ecology and Management 255:2085-2093.

Worton, B. J. 1989. Kernel methods for estimating the utilization distribution in home range studies. Ecology 70:164-168.

Young, D. P. Jr., K. Bay, S. Nomani, and W. Tidhar, 2011. NedPower Mount Storm Wind Energy Facility post-construction avian and bat monitoring April-July 2010. Prepared for NedPower Mount Storm LLC, Houston, Texas. Western EcoSystems Technology, Inc., Cheyenne, Wyoming.

Young, D. P., Jr., W.P. Erickson, K. Bay, S. Nomani, and W. Tidhar. 2009a. Mount Storm Wind Energy Facility, phase I post-construction avian and bat monitoring, July – October 2008. Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

Young, D. P., Jr., K. Bay, S. Nomani, and W. Tidhar. 2009b. Mount Storm Wind Energy Facility, post-construction avian and bat monitoring, March – June 2009. Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

Young, D. P., Jr., K. Bay, S. Nomani, and W. Tidhar. 2010. Mount Storm Wind Energy Facility, post-construction avian and bat monitoring, July - October 2009. Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

Young, D.P. Jr., W.P. Erickson, J. Jeffrey, and V.K. Poulton. 2007. Puget Sound Energy Hopkins Ridge Wind Project Phase 1 post-construction avian and bat monitoring first annual report, January - December 2006. Technical report for Puget Sound Energy, Dayton, Washington and Hopkins Ridge Wind Project Technical Advisory Committee, Columbia County, Washington. Western EcoSystems Technology, Inc. (WEST) Cheyenne, Wyoming, and Walla Walla, Washington. <http://wind.nrel.gov/public/library/young9.pdf>. Accessed 23 February 2011.

Young, D. P. Jr., J.D. Jeffrey, W.P. Erickson, K.J. Bay, V.K. Poulton, K. Kronner, B. Gritski, and J. Baker, 2006. Eurus Combine Hills Turbine Ranch Phase I post construction wildlife monitoring first annual report February 2004-February 2005. Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming and Walla Walla, Washington; Northwest Wildlife Consultants, Pendleton, Oregon.

Young, D. P., Jr., W. P. Erickson, R. E. Good, M. D. Strickland, and G. D. Johnson. 2003. Avian and bat mortality associated with the initial phase of the Foote Creek Rim Wind power Project, Carbon County, Wyoming: November 1998 June 2002. SeaWest Energy Corporation, Livermore, California, USA and U.S. Bureau of Land Management, Cheyenne, USA.

Zinn, T. L., and W. W. Baker. 1979. Seasonal migration of the hoary bat, *Lasiurus cinereus*, through Florida. Journal of Mammalogy 60:634-635.

Appendix A

Indiana Bat Collision Risk Model

Indiana Bat Collision Risk Model for the Buckeye Wind Power Project

Champaign County, Ohio

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1.0 INTRODUCTION

This collision risk model was developed to evaluate the probability of Indiana bat (*Myotis sodalis*) collision with wind turbines at the proposed Buckeye Wind Power Project (the Project) in Champaign County, OH. Buckeye Wind LLC, a wholly owned subsidiary of EverPower Wind Holdings, Inc., (EverPower; hereafter referred to as "Buckeye Wind" or the "Applicant") proposes to construct and operate a wind-powered electric generation facility that would include installation of up to 100 wind turbine generators (turbines), each with a generating capacity of 1.8-megawatts to 2.5-megawatts (MW), resulting in a maximum capacity of 250 MW. The facility will be situated within an area that encompasses approximately 32,395 hectares (ha; 80,051 acres [ac]; hereafter "Action Area") (refer to Figure 1-1 in the HCP). The results of this model will be used to estimate mortality (i.e., "take") that would be permitted under an Incidental Take Permit (ITP) issued by the U.S. Fish and Wildlife Service (USFWS) in accordance with the Buckeye Wind Project Habitat Conservation Plan (HCP).

Operation of the Project has the potential to result in mortality of Indiana bats, listed as federally endangered under the Endangered Species Act (ESA) of 1973 (7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.), as amended. Indiana bats are known to fly within and near the Action Area during summer based on summer mist netting captures. Indiana bats are also likely to pass through the Project area during spring and fall migration. Bats using the Action Area could be injured or killed if individuals collide with turbines or come in close proximity to spinning blades, which can result in rapid pulmonary pressure changes leading to death as a result of barotrauma (Baerwald et al. 2008).

Impacts to bats from wind facilities are well documented in the continental United States (Johnson et al. 2003, Kunz et al. 2007, Arnett et al. 2008, Horn et al. 2008), with long-distance migratory bats being the most affected, particularly during the late-summer through fall migratory period. Prior to fall 2009, no Indiana bats were known to have been killed at a wind facility. However, the 2 documented fatalities of Indiana bats at the Fowler Ridge wind facility in Benton County, Indiana during the fall migratory periods in 2009 and 2010 confirm that Indiana bats are at risk of collision with wind facilities during the fall (Good et al. 2011). Indiana bats are also suspected to be at risk during the spring and summer periods, but mortality during these periods has not been documented.

Indiana bat use of the Action Area and their associated collision risk was estimated during 3 periods in which Indiana bats display distinct behavioral characteristics that could differentially affect their exposure to wind turbines: spring emergence and migration, or "spring" (1 Apr to 31 May), summer habitat use, or "summer" (1 Jun to 31 Jul), and fall migration and swarming, or "fall" (1 Aug to 31 Oct). The modeling technique presented here estimates mortality on a seasonal basis.

1.1 Model Approach

This collision risk model seeks to estimate Indiana bat mortality resulting from the rotating blades of operating wind turbines in the Action Area. Choosing the appropriate modeling approach for Indiana bat mortality estimation is a difficult process, because relatively few collision risk models are available for use in assessing collision based mortality at wind facilities, and none have previously been used to estimate bat mortality. Madders and Whitfield (2006) reviewed existing models that have been used for inland wind facilities and found that in general, existing mathematical models can be categorized into (1) simple correlations between the rate of mortality and turbine characteristics (Erickson et al. 2001; Barclay et al. 2007), and (2) highly detailed models requiring a large amount of information on the physical characteristics of the turbine geometry and bird size and speed (Tucker 1996a, 1996b; Podolsky 2003, 2005; Band 2000; Band et al. 2005). A third type of model exists that uses simple geometry with a minimum of information on the physical characteristics of a turbine (Hatch and Brault 2007; Bolker et al. 2006). The usefulness of a particular model is dependent upon the situation to which it is applied.

Under conditions of high uncertainty, simple models with minimal inputs are generally preferred in the risk assessment literature to more complex models with a large number of inputs (Warren-Hicks and Moore 1998). In cases where many key elements that influence risk are not well documented or understood, over-complication of mathematical models can lead to correspondingly high uncertainty in the model predictions, potentially giving decision makers a false sense of accuracy in the model findings. In these situations, the use of simple models that incorporate uncertainty analysis focused on the model equations and inputs can provide decision makers with a framework for understanding the degree of confidence that can be assigned to model outputs (Warren-Hicks 1999, Canham et al. 2003, Warren-Hicks and Hart 2010).

An example of this type of model was developed by Bolker et al. (2006) to estimate avian mortality at the proposed Cape Wind offshore wind facility in MA. The Bolker et al. (2006) model requires minimal inputs and employs simple geometry and basic probability theory. Given the uncertainty in modeling Indiana bat collision in the Action Area, the Bolker et al. (2006) model was used but expanded upon by incorporating empirical data and expert opinion on Indiana bat behaviors and conditions leading to risk into the published mathematical framework. Additionally, the Bolker et al. (2006) framework was modified by formally incorporating a risk-based approach to decision-making based on the model outputs, including the use of a formal uncertainty analysis.

A probabilistic approach was used in this collision risk model that relied on either a range of values, or on a formal distribution for each model input, rather than a deterministic approach based on single-point estimates. A large variety of assumed or theoretical distributions can be fit to the data used for each model input (Hogg and Craig 1978). A Beta distribution was used when input values varied between 2 limits, but there was reason to believe that a subset of values within those limits was more likely to occur, as with proportions or probabilities. A uniform distribution was used when there was limited information about whether 1 value was more likely to occur than another. In some cases, random samples were drawn from an actual distribution based on empirical data, rather than a theoretical distribution. The distributions used for each model input will be described in the following sections.

Most model input distributions were based either directly on empirical data (e.g., weather conditions), or indirectly by extrapolating empirical data (e.g., summer population size extrapolated from field data). However, some inputs either had missing empirical data from some important portion of the distribution (e.g., activity rate within the rotor swept zone), or no empirical data at all (e.g., survival probability). For model inputs whose distributions were based only partially or not at all on empirical data, a sensitivity analysis was conducted to investigate the degree to which changes in the input distributions affected model results.

To test the uncertainty of collision risk estimates to parameter assumptions, a Monte Carlo analysis was used (Manly 2007). Monte Carlo analysis propagates uncertainty in model inputs, through the model equation, into uncertainty in the model predictions. Random sampling of model input distributions (or measured data) generates a distribution of model predictions. Monte Carlo analysis is useful for modeling phenomena with uncertainty in the model inputs, such as the calculation of collision risk for Indiana bats. Repeated sampling based on 100,000 iterations was used (10,000 or more iterations are recommended for biological studies by Jackson and Somer 1989, as cited by Manly 2007).

This probabilistic framework was used to represent uncertainty in model inputs, as well as the final estimation of mortality. Thus, the model output is presented in terms of what is most likely to occur, but also in terms of the range of Indiana bat mortality that is estimated to occur under best case and worst case scenarios. This approach is most defensible, given the uncertainty in the underlying model inputs, and it is lends itself well to the development of adaptive management strategies presented in the HCP.

1.1.1 Model Limitations

In the case of bats, little empirical information is available on the number of bats that have the potential to encounter wind facilities, avoidance or attraction behavior of the wind facilities completely or turbines individually, flight height, angle of flight, the influence of weather conditions and wind direction, and other variables that may be highly correlated to the probability of mortality. As a result of these data limitations, in addition to available empirical data, this model used professional scientific opinion informed by published literature, expert opinion, and consultation with the USFWS.

Because a collision risk model has not previously been developed for bats, this model was modified from an existing model developed for birds and wind facilities. A potential limitation of using a model developed for birds is the assumption of straight-line flight, an assumption which has been made by all collision risk models developed for wind facilities to date (Tucker 1996a, 1996b, Band 2000, Podolsky 2003, 2005, Band et al. 2005, Bolker et al. 2006, Nations and Erickson 2009). Bats display erratic flight behavior both vertically and horizontally relative to the ground, while existing models assume straight-line flight across the turbine array. However, only flight behavior at the height of spinning turbine blades affects mortality risk. For the purposes of this model, it is assumed that non-linear and erratic flight characteristic of foraging bats occurs primarily at or below tree canopy height (Humphrey et al. 1977, Brack 1983, Gardner et al.

1989) and that any flight behavior within the rotor swept zone that could lead to an encounter with a spinning turbine blade would primarily consist of straight-line travel.

It is possible that this assumption could be violated if Indiana bats do not exhibit primarily straight-line flight when flying at turbine height. For example, if Indiana bats are attracted to turbines they could exhibit non-linear flight in the rotor swept zone as they fly in and around spinning turbine blades to investigate. However, there is currently no indication that Indiana bats are attracted to wind turbines. The only 2 documented Indiana bat fatalities at wind facilities occurred during the fall migratory period when bats must travel long distances from summer reproductive areas to hibernacula over short periods of time. While little empirical data exist on Indiana bat flight behavior during migration, it is reasonable to expect that such long traveling bouts at a time when energy stores are critically important likely necessitates direct, energy efficient, linear flight. Therefore, the timing of documented Indiana bat mortality at wind facilities provides further support for the appropriateness of assuming linear flight within the rotor swept zone and use of the Bolker et al. (2006) model. Further discussion about flight behavior is included in Section 2.3 – Movement within the Turbine Array.

Another potential limitation of this model includes assumptions about survival probability when an Indiana bat is within the rotor swept zone, since no empirical data on Indiana bats exist from which to base model inputs. A critically important parameter in collision risk modeling is behavioral avoidance of turbines (Fox et al. 2006). Both avoidance and attraction (the latter has not been addressed for birds, but is assumed to be a potential factor in bat collision risk [Kunz et al. 2007]) have direct implications for a bat's ability to survive if it flies at rotor swept height within a turbine array. Behavioral avoidance and attraction are difficult to measure empirically, and have not been incorporated into collision models that have been published to date.

However, a Horn et al. (2008) study using thermal infrared cameras at the Mountaineer, WV wind facility showed that bats have the ability to avoid spinning turbine blades. From 998 total bat passes observed in the rotor swept area, direct contact with moving blades was observed only 5 times (0.5%) and avoidance behavior was observed 41 times (4.1%). Avoidance involved sharp, evasive flight maneuvers, with many instances involving multiple passes in which bats appeared to repeatedly investigate turbine blades after multiple near misses, rather than flying off quickly. In these cases, bats often appeared to be buffeted by turbulence close to the blade surface (Horn et al. 2008). Given that the majority of documented fatalities at this facility were long-distance migratory tree bats, it is likely that it was also these species of bats that displayed avoidance behavior. However, given that Indiana bats are more maneuverable than migratory tree bats as a result of their lower wing aspect ratio (see Section 4.5.5.3 of the HCP for more information), it is likely that Indiana bats also have the ability to avoid spinning turbine blades and have the potential to survive an encounter with a spinning blade. Based on this assumption, survival probabilities between 48% and 97% were included in this model, meaning that bats that fly within the rotor swept zone survive approximately half of the time or more. Given that only 0.5% of observed bat passes within the rotor swept zone resulted in direct contact with blades in the Horn et al. (2008) study and Indiana bats are even more maneuverable than migratory tree bats, these survival probabilities are considered reasonable and conservative.

Similarly, there are no empirical data on flight activity of Indiana bats under different temperature and wind speed conditions. Based on data from acoustic monitoring, post-construction fatality, mist-netting, and operational curtailment studies, assumptions were made about the reductions in bat activity under different temperature and wind speed conditions. Specifically, the estimated population size exposed to risk was reduced by 90% for a proportion of time that corresponds to conditions in the Action Area when documented wind speeds were above 6 meters per second (m/s). Similarly, the estimated population size exposed to risk was reduced by 80% for a proportion of time that corresponds to conditions in the Action Area when documented temperatures were below 10°C (50°F).

If these assumptions are inaccurate, the mortality risk predicted by this model could be higher or lower. However, given that conditions in which assumed bat activity was reduced occurred during a relatively small proportion of the time (i.e., temperatures < 10°C occurred 32%, 0%, and 18% of the time in the spring, summer, and fall respectively; wind speeds > 6 m/s 53%, 20%, and 38% of the time in the spring, summer, and fall respectively), adjustments to risk based on these weather conditions had a relatively small affect on overall mortality estimates. Also, since multiple lines of evidence from different types of studies point to similar thresholds in reductions in activity based on these temperature and wind conditions (see additional information in Section 2.2 – Effect of Weather Conditions on Activity), even if the exact thresholds that have been assumed in this model are not completely accurate, temperature and wind conditions under which activity is substantially reduced are likely not substantially different than what has been assumed in this model.

2.0 DESCRIPTION OF MODEL INPUTS

The total number of bats at risk on any random night is a function of the seasonal population size (see Section 2-1) and the weather conditions (see Section 2-2) thought to affect whether bats in that population are actively flying. Summer population sizes were estimated from emergence counts at roost trees within and in the vicinity of the Action Area; spring and fall population sizes were estimated from the 2009 winter census of Indiana bats at hibernacula in the Midwest Recovery Unit within migrating distance of the Action Area. A frequency histogram of wind speed and temperature were individually generated for summer, fall, and spring periods based on more than 3 years of data collected at meteorological towers in the Action Area. The relative frequency of specific wind speeds and temperature conditions were used to randomly select representative weather conditions on any given night during each season. Based on this distribution of weather conditions, the total number of bats at risk of collision on any given night was reduced under weather conditions known to be associated with low bat activity: low temperature and high wind speed. The number of bats at risk was further adjusted based on the number of times these bats are estimated to move within the Action Area (see Section 2-3). The number of large-scale movement bouts was calculated as a function of distance traveled across the turbine array and the probability of a bat traveling that distance. Probability of mortality was calculated as a function of flight height (see Section 2-4), flight direction (see Section 2-5), probability of survival (see Section 2-6), and turbine design and location (see Section 2-7). Each of these factors was used to estimate the total number of turbine encounters expected, and ultimately, estimates of mortality (see Section 3.0). The following narrative describes each of the above model input parameters and provides details on the generation of uncertainty estimates and distributions for each model input.

2.1 Seasonal Population Size

The number of Indiana bats likely to be present in the Action Area was estimated separately for the summer maternity period and for the spring and fall migratory periods; referred to as the "summer population" and the "migratory population". These seasons are presented as being discrete; however, it is expected that there is overlap in seasonal behaviors (i.e., migration and summer habitat use) and that weather conditions and other stochastic factors could affect the exact timing of this annual chronology. As such, these cut-off dates (presented in Section 1.0) have been selected to adequately encapsulate seasonal behaviors that could differentially affect collision risk, but it is recognized that the exact timing of these events may differ based on a number of varying factors that cannot be known. It should also be noted that the term "population" is used to define the number of individuals in the Action Area, but does not include any assumptions about death, birth, immigration, and emigration rates that are associated with the term in the field of ecology.

2.1.1 Summer Population

The potential summer population of Indiana bats in the Action Area was estimated using emergence count and home range data from 3 adult female Indiana bats captured and radio tracked in the Action Area in 2009 (in Champaign County), as well as 7 adult female Indiana bats captured and radio tagged in 2008 and 2009 during summer mist netting surveys in Logan and Hardin Counties, OH[1] (hereafter, Champaign, Logan, and Hardin Counties will be referred to as the tri-county area). Summer population estimates were based on 76 emergence counts[2] at 23 roost trees, the home range sizes (estimated from nighttime telemetry) of the female bats using those roost trees, and the number of maternity colonies the landscape could support. These methods followed 2 USFWS Biological Opinions for Indiana bats (2005*a*, 2005*b*) which used average Indiana bat emergence counts and home range sizes reported in the literature to estimate summer population sizes. Data on Indiana bats in the tri-county area used in this analysis were supplied by the Ohio Department of Natural Resources (ODNR).

The average emergence count on nights when at least 1 bat was observed emerging from a maternity roost ranged was 18 bats ± 17 bats (mean ± standard deviation; range from 1 bat to 83 bats). Emergence counts in the tri-county area were similar to those reported by Kurta et al. (1996) for a maternity colony in south central MI, where 89% of 150 observed emergence counts

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[1] Although a total of 24 adult female and 2 male Indiana bats were captured in the tri-county area in 2008 and 2009, only 17 females and 2 males were radio tagged, only 12 females and 2 males were tracked to roost trees, and only 10 females had home range information and emergence count numbers sufficient to generate a summer population estimate.

[2] This sample size was derived by treating observations of multiple radio tagged females exiting the same roost tree as individual emergence counts, and associating home ranges for an individual with all roost trees used by that individual.

documented between 2 and 21 bats. However, a study by Whitaker and Brack (2002) documented as many as 384 bats emerging from 1 maternity roost tree in IN, and found that the average maternity colony size was approximately 80 adult female bats. Similarly, the mean maximum emergence count after young began to fly (measured in 12 studies) was approximately 119 bats (Kurta 2005), suggesting that 60 adult females to 70 adult females were present. Harvey (2002) reported that most documented Indiana bat maternity colonies contained 100 or fewer adult females.

Although summer use estimates relied on emergence count data, there are limitations to using these data to determine the size of a maternity colony, because colony members are dispersed among various roosts at any given time (Kurta 2005). Also, estimating colony size relies on the following assumptions, which may not be applicable in all cases:

1. Emerging bats are adult female Indiana bats if counts occur prior to dates when young typically become volant, or they include young of the year if counts occur after juveniles become volant. Kurta and Rice (2002) and Humphrey et al. (1977) reported that most pups become volant between early July through early August in southern MI and southern IN. Although adult male bats have been documented in maternity roosts, it is considered unlikely that large numbers of male bats occupy maternity roosts (USFWS 2007).
2. All bats emerging from the roost are Indiana bats, although there are documented cases of more than 1 species of bats using the same maternity roost (T. Carter, Ball State University, personal communication).
3. Assumptions must be made regarding what proportion of the colony may have been counted during the count. Counts conducted on multiple nights at multiple known roost sites over the course of the maternity season provide better estimates than a single count at a single tree.

While some of the emergence counts in the tri-county area were conducted on the same night at multiple roost trees used by the same maternity colony, the majority (87%) were counts conducted at a single tree on a single night. Therefore, by necessity each emergence count was considered a single estimate of the maternity colony size. To adjust the population to include juveniles that were not yet volant at the time emergence counts were conducted, the number of emerging bats was multiplied by 2 for counts conducted before 15 July, similar to methods used by the USFWS (2005*a*, 2005*b*). This multiplier is based on data from Kurta and Rice (2002) and Humphrey et al. (1977) which suggest that approximately 90% of captured females are in reproductive condition (i.e., pregnant, lactating, or post-lactating) during the summer reproductive period (see Section 4.3 of the HCP – Demographics for further detail).

Summer use estimates relied on home range sizes of radio tagged females to approximate the total area used by all members of their associated maternity colonies, because the area used by multiple bats from the same maternity colony was not available. In other words, individual home ranges from radio tagged Indiana bats were treated as approximations of the total area used by the entire maternity colony. The average minimum convex polygon (MCP) estimate of home range size was 1,021 ha ± 732 ha (2,523 ac ± 1,809 ac); with a range from 217 ha to 2,704 ha

(536 ac to 6,682 ac). Sample sizes ranged from 34 to 208 radio telemetry locations per home range estimate (93.7 ± 56.4).

Because portions of the Action Area are dominated by large expanses of agriculture or urban areas that are likely unsuitable for Indiana bat roosting and foraging activities, the amount of habitat considered suitable for Indiana bat roosting and foraging activities was reduced. Only habitat that was ranked in the top 3 suitability categories in the habitat suitability model (i.e. Categories 1, 2, and 3; see Appendix B for further detail) was included. This resulted in a 9,847 ha (24,331 ac) area which comprised approximately 30% of the total Action Area.

The amount of suitable habitat in the Action Area was divided by each home range size to estimate the number of maternity colonies the Action Area could support. For each home range size estimate, the number of home ranges the Action Area could support was then multiplied by emergence count results for the associated bat to determine the potential summer population of bats in the Action Area (Table 2-1). For example, an emergence count conducted on July 9, 2008 documented 36 bats emerging from a roost tree. This count occurred prior to 15 July, so the number of emerging bats was doubled to account for non-volant juveniles. The radio tagged female that was tracked to this roost tree had a home range size of 862.7 ha (2,131.8 ac). Based on this home range size, a total of 11 maternity colonies could be present within the Action Area (9,847 ha of suitable area), or a total of 822 bats (11 maternity colonies x 72 bats per maternity colony).

Table 2-1. Estimates of Indiana bats using the Buckeye Wind Power Action Area during summer based on emergence counts conducted at 23 roost trees occupied by 10 radio-tagged female Indiana bats and their associated home range sizes. When multiple bats used a single roost tree, multiple population size estimates were created; therefore, 76 separate estimates of summer population size were created from 57 emergence counts.

Count Date	# Emerging bats	# Adjusted for non-volant juveniles	Home range size (ha)	# of maternity colonies in Action Area	Estimate of # bats in Action Area[3]
07/09/08	36	72	862.7	11	893
07/11/08	44	88	862.7	11	1092
07/14/08	22	44	862.7	11	546
07/15/08	19	19	862.7	11	236
07/16/08	40	40	862.7	11	496
07/17/08	35	35	862.7	11	434
07/18/08	26	26	862.7	11	323
07/09/08	36	72	601.3	16	1281
07/11/08	44	88	601.3	16	1566
07/14/08	22	44	601.3	16	783
07/15/08	19	19	601.3	16	338

[3] Equal to the number of maternity colonies in the Action Area, multiplied by the emergence count adjusted for non-volant juveniles, increased by 8% to incorporate males into the estimate.

Table 2-1. Estimates of Indiana bats using the Buckeye Wind Power Action Area during summer based on emergence counts conducted at 23 roost trees occupied by 10 radio-tagged female Indiana bats and their associated home range sizes. When multiple bats used a single roost tree, multiple population size estimates were created; therefore, 76 separate estimates of summer population size were created from 57 emergence counts.

Count Date	# Emerging bats	# Adjusted for non-volant juveniles	Home range size (ha)	# of maternity colonies in Action Area	Estimate of # bats in Action Area[3]
07/16/08	40	40	601.3	16	712
07/17/08	35	35	601.3	16	623
07/18/08	26	26	601.3	16	463
07/16/08	1	1	862.7	11	12
07/17/08	1	1	862.7	11	12
07/17/08	1	1	216.7	45	49
07/18/08	1	1	216.7	45	49
07/19/08	1	1	216.7	45	49
07/20/08	1	1	216.7	45	49
07/21/08	46	46	216.7	45	2271
07/10/09	9	18	1000.1	10	193
07/11/09	14	28	1000.1	10	300
07/12/09	15	30	1000.1	10	321
07/20/09	3	3	1000.1	10	32
07/10/09	2	4	1000.1	10	43
07/10/09	17	34	1000.1	10	364
07/12/09	4	8	1000.1	10	86
07/13/09	8	16	1000.1	10	171
07/20/09	22	22	1000.1	10	235
07/15/09	35	35	1000.1	10	375
07/18/09	83	83	1000.1	10	888
07/20/09	70	70	1000.1	10	749
07/16/09	23	23	1000.1	10	246
07/17/09	18	18	1000.1	10	193
07/20/09	2	2	1000.1	10	21
07/16/09	23	23	1000.1	10	246
07/17/09	18	18	1000.1	10	193
07/20/09	2	2	1000.1	10	21
07/15/09	21	21	1837.1	5	122
07/16/09	23	23	1837.1	5	134
07/18/09	4	4	1059.8	9	40
07/19/09	1	1	1059.8	9	10
07/19/09	5	5	1059.8	9	50
07/23/09	2	2	1059.8	9	20

Table 2-1. Estimates of Indiana bats using the Buckeye Wind Power Action Area during summer based on emergence counts conducted at 23 roost trees occupied by 10 radio-tagged female Indiana bats and their associated home range sizes. When multiple bats used a single roost tree, multiple population size estimates were created; therefore, 76 separate estimates of summer population size were created from 57 emergence counts.

Count Date	# Emerging bats	# Adjusted for non-volant juveniles	Home range size (ha)	# of maternity colonies in Action Area	Estimate of # bats in Action Area[3]
07/02/09	12	24	803.4	12	320
07/03/09	8	16	803.4	12	213
07/04/09	5	10	803.4	12	133
07/05/09	4	8	803.4	12	107
07/02/09	2	4	598.2	16	72
07/03/09	3	6	598.2	16	107
07/05/09	2	4	598.2	16	72
06/29/09	38	76	803.4	12	1012
06/30/09	20	40	803.4	12	533
06/01/09	34	68	803.4	12	906
06/02/09	15	30	803.4	12	400
06/03/09	3	6	803.4	12	80
06/04/09	16	32	803.4	12	426
06/29/09	38	76	598.2	16	1360
06/30/09	20	40	598.2	16	716
06/01/09	34	68	598.2	16	1217
06/02/09	15	30	598.2	16	537
06/03/09	3	6	598.2	16	107
06/04/09	16	32	598.2	16	573
06/29/09	38	76	526.9	19	1544
06/30/09	20	40	526.9	19	813
06/01/09	34	68	526.9	19	1381
06/02/09	15	30	526.9	19	609
06/03/09	3	6	526.9	19	122
06/04/09	16	32	526.9	19	650
07/17/08	11	11	2703.8	4	44
07/24/08	28	28	2703.8	4	111
07/18/08	7	7	2703.8	4	28
07/19/08	3	3	2703.8	4	12
07/24/08	10	10	2703.8	4	40
07/24/08	5	5	2703.8	4	20

To estimate the number of males in the summer population, the population sizes estimated using the above methods were adjusted based on the proportion of males to females observed in the Action Area during mist-netting surveys. A total of 24 females and 2 males were captured in

2008 and 2009, indicating that females made up approximately 92% and males made up 8% of the summer population. This is similar to the proportion of males captured during summer mist-netting in southern MI from 1977 to 2002 (11% of the 87 Indiana bats captured were male; Kurta and Rice 2002). In other words, population sizes estimated from maternity colony data (emergence counts and associated home ranges) were assumed to represent only 92% of the total population size (comprised of females and juveniles), which was increased by 8% to account for males in the summer population. After increasing the estimated population by 8% to account for males, the estimated mean summer Indiana bat population was 415.7 bats ± 461.2 bats (range from 10.1 bats to 2,271.4 bats).

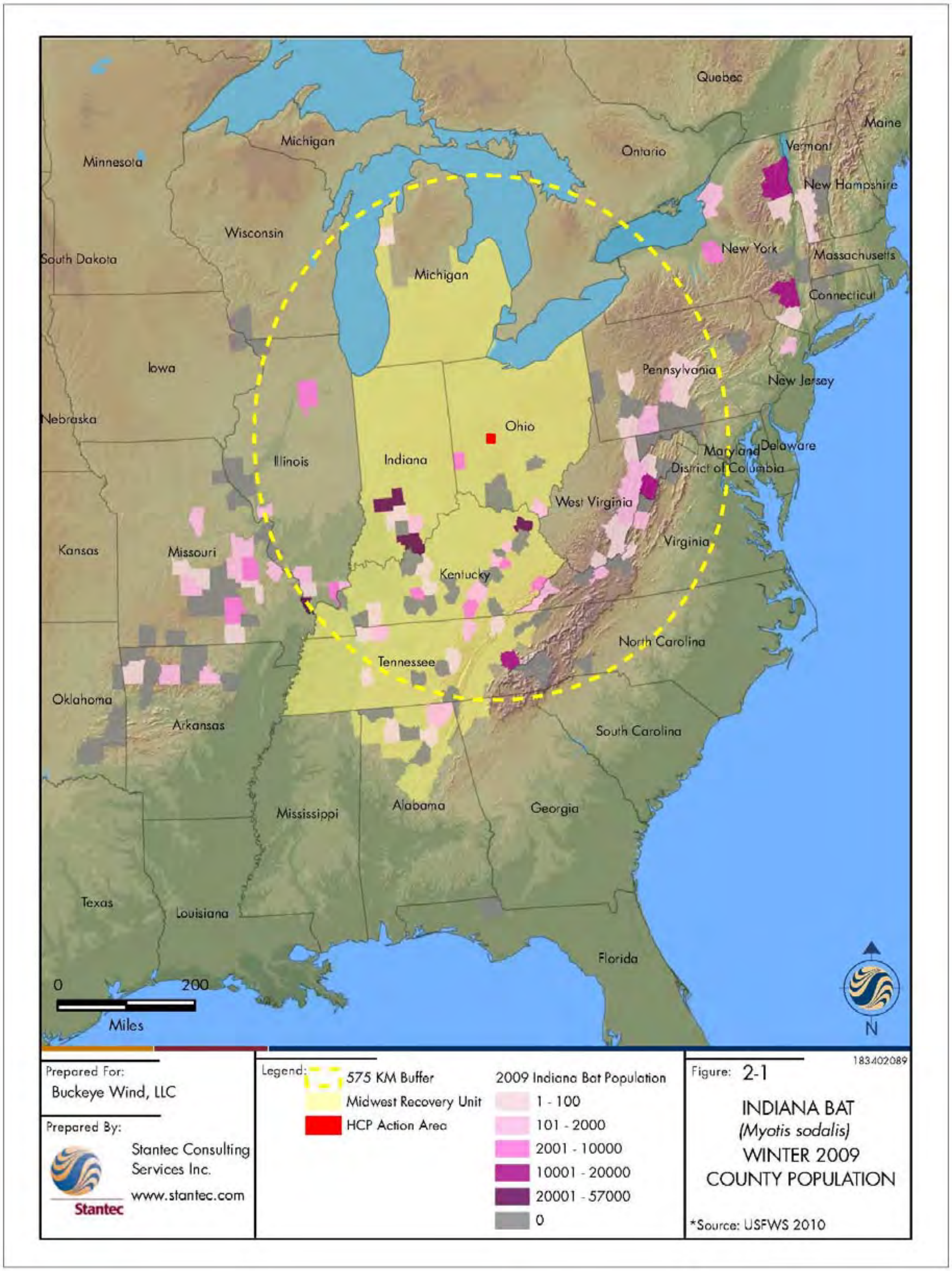
Since the size of an area used by all members of a maternity colony may be larger than that used by each individual colony member, using individual home ranges as estimates of maternity colony home range area likely overestimated the number of maternity colonies the Action Area. Furthermore, this method assumes that maternity colonies are non-overlapping and all are occupied. Recognizing these limitations and the assumptions discussed above, instead of using a static number to represent the likely size of the summer population, a range of potential summer population sizes was generated from the emergence count and home range data (Table 2-1). Although this method of calculating summer population size likely overestimates the actual number of Indiana bats using the Action Area during summer, it provides a conservative estimate of population size, and empirical random sampling from the 76 population observations provides a basis for incorporating population uncertainty into the model.

2.1.2 Migratory Population

To calculate the number of Indiana bats likely to pass through the Action Area during spring and fall migration (hereafter referred to as the spring and fall population), the number of bats within a 12-km (7.5-mi) radius of the geometric center of the Action Area was estimated. This buffer size encompassed the area in which all 100 turbines could possibly be sited in the Action Area. The Indiana bat migratory range from the Action Area was defined by a buffer around the Action Area with a 575-km (357-mi) radius, equal to the maximum recorded Indiana bat migratory distance (Winhold and Kurta 2006) (Figure 2-1). The total number of Indiana bats within the migratory range of the Action Area was estimated from the most current winter census data provided by the USFWS (A. King, personal communication). This included 56 counties in IL, IN, KY, MI, MO, OH, PA, WV, TN, and VA, with a total winter 2008-2009 population of 333,079.

The migratory population was further restricted to include only hibernacula within the Midwest Recovery Unit (RU, refer to Figure 4-1 in the HCP) based on genetic (USFWS 2007), morphometric (Hall 1962 as cited by USFWS 2007), and migratory records (Barbour and Davis 1969, Kurta 1980, Gardner and Cook 2002, Kurta and Murray 2002, A. Kurta, Eastern Michigan University, personal communication, and K. Lott, ODNR, personal communication) that indicate bats hibernating within the Midwest RU migrate to summer habitat also within the Midwest RU (refer to Figure 4-1 in the HCP). The total number of Indiana bats hibernating within the migratory range of the Action Area in the Midwest RU during winter of 2008-2009 included hibernacula in 51 counties in IN, KY, MO, OH, TN, and VA, totaling 252,350 bats.

Based on migration records from the late 1970s to the present, Indiana bats appear to migrate in a south-north pattern in the Midwest RU (refer to Figure 4-1 in the HCP). Band returns reported by Barbour and Davis (1969), Kurta (1980), Gardner and Cook (2002), Kurta and Murray (2004), A. Kurta (personal communication), and K. Lott (personal communication) showed bats fanning out from hibernacula in KY and southern IN primarily in a northward direction to summer breeding areas in MI and OH. Based on these observed patterns, most bats in the Midwest RU appear to migrate within in a 180-degree arc from hibernacula to summer breeding areas. However, bats in the Northeast and Appalachian Mountains RUs appear to disperse from hibernacula in multiple directions, with no consistent migration direction pattern (refer to Figure 4-1 in the HCP).


Quebec
Maine
Vermont
New Hampshire
Ontario
Michigan
Minnesota
Wisconsin
South Dakota
Michigan
New York
Massachusetts
Connecticut
Iowa
Pennsylvania
New Jersey
Nebraska
Ohio
Illinois
Indiana
Maryland
Delaware
District of Columbia
West Virginia
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Kentucky
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Oklahoma
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South Carolina
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Georgia
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0
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Miles
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Prepared For:
Buckeye Wind, LLC
Prepared By:
Stantec Consulting Services Inc.
www.stantec.com
Stantec
Legend:
575 KM Buffer
Midwest Recovery Unit
HCP Action Area
2009 Indiana Bat Population
1 - 100
101 - 2000
2001 - 10000
10001 - 20000
20001 - 57000
0
183402089
Figure: 2-1
INDIANA BAT
(Myotis sodalis)
WINTER 2009
COUNTY POPULATION
*Source: USFWS 2010

To account for the uncertainty in migration direction, migratory population sizes were calculated under both assumptions (i.e., assuming that bats migrate within a possible 180 degrees and 360 degrees surrounding hibernacula) and represent the estimated migratory population under both assumptions. The migratory population of bats in the Action Area was estimated by calculating the distance from the geometric center of each county containing a hibernaculum (since exact hibernacula locations were not available) to the center of the Action Area. Trigonometric principle were then applied to calculate the proportion of a 180-degree or 360-degree arc that intersected the 12-km Action Area buffer using the following formula:

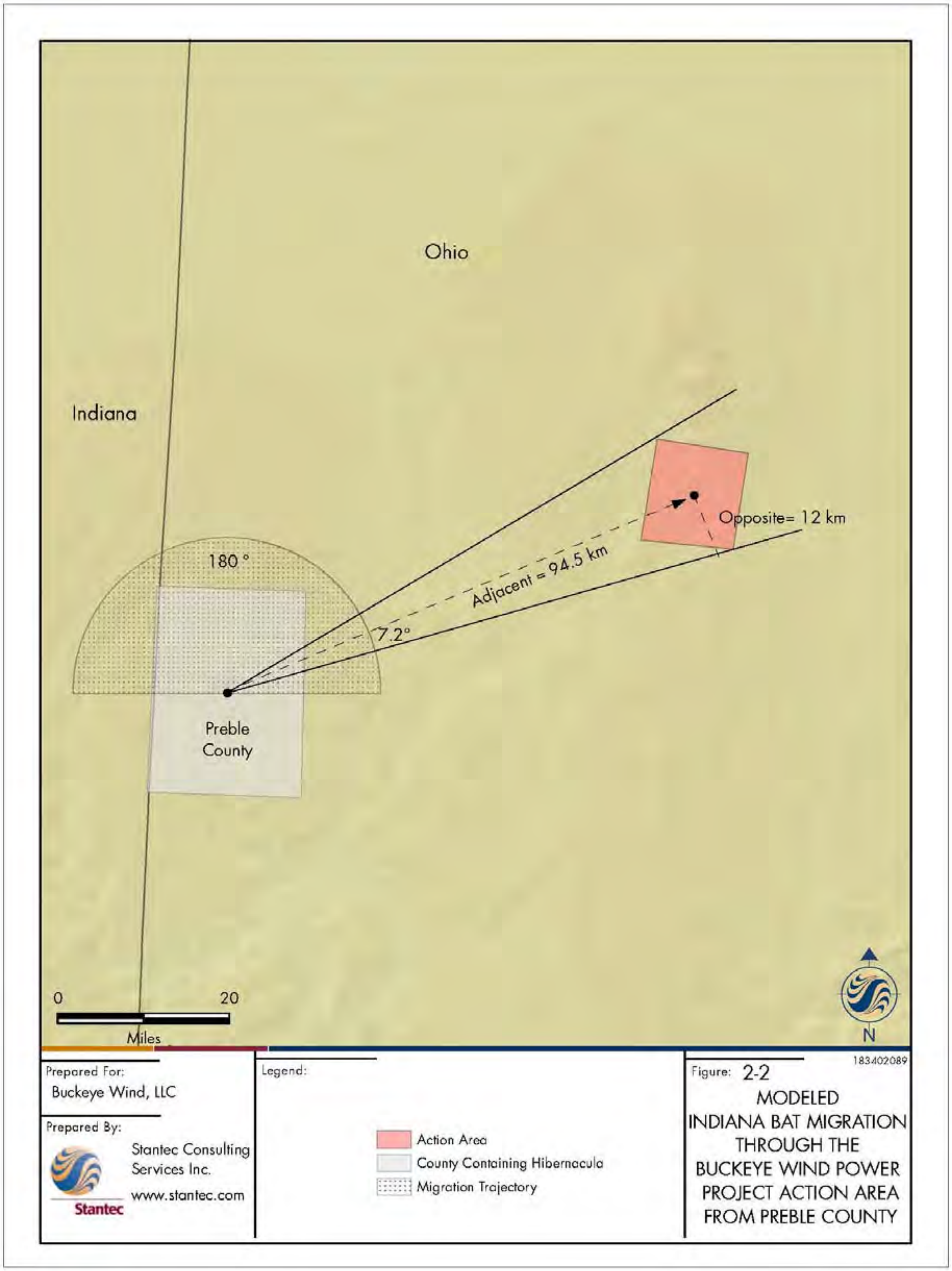
$$\textit{Degrees} = \textit{Tangent}^{-1}\ (\textit{Opposite/Adjacent})$$

Because this only solved for half of the arc of intersection, this value was multiplied by 2 to get the full arc of intersection, which becomes narrower as distance between the hibernaculum of origin and the Action Area increases. Using Preble County, OH (which contains the Priority 2 Lewisburg Limestone Mine) as an example, the geometric center of the County is 94.5 km (58.7 mi) miles southwest of the Action Area center (Figure 2-2), resulting in 14.5 degree arc that intersected the 12-km Action Area buffer, based on the below equation:

$$\textit{Arc of Intersection} = 2 * (7.2° = \textit{Tangent}^{1}(12\ km\ 94.5\ km))$$

The estimate of the migratory population of bats in the Action Area was then refined by multiplying the hibernacula population within each county by the proportion of the 180-degree or 360-degree arc that each calculated arc of intersection represented. For the Preble County example, the 14.5-degree arc represented 8% of a 180 degree arc (i.e., 14.5/180 = 0.08). Therefore, it is estimated that of the 9,007 Indiana bats emerging from Preble County hibernacula in 2009, 8% or 721 bats were likely to travel through the Action Area during migration under the 180-degree assumption; half that number, or 360 bats, were likely under the 360-degree assumption. Assuming the 180-degree migration pattern for the Midwest RU, the estimated migratory population was reduced from a total possible 252,350 bats to 7,242 bats that could potentially migrate through the Action Area. When 360-degree dispersal was assumed from hibernacula, the population was reduced to 3,621.

The migratory population was further refined by assuming that the male population was lower than the female population at the furthest migration distances. Gardner and Cook (2002) and Whitaker and Brack (2002) reported that male Indiana bats typically remain in the vicinity of their hibernaculum throughout the summer. Mist-netting studies conducted from 1978 to 2002 in southern Lower MI showed only 11% of the adults captured were males (Kurta and Rice 2002). Band returns from this population revealed that males likely migrated over 400 km (249 mi) from hibernacula in southern IN and KY (Kurta and Murray 2002, Kurta and Rice 2002). Kurta and Rice (2002) cautioned that 11% probably underestimated the proportion of adult males in the summer population, because netting preferentially occurred near maternity roosts (Kurta et al. 1996, 2002), and male Indiana bats often do not roost with females during the maternity period (Gardner et al. 1991). Therefore, the male populations were assumed to be reduced to 11% only at the furthest migration distances (i.e., 575 km), resulting in an average population estimate composed of 73% females and 27% males over the Action Area.


Ohio
Indiana
180 °
7.2°
Adjacent = 94.5 km
Opposite= 12 km
Preble County
0
20
Miles
N
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Prepared For:
Buckeye Wind, LLC
Prepared By:
Stantec Consulting Services Inc.
www.stantec.com
Stantec
Legend:
Action Area
County Containing Hibernacula
Migration Trajectory
Figure: 2-2
MODELED INDIANA BAT MIGRATION THROUGH THE BUCKEYE WIND POWER PROJECT ACTION AREA FROM PREBLE COUNTY

To estimate the male migratory population, a 50:50 sex ratio was assumed at each hibernaculum (Hall 1962, Myers 1964, LaVal and LaVal 1980) and the male population was then adjusted based on a presumed negative linear relationship with increasing distance away from the hibernaculum of origin. In other words, the male population was assumed to be 100% at a distance of 0 km from the hibernaculum of origin and 11% at a distance of 575 km. Using the 2 known data points: ($x_1 = 0$, $y_1 = 1$; or 0 km from Action Area, 100% male population) and ($x_2 = 575$, $y_2 = 0.11$; 575 km from project site, 11% population) the slope of the linear relationship was:

$$Slope = (y_2\ y_1)\ (x_2\ x_1) \rightarrow (0.11\ \ 1)\ (575\ \ 0) = 0.00155$$

The slope-intercept equation was used to estimate the male migratory population in the Action Area, given the known distances from each hibernaculum, as follows:

Slope-intercept equation: $y = mx+b$, where:

m is the slope of the line
x is the independent variable of the function *y*, or the distance from the hibernacula to the Action Area; and
b is the y-intercept of the line.

Estimated percentage of population = 0.00155 (distance from Action Area*) + 1*

Using Preble County as an example, the estimated male population of bats in the Action Area was reduced to 85% of the population at the hibernaculum (from 362 bats to 309 bats, or from 50% of the population to 43% of the population), based on the following equation:

0.8535 = 0.00155 (94.5) + 1 (or 85% of population at the hibernacula).

Using this method, the percent of males in the migratory population ranged from 8% to 46%, with an average of 27% ± 9%. Based on the aforementioned assumptions, the estimated Indiana bat migratory population in the Action Area is 5,756 (n = 3,621 females; n = 2,136 males) under the 180-degree migratory assumption, and 2,878 Indiana bats (n = 1,810 females; n = 1,068 males) under the 360-degree migratory assumption. These migratory populations represent approximately 2% and 1%, respectively, of the total number of Indiana bats hibernating in the Midwest RU within the 575 km migratory range of the Action Area. Because these estimates are based on a series of assumptions, a Beta distribution (Figure 2-3) was selected to describe the possible migratory population size. The maximum population estimate was derived using the 180-degree migratory assumption (approximately 5,800 Indiana bats), and the distribution was weighted toward the results of the 360-degree migratory assumption (2,900 Indiana bats). In this way, all possible population sizes between 0 and 5,800 were included. The migratory population was assumed to be the same during both spring and fall migration. The number of bats at risk on any given night was further adjusted based on temperature and wind speed, as explained in the next section.

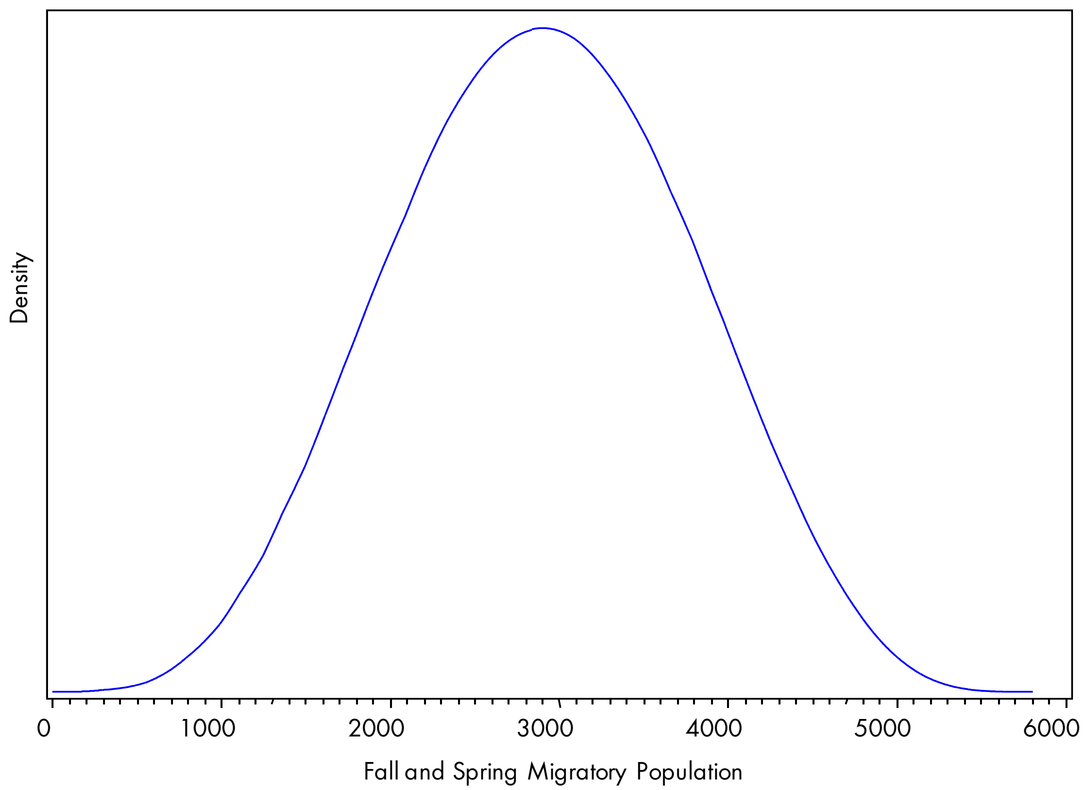

Figure 2-3. Distribution of bat populations during the fall and spring seasons; minimum=0, maximum=5800, shape=5, scale=5

2.2 Effect of Weather Conditions on Activity

Weather variables such as wind speed and temperature have been shown to affect activity patterns of bats; bats are known to suppress their activity during periods of rain, low temperatures, and strong winds (Erkert 1982, Adam et al. 1994, Erickson et al. 2002, Russo and Jones 2003). Accordingly, weather variables such as wind speed, temperature, and barometric pressure have been found to influence bat activity and mortality rates at some wind facilities. Of the 19 wind facilities across the United States reviewed by Arnett et al. (2008), all studies that addressed relationships between bat fatalities and weather patterns found that most bats were killed on nights with low wind speed (<6 m/s) and that fatalities increased immediately before and after passage of storm fronts.

For example, at studies conducted at the Mountaineer, WV and Meyersdale, PA wind facilities in 2004, the proportion of the night when wind speed was < 4 m/s was positively related to bat fatalities, whereas the reverse was true for proportion of the night when winds were > 6 m/s (Kerns et al. 2005). At Mountaineer and Meyersdale, during 81% of nights when no bats were found the next day, median nightly wind speed was on average > 6 m/s. Conversely, on nights before days when the highest numbers of bats were found, median nightly wind speed was 4.1 m/s at Mountaineer and 4.2 m/s at Meyersdale, and only 6.5 to 18.2% of these nights had wind speeds > 6 m/sec, respectively. Consistent with this, average nightly turbine blade speed (RPM) was negatively related to bat fatalities at both facilities (Kerns et al. 2005). Horn's (2008) thermal infrared camera study at Mountaineer also showed that blade rotational speed was a significant negative predictor of observed collisions with turbine blades, suggesting that bats may be at higher risk of fatality on nights with low wind speeds. The association of bat activity with wind speed is not unexpected, given that their flight ability is limited by wind strength, as is the ability of their airborne, insect prey (Fiedler 2004).

This pattern has also been supported by pre- and post-construction acoustic monitoring of bat activity, which has documented a negative relationship with average nightly wind speed (Fiedler 2004, Reynolds 2006). Reynolds (2006) found activity of bats to be highest on nights with wind speeds of < 5.4 m/s during the spring migratory period at the Maple Ridge, NY, wind facility. Bat activity levels at Buffalo Mountain, TN also showed a negative association with average nightly wind speeds (Fiedler 2004).

The relationship between low wind speed and high activity is reinforced by operational curtailment experiments which have documented reductions in bat mortality by reducing the speed at which turbines become operational, or the "cut-in speed". During 2 years of study during the peak fall fatality period at the Cassleman, PA, wind facility, 12 turbines were randomly assigned each night to 1 of 3 experimental groups: fully operational, cut-in speed of 5.0 m/s, or cut-in speed of 6.5 m/s. Total fatalities at fully operational turbines were estimated to be 5.4 times greater on average than at curtailed turbines in 2008, and 3.6 times greater in 2009[4]. In other words, 82% (95% confidence interval [CI] = 52% to 93%) of all fatalities at experimental turbines in 2008 and 72% (CI = 44% to 86%) in 2009 likely occurred when the turbines were fully operational (Arnett et al. 2010).

A similar study was conducted at the Fowler Ridge, IN wind facility in 2010, after the first documented Indiana bat fatality was discovered there in 2009 (Good et al. 2011). From 1 August 2010 to 15 October 2010, 27 turbines were randomly assigned on a weekly basis to 1 of 3 experimental groups: fully operational, cut-in speed of 5.0 m/s, or cut-in speed of 6.5 m/s. An additional 9 turbines were fully operational for the entire survey period. Curtailment at 5.0 m/s was found to reduce mortality by 50% (90% CI = 37% to 61%), and curtailment at 6.5 m/s was found to reduce mortality by 79% (90% CI = 71% to 85%).

At a similar study in southwestern Alberta, Canada, Baerwald et al. (2008) examined the difference in fatality rates under 2 experimental treatments: 1) turbines were curtailed below wind speeds of 5.5 m/s, and 2) a low-speed idle strategy was used whereby operations of turbines were manipulated to change the pitch angle of the blades and lower the generator speed required to start energy production, which caused turbines to be motionless in low wind speeds.

[4] There was no statistical difference between the numbers of fatalities at the 2 different cut-in speeds (Arnett et al. 2010). A difference in mortality can only be measureable when the wind speed is between the 2 operational treatments. Wind speeds at Casselman were not within this range for a long enough period of time to show a statistical difference, if one existed (M. Huso, Oregon State University, personal communication).

Fatalities were significantly reduced by 60.0% and 57.5%, respectively, under the 2 different treatments.

Similar to low wind speed, positive correlations between bat activity and temperature are common in bat literature, both on a nightly basis (Lacki 1984, Negraeff and Brigham 1995, Hayes 1997, Vaughan et al. 1996, Gaisler et al. 1998, Shiel and Fairley 1998) and annual basis (O'Farrell and Bradley 1970, Avery 1985, Rydell 1991). Some pre- and post-construction acoustic surveys at wind facilities have documented bat activity to be negatively correlated with low nightly mean temperatures (Fiedler 2004, Reynolds 2006). Reynolds (2006) found that no detectable spring migratory activity occurred on nights when the daily mean temperature was below 10.5°C (50.9°F). Bat activity at Buffalo Mountain, WV, from 2000 to 2003 was most closely correlated with average nightly temperature (Fiedler 2004).

This is consistent with the observations of J. Kiser (personal communication), developed over 19 years of summer mist-netting surveys in the Midwest and eastern U.S. According to Kiser, bat activity declined dramatically once nighttime temperatures dropped below approximately 12°C (54.5°F). Associations between temperature and bat fatalities in post-construction monitoring studies have been less consistent than for wind speed, but still have been documented. Although a correlation between temperature and bat fatality was not documented at Mountaineer, WV, there was a positive association between temperature and fatality at Meyersdale, PA (Kerns et al. 2005). At the Fowler Ridge, IN wind facility, 91.1% of fatalities during the fall migratory period occurred on nights with mean nightly temperature above 20.1°C (68.1°F) (Good et al. 2011).

High barometric pressure at both Mountaineer and Meyersdale and low relative humidity at Meyersdale, conditions associated with the passage of storm fronts, were also associated with higher bat fatality rates (Kerns et al. 2005). However, because relative humidity is confounded by temperature, it is not a reliable predictor of ecological variables, including mortality (Thornthwaite 1940, A. Kurta, personal communication). Storm activity was associated with bat mortality at both Mountaineer and Meyersdale: few bat fatalities were discovered during storms at Mountaineer and Meyersdale, contrasted by the days with the highest number of fatalities which occurred in the few days after the storm, especially on low wind nights (Kerns et al. 2005). At the Fowler Ridge facility, the night with the most bat casualties appeared to be associated with the passage of one or more weather fronts (Good et al. 2011).

Based on the aforementioned studies and observations, assumptions were made about bat activity and the proportion of the seasonal populations likely to be active as a function of wind speed and temperature on any given night. Although some studies also indicated that the passage of storm fronts was an index to bat activity, storm events were not able to be modeled given their stochastic nature. Temperature and wind speed data collected from a 60-m (197-ft) meteorological tower from June 2007 to July, 2010 in the Action Area (Tables 2-2 and 2-3) were used to estimate the proportion of time during each season that wind speeds were > 6 m/s and temperatures were < 10 °C (50 °F), conditions that have been shown to strongly influence bat activity and collision risk.

Table 2-2. Average nightly temperatures measured at 60-m meteorological towers in the proposed Buckeye Wind Power Project area from June 2007 to January 2010 during spring (1 Apr to 31 May), summer (1 Jun to 31 Jul), and fall (1 Aug to 31 Oct).

Temperature (°C)	Proportion of nights in spring (n=362)	Proportion of nights in summer (n=427)	Proportion of nights in fall (n=552)
<2	2.2%	0.0%	1.1%
2-4	3.9%	0.0%	2.4%
4-6	7.5%	0.0%	2.9%
6-8	6.6%	0.0%	4.5%
8-10	12.2%	0.0%	7.2%
10-12	12.4%	0.5%	6.2%
12-14	17.1%	1.6%	6.9%
14-16	12.2%	8.4%	12.5%
16-18	11.0%	14.5%	17.4%
18-20	8.3%	23.9%	13.6%
20-22	6.6%	30.4%	13.0%
22-24	0.0%	16.6%	9.2%
24-26	0.0%	3.5%	2.5%
26-28	0.0%	0.5%	0.5%

Table 2-3. Average nightly wind speeds measured at 60-m meteorological towers in the proposed Buckeye Wind Power Project area from June 2007 to January 2010 during spring (1 Apr to 31 May), summer (1 Jun to 31 Jul), and fall (1 Aug to 31 Oct).

Wind speed (m/s)	Proportion of nights in spring (n=358)	Proportion of nights in summer (n=427)	Proportion of nights in fall (n=548)
<2	0.0%	0.0%	0.0%
2-2.5	0.0%	1.4%	0.7%
2.5-3	1.1%	2.6%	1.8%
3-3.5	3.4%	2.8%	3.1%
3.5-4	5.0%	7.5%	5.1%
4-4.5	5.0%	14.8%	8.8%
4.5-5	7.5%	20.4%	13.9%
5-5.5	8.9%	16.9%	14.1%
5.5-6	15.9%	13.8%	15.0%
6-6.5	12.3%	7.5%	10.0%
6.5-7	9.2%	7.7%	10.6%
7-7.5	9.2%	3.3%	6.6%
7.5-8	6.1%	0.5%	3.5%
8-8.5	7.3%	0.2%	3.6%
8.5-9	4.2%	0.7%	1.1%
9-9.5	2.8%	0.0%	1.8%
9.5-10	1.7%	0.0%	0.0%
10-10.5	0.0%	0.0%	0.4%
10.5-11	0.3%	0.0%	0.0%

For each seasonal simulation in the Monte Carlo analysis, a random population size was drawn from the seasonal population distribution. In addition, a random wind speed and temperature were drawn based on the weighted distributions shown in Tables 2-2 and 2-3. Based on the random wind speed and temperature drawn, the random population size was adjusted according to the information in Table 2-4. The reduction scenarios given in Table 2-4 were inferred from the aforementioned studies. To reflect reduced bat activity and correspondingly low rates of observed mortality at wind facilities at high wind speeds, the estimated population size exposed to risk was reduced by 90% for wind speeds above 6 m/s. Similarly, the estimated population size exposed to risk was reduced by 80% for temperatures below 10°C (50°F) based on numerous studies and observations showing that only low levels of bat activity are observed at low temperatures.

Table 2-4. Reductions in Indiana bat activity and the numbers of bats exposed to collision risk as a function of wind speed and temperature.

		Temperature	
		<10° C	>10° C
Wind Speed	>6 m/s	reduce activity by 90%	reduce activity by 90%
	<6 m/s	reduce activity by 80%	no reductions in activity

2.3 Movement within the Turbine Array

Previous sections have described how the seasonal population size of Indiana bats was estimated and adjusted based on the expected activity patterns of bats under differing weather conditions. The outcome is populations of bats that may pass partially or completely through the turbine array in any given night, and may do so once or multiple times. The total number of individual bats that encounter turbines and the resulting probability of mortality are a function of distance traveled into the wind facility and the number of times this distance is travelled during a movement event. The Bolker et al. (2006) model calculates the total number of turbine encounters expected when a single bat makes a complete pass through the wind facility (discussed in full in Section 3.1). In order to use the Bolker et al. (2006) model to calculate mortality probability, the results must be adjusted by the expected number of full or partial crossings of the turbine array.

This section discusses the large-scale movements Indiana bats are estimated to make during the course of a given night. While bats can display erratic flight behavior both vertically and horizontally relative to the ground as a result of foraging, most collision risk models, including the Bolker et al. (2006) model used here, assume a straight-line flight path across the entire turbine array. However, it is important to note that only flight behavior at the height of spinning turbine blades affects the amount of estimated mortality, because mortality occurs by colliding with (or flying near the edges of) spinning turbine blades. For the purposes of this model, it is assumed that non-linear flight occurs primarily during foraging, foraging occurs primarily at or below tree canopy height (Humphrey et al. 1977, Brack 1983, Gardner et al. 1989), and therefore non-linear flight patterns do not contribute to risk of collision with turbine blades that are located well above tree-canopy height. Conversely, it has been assumed that any flight behavior within rotor swept zone height that could lead to an encounter with a spinning turbine blade would primarily consist of straight-line travel, and therefore the Bolker et al. (2006) model can be adapted for use here. Supporting information on flight height is presented in Section 2.4 (Flight Height).

Because of the aforementioned assumptions, the model has been applied to presumed straight-line movements. It is important to note that no assumptions are made with regard to the number of small-scale foraging movements that may contribute to a single large-scale movement bout. For example, during the summer, a bat may leave a roost and move between several foraging areas before returning to its roost tree. However, this model is concerned only with the large-scale movement away from the roost and back, since it has been assumed that foraging behavior occurs at or below tree canopy height and therefore does not result in collision risk. It is possible that these assumptions could be violated if Indiana bats are attracted to turbines and exhibit non-linear flight patterns in the rotor swept zone as a result of their attraction. However, there is currently no indication that Indiana bats are attracted to wind turbines due to the very low rates of observed Indiana bat mortality at wind facilities.

2.3.1 Movement during Summer

Bats using the Buckeye Action area during summer are presumed to travel in many directions with no dominant movement patterns, such as primarily northward or primarily between a certain number of foraging areas for a certain number of times per night (which is different from collision risk models developed for migrating birds such as seaducks [Desholm and Kalhert 2006], or marbled murrelets [Nations and Erickson 2009]). Although empirical data on Indiana bats in the tri-county area was provided by the ODNR, the available telemetry data did not provide information on local foraging behavior, as flight behavior is difficult to assess during nighttime telemetry and therefore is not typically collected. Therefore, the number of foraging areas that bats visited during the course of their nightly movements could not be estimated, nor could the distances traveled between multiple foraging areas. Instead, large-scale movement bouts between roost trees and foraging locations were used in the model, which could be derived from the available telemetry data.

The area in which 100 turbines are proposed to be installed is approximately 16.3 kilometers (km) by 19.0 km (10.1 by 11.8 miles [mi]) at its widest points. Indiana bats may fly linear distances between 0.5 km and 8.4 km (0.3 mi and 5.2 mi) while traveling from their roost trees to foraging areas, but most distances are about half the maximum, or approximately 4.0 km (2.5 mi) (Murray and Kurta 2004, Sparks et al. 2005). For the 10 female radio tagged bats captured in the tri-county area in 2008 and 2009, the average distance between roost trees and telemetry points was 1.1 km ± 0.9 km (0.7 mi ± 0.5 mi), and the maximum distance was 5.6 km (3.5 mi) (K. Lott, personal communication). This was similar to the average distance of 1.0 km (0.6mi) traveled between roost trees and the geometric centers of foraging areas for 5 adult female post-lactating Indiana bats tracked over 16 nights in Illinois (Garner and Gardner 1992). The average distance in the same Illinois study for 14 bats including pregnant, lactating, and post-lactating females, males, and juveniles was 2.3 km (1.4 mi).

Differences in commuting distances between summer foraging and roosting areas may be attributed to rangewide differences in habitat type, interspecific competition, and landscape terrain (USFWS 2007). Typically, Indiana bats do not cross large, open areas and instead follow tree lines or other habitat features that provide protective cover, when available. However, Indiana bats may have to travel larger distances or across open areas in areas where connectivity of suitable habitat is limited. For example, Murray and Kurta (2004) found that bats increased their commuting distance by 55% to follow tree-lined paths rather than flying over large agricultural fields, some of which were at least 1 km (0.6 mi) wide. Further studies by Kurta (2005) and Winhold et al. (2005) found that this colony used the same wooded fenceline as a commuting corridor that connected forested areas situated in a largely agricultural area for at least 9 years. Similarly, in a study area where over 60% of the landscape was either agricultural fields or urbanized areas, 12 of 13 foraging sites used by this colony were dominated by forest (Kurta et al. 2002).

Given the disparity in foraging distances traveled in different geographic areas, it was most appropriate to use site-specific, empirical data to inform assumptions about distances traveled by bats during summer foraging and commuting behaviors. Thus, based on Indiana bat foraging distances estimated from 1,124 telemetry locations that were collected from 10 adult female radio tagged bats in the tri-county area, it is known that Indiana bats in the Action Area rarely travel distances large enough to completely cross an area the size of the proposed turbine array (i.e., 19 km [11.8 mi]). Bats traveled an average distance of 1.1 km between roost trees and foraging areas, which equates to traveling across 6% of the proposed turbine array. All recorded distances were < 5.6 km (3.5 mi), or approximately 30% of the maximum width of the turbine array (Figure 2-4).

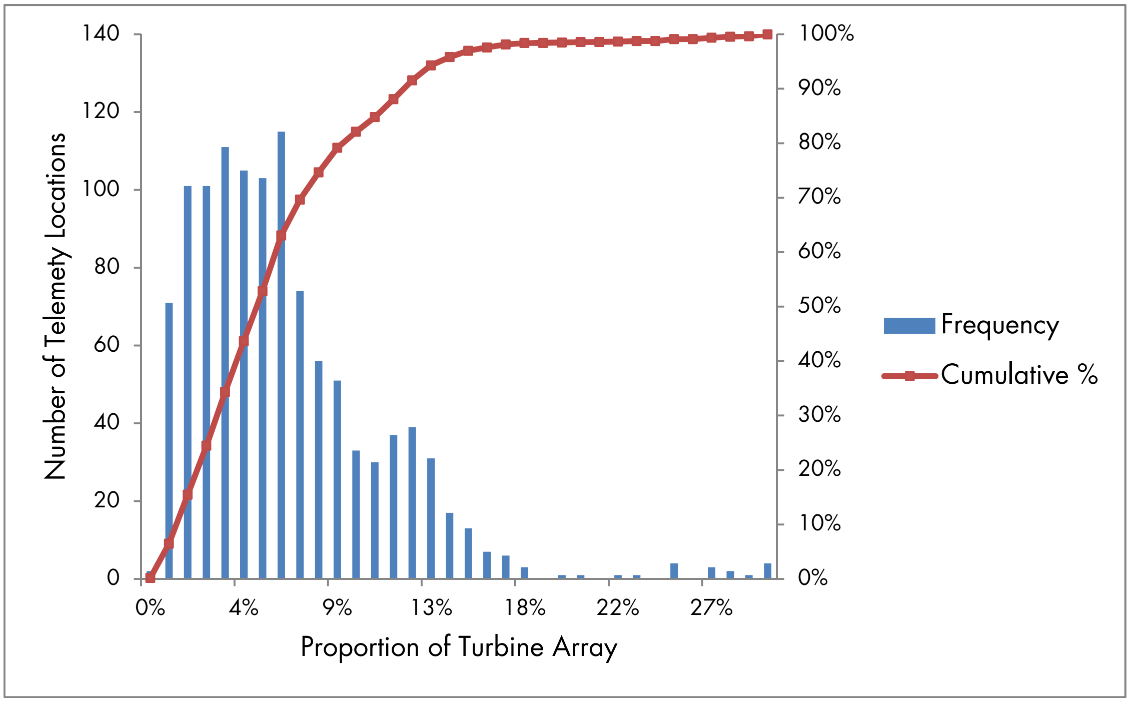

Figure 2-4. Estimated proportions of the turbine array represented by distances between roost locations and 1,124 telemetry locations collected for 11 adult female Indiana bats radio tagged in Champaign, Logan, and Hardin counties, OH during the summer in 2008 and 2009.

In order to incorporate known traveling distances into the model, the maximum distance across the turbine array was divided into 10% bins (Table 2-5). Each distance bin was then given a probability of occurrence based on the distances recorded between Indiana bat roost and telemetry locations. For example, since 82% of the distances between telemetry and roost locations were equal to 10% of the proposed turbine array, it was assumed that there was an 82% probability of a bat traveling a distance equal to 10% of the array. Similarly, 14% of telemetry locations occurred at distances between 10% and 20% of the way across the turbine array. Although no Indiana bats were recorded at distances greater than 5.6 km (3.5 mi; or 30% of the maximum width of the turbine array), a very small proportion in each 10% distance bin greater than this was included to take the most conservative approach.

For the purposes of this model, it was assumed that summer activity could be summarized by 4 large-scale movement bouts during a night:

1. Leaving a roost tree at dusk;
2. Arriving at a night roost, or returning to a roost;
3. Leaving a roost for a second time; and
4. Returning to a roost at dawn.

The distance traveled during each of these large-scale movement bouts was based on the average distances documented between roost trees and foraging locations for Indiana bats in the tri-county area (Table 2-5). The 4 large-scale movement bouts are assumed to represent the maximum number of large-scale movements a bat may make within the turbine array on a given night. However, consistent with the assumptions stated above in Section 2.3, a bat may make an unspecified number small-scale foraging bouts within each large-scale movement bout, that presumably do not affect their risk of collision because they occur at or below tree canopy height.

Table 2-5. Estimated Indiana bat distances traveled within the turbine array during summer.

Distance traveled (proportion of turbine array area)	No. large-scale movements	Total distance traveled (distance traveled x no. movements)	Probability (based on Fig 2-5)
0 0.1	4	0.4	0.82
0.1 0.2	4	0.8	0.14
0.2 0.3	4	1.2	0.03
0.3 0.4	4	1.6	0.009
0.4 0.5	4	2	0.00017
0.5 0.6	4	2.4	0.00017
0.6 0.7	4	2.8	0.00017
0.7 0.8	4	3.2	0.00017
0.8 0.9	4	3.6	0.00017
0.9 1.0	4	4	0.00017

2.3.2 Movement during Migration

It is likely that Indiana bats follow relatively straight-line paths during migration. Migration is an energetically expensive and risky undertaking (Fleming and Eby, 2003) and bats may try to minimize the time spent in transit (Winhold and Kurta 2006). Spring radio telemetry studies have documented migrating Indiana bats traveling in relatively direct flight patterns towards their summer ranges shortly after they emerge from hibernacula (Butchkoski and Turner 2006, Britzke et al. 2006, Gumbert et al. 2011). According to Hicks et al. (2005), a comparison between the range of initial bearings and the final bearings for 82 reproductive female bats radio tracked to 65 maternity colonies in NY from 2000 to 2005 showed that bats followed more or less direct routes from the hibernacula to their summer ranges. Based on a combination of aerial and ground tracking, Indiana bats tracked from a hibernaculum in PA flew almost straight lines to their roost trees 135 km to 148 km (83 mi to 92 mi) away in MD (Butchkoski and Turner 2005). Migrating Indiana bats in eastern Tennessee only changed course in response to mountain gaps or ranges, or to follow rivers, suggesting primarily straight-line travel (Gumbert et al. 2011).

The assumption of straight-line migration paths is supported by these telemetry studies, as well as the lack of hibernacula within 20 miles of the Action Area (where swarming activities would result in non-linear flight behavior). Migration paths may take a bat directly through the center of the wind facility, which would result in 1 complete pass through the turbine array, or alternatively may result in only a partial traverse of a section of the turbine array. Additionally, bats likely forage and roost during the course of their migration, and these activities may result in partial or complete passages through the turbine array. Given the uncertainty in migration flight paths through the turbine array, a uniform probability distribution was used to reflect the number of potential crossings between 0 and 1, with each possible distance traveled through the turbine area having an equal chance of occurrence (Table 2-6).

Table 2-6. Estimated Indiana bat distances traveled within the turbine array during spring and fall migration.

Distance traveled (proportion of turbine array area)	No. large-scale movements	Total distance traveled (distance traveled x no. crossings)	Probability
0 0.1	1	0.1	0.1
0.1 0.2	1	0.2	0.1
0.2 0.3	1	0.3	0.1
0.3 0.4	1	0.4	0.1
0.4 0.5	1	0.5	0.1
0.5 0.6	1	0.6	0.1
0.6 0.7	1	0.7	0.1
0.7 0.8	1	0.8	0.1
0.8 0.9	1	0.9	0.1
0.9 1.0	1	1	0.1

The number of crossings, therefore, is a function of the total distance traveled within the turbine array, the number of times that a given distance will be traveled during a single large-scale movement bout, and the probability that a given distance will be traveled. For each season, a Monte Carlo analysis was used to randomly sample the estimated number of partial or complete crossings, weighted by the probability that the distance traveled would be observed (Tables 2-5 and 2-6). This value was then used to adjust the outcome of the Bolker et al. (2006) model, as discussed in Section 3.1.

2.4 Flight Height

Flight height is thought to play a large role in bat collision risk with turbines. Only flight behavior at the height of spinning turbine blades affects the amount of estimated mortality, because mortality occurs by colliding with (or flying near the edges of) spinning turbine blades. The low incidence of *Myotis* species in post-construction mortality monitoring studies across the country (Arnett et al. 2008, Kunz et al. 2007) compared to species of long-distance migrants which typically fly at higher altitudes provides support for the assumptions that *Myotis* bats fly at relatively low heights, which places them at lower risk of collision with wind turbines.

Relatively few empirical data exist from which to base assumptions about Indiana bat flight height. Acoustic data collected by Stantec at 19 proposed wind power projects (96 Anabat detectors) in 6 states (ME, NH, NY, OH [including the Action Area], VT, and WV) from 2005 to 2009 indicate that bats belonging to the genus *Myotis* fly at low heights relative to the rotor swept zone. Data collected during spring, summer, and fall were not statistically different and were therefore pooled. Ninety-five percent of *Myotis* activity was recorded at detectors placed at or below a height of 10 meters (m; 33 feet [ft]) and *Myotis* activity recorded at 50 m (164 ft) was approximately 3% of that recorded at 2 m (7ft; Figure 2-5). While acoustic call files were not identified to species, the vertical distribution of calls identified to the genus *Myotis* may adequately represent activity patterns of the Indiana bat.

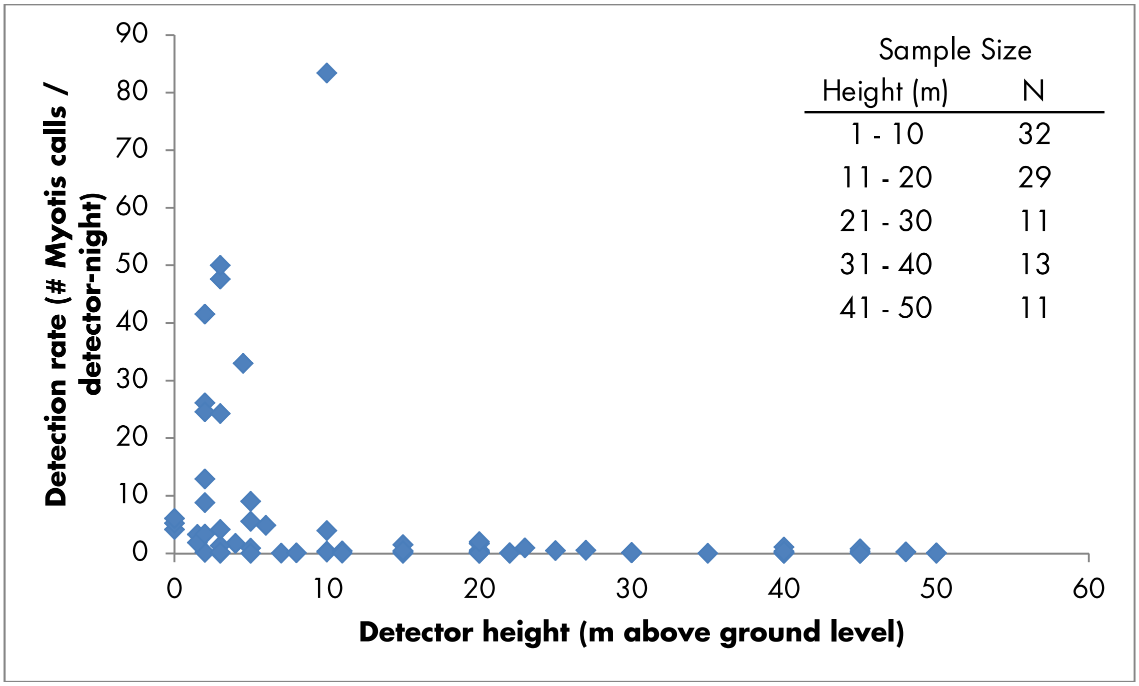

Figure 2-5. Detection rate (number of call sequences recorded per detector-night) for *Myotis* species from acoustic data collected by Stantec at 19 proposed wind power projects (96 Anabat detectors) in 6 states (ME, NH, NY, OH [including the Action Area], VT, and WV) from 2005 to 2009.

The low flying height of *Myotis* during summer foraging and traveling activities, and during migration, is supported by information from spring radio telemetry studies (Turner 2006, Gumbert et al 2011, J. Chenger, personal communication), summer foraging observations (LaVal and LaVal 1980, Russell et al. 2008, others), aircraft bat strike data (Peurach et al. 2009), acoustic studies associated with pre- and post- construction studies at wind facilities (Stantec unpublished data, Reynolds 2006, Fiedler 2004), morphological characteristics (i.e., low aspect ratio and high wing loading), and echolocation call signatures adapted to cluttered environments (Saunders and Barclay 1992).

Although these data collectively present fairly strong support for the assumption that *Myotis* bats fly at low heights relative to the rotor swept zone, their reliability is uncertain because acoustic studies may not detect higher flying bats (e.g., the maximum detector height used in the Stantec acoustic dataset presented in Figure 2-5 was 50 m [164 ft], which is at the lowest extent of the rotor swept zone) and while radio telemetry can detect higher flying bats, it cannot distinguish flight height. Additionally, radio telemetry studies to date have largely been conducted in the East and Indiana bat flight behaviors observed in these studies may not hold true for Indiana bats in other regions that likely migrate across large expanses of open terrain. . Further, Indiana bat researchers, V. Brack and D. Sparks (as per M. Seymour, personal communication), have observed Indiana bats above tree canopy, approximately 60 m to 90 m (200 ft to 300 ft) above ground level.

A further complicating factor to estimating Indiana bat flight height relative to the rotor swept zone is the issue of potential attraction to turbines or wind facilities. Kunz et al. (2007) summarized 11 hypotheses that have been postulated by leading bat researchers to explain where, when, how, and why insectivorous bats are killed at wind energy facilities, of which 7 included ideas about possible attraction:

- Linear corridor hypothesis wind energy facilities constructed along forested ridgetops create clearings with linear landscapes that are attractive to bats;
- Roost attraction hypothesis wind turbines attract bats because they are perceived as potential roosts;
- Landscape attraction hypothesis bats feed on insects that are attracted to the altered landscapes that commonly surround wind turbines;
- Heat attraction hypothesis flying insects upon which bats feed are attracted to the heat produced by nacelles of wind turbines;
- Acoustic attraction hypothesis bats are attracted to audible and/or ultrasonic sound produced by wind turbines;
- Visual attraction hypothesis nocturnal insects are visually attracted to wind turbines; and
- Thermal inversion hypothesis thermal inversions create dense fog in cool valleys, concentrating both bats and insects on ridgetops.

If Indiana bats are attracted to wind turbines, acoustic and radio telemetry studies conducted in areas with no wind facilities would not accurately reflect flight height distributions that could be expected post-construction. However, attraction to turbines is speculative at best for Indiana bats, as most of these hypotheses have been put forth for long-distance migratory bat species due to their high rates of mortality at wind facilities. For the purposes of this model, it is assumed that Indiana bats are not attracted to operating turbines.

Given that available acoustic data did not survey the entire airspace relative to the rotor-swept zone, 3 flight height scenarios were developed to model the existing uncertainty regarding Indiana bat flight height above 50 m. Acoustic studies indicated that 99.9% of *Myotis* activity was recorded below 47 m, regardless of season (Figure 2-5). This information was used to develop a baseline flight distribution of the proportion of activity expected below the rotor-swept zone (< 47 m), within the rotor-swept zone (> 47 m and < 153 m, in 10 m bins), and above the rotor-swept zone (> 153 m; cut-off altitudes of 47 and 153 m reflect the 3 m addition to rotor blade length to account for barotrauma, as discussed in Section 2-7). This baseline flight distribution was used for the "low flight height" scenario in summer (see Table 2-7). Moderate flight height and high flight height scenarios were derived by adjusting the proportion of the bats assumed to be flying within the rotor-swept zone upwards of the low flight height distribution indicated by acoustic studies conducted by Stantec. The moderate flight height scenario has 10% more activity within the rotor-swept zone than the low flight height scenario; the high flight height scenario has 20% more activity within the rotor-swept zone than the low flight height scenario. Note that for every scenario, most activity still occurs below the rotor-swept zone.

The flight distribution for the summer season was derived from literature and acoustic survey results. Observations of Indiana bats (Humphrey et al. 1977, Brack 1983, Gardner et al. 1989), and little brown bats (*Myotis lucifugus*) (Russell et al. 2008) during the summer indicate that they fly relatively low to the ground while foraging (i.e., between 2 m and 30 m [6 ft to 100 ft.] above ground level). Consistent with this and with acoustic studies, it was assumed that 99% of summer activity would occur below 47 m, and the remaining 1% of summer activity was divided among the remaining flight heights, decreasing the percentage within each flight height bin as flight height increased, so as to not eliminate the possibility that activity could occur within the rotor swept zone during the summer (Table 2-7).

As stated previously, the flight height of migrating Indiana bats is not known. However, it seems likely that migrating Indiana bats would have to fly at higher altitudes than summer foraging Indiana bats in order to efficiently travel to their winter hibernacula, documented to occur as far as 575 km (357mi) away (Winhold and Kurta 2006). Because migration is an energetically expensive undertaking (Fleming and Eby 2003), bats may try to minimize the time spent in transit (Winhold and Kurta 2006). For example, a male Indiana bat that was banded at a cave in KY traveled approximately 530 km (329 mi) to southern MI in 9 days (Davis 1964, Kurta 1980). Spring radio telemetry studies in PA have documented migrating Indiana bats traveling in relatively direct flight patterns towards their summer ranges shortly after they emerge from hibernacula (Butchkoski and Turner 2006, Britzke et al. 2006). Radio-tagged Indiana bats recently followed by aircraft during their spring migration in NY and PA usually maintained flight speeds between 13 kilometers per hour (km/hr) and 20 km/hr (8 miles per hour [mph] and 12 mph), with 1 bat perhaps traveling at 24 km/h (15 mph; Butchkoski and Turner 2005; C. Herzog, in litt., as cited by Winhold and Kurta 2006). Given the assumed efficiency with which Indiana bats must migrate, it seems likely that they would have to fly higher than summer foraging Indiana bats to avoid obstructions such as vegetation and anthropogenic structures that might impede direct and efficient travel. Therefore, the flight distribution of Indiana bats was assumed to be higher during spring and fall migration compared with assumed flight behavior during summer. This assumption was also made because since the only documented Indiana bats at a wind facility occurred during the fall migratory period, we know that some Indiana bats must fly within the rotor swept zone during this period.

Finally, because documented bat mortality has been highest in the fall, irrespective of geographic location, habitat in which a wind facility is located, or species of bat (see Section 4.5.5 of the HCP for more details), flight height was assumed to be highest during the fall. Further, the only 2 documented Indiana bat mortalities occurred in the fall (Good et al. 2011). This assumption is based on the notion that in order for a disproportionate number of bats to be killed during the fall, there must be a greater proportion of bats flying within the rotor swept zone compared with the spring and summer. However, the model makes no assumptions about the causal factors for this increased flight height in the fall.

Based on the previously stated assumptions, a range of flight distributions was generated that reflect uncertainty about Indiana flight height during each season. The proportion of activity below the rotor-swept zone was decreased in the summer (99%) in 5% increments, starting with spring (95%) and then fall (90%). Similar to summer, the remaining proportion of activity among the remaining flight height categories was divided, decreasing the percentage within each flight height bin as flight height increased. This resulted in an increasing proportion of activity at higher altitudes for the spring and fall, respectively, which in turn would result in an increase in turbine encounters, and thus mortality, for the migratory seasons (Table 2-7). Similarly, the proportion of activity below the rotor swept zone was decreased in 10% increments to generate moderate and high flight height scenarios for each season (Table 2-7).

Table 2-7. Proportion of bats flying at low, moderate, and high flight heights relative to the rotor swept zone during spring, summer, and fall.

Low Flight Height Model			
Flight Height (m)	**Spring**	**Summer**	**Fall**
< 47	95.0%	99.0%	90.0%
47-60	1.0%	0.3%	2.0%
61 70	1.0%	0.3%	2.0%
71 80	0.5%	0.1%	1.0%
81 90	0.5%	0.1%	1.0%
91 100	0.5%	0.1%	1.0%
101 110	0.3%	0.1%	0.5%
111 120	0.3%	0.1%	0.5%
121 130	0.3%	0.1%	0.5%
131 140	0.3%	0.1%	0.5%
141 153	0.3%	0.0%	0.5%
> 153	0.3%	0.0%	0.5%
Moderate Flight Height Model			
Flight Height (m)	**Spring**	**Summer**	**Fall**
< 47	85.0%	90.0%	80.0%
47-60	5.0%	2.0%	5.0%
61 70	2.0%	2.0%	5.0%
71 80	2.0%	1.0%	2.0%
81 90	1.0%	1.0%	2.0%
91 100	1.0%	1.0%	1.0%
101 110	1.0%	0.5%	1.0%
111 120	1.0%	0.5%	1.0%
121 130	0.5%	0.5%	1.0%
131 140	0.5%	0.5%	1.0%
141 153	0.5%	0.5%	0.5%
> 153	0.5%	0.5%	0.5%
High Flight Height Model			
Flight Height (m)	**Spring**	**Summer**	**Fall**
< 47	75.0%	80.0%	70.0%
47-60	10.0%	5.0%	10.0%
61 70	5.0%	5.0%	5.0%
71 80	2.0%	2.0%	5.0%
81 90	2.0%	2.0%	2.0%
91 100	2.0%	1.0%	2.0%
101 110	1.0%	1.0%	2.0%
111 120	1.0%	1.0%	1.0%
121 130	0.5%	1.0%	1.0%
131 140	0.5%	1.0%	1.0%
141 153	0.5%	0.5%	0.5%
> 153	0.5%	0.5%	0.5%

The available information on Indiana bat foraging and traveling flight heights, and the low incidence of Indiana bat mortality at operating wind facilities, both seem to support the assumption that that the majority of Indiana bat activity occurs below typical rotor swept zone heights. Further, *Myotis* species as a whole contribute only a small proportion of total bat mortality, despite their abundance on the landscape (see HCP Section 4.4.5.2 – Geographic Variation [Species Distribution]). Still, a conservative approach was taken in order to address flight height uncertainty by allowing for up to 30% of activity to occur in the rotor swept zone during the fall under the high flight height scenario.

2.5 Flight Direction

There is little information on which to infer a prevailing flight direction across the turbine array, and there is no reason to suspect that any direction would prevail during the summer months. Therefore, a distribution of expected turbine encounters was created for all possible flight directions. For any given flight height (see above), the number of encounters was generated using the Bolker et al. (2006) model for 1 degree increments of flight angle (perpendicular to the rotor swept area) ranging from 0 to 180 degrees (the number of encounters for flight angles of 180 to 360 were equal to those for angles 0 to 180). Combining the probability of flight height with a randomly selected angle of flight provides an estimate of the total collisions for any event (see Section 3.0).

2.6 Survival Probability

Survival probability is the probability that a bat survives an imminent collision with a turbine rotor (i.e., a turbine encounter) that would occur if its flight height was within the rotor swept zone and its flight path intersected a turbine location; effectively if it is within striking distance of a rotor blade. Survival probability in this case represents any number of reasons an individual bat might survive an encounter including avoidance, body size, flight speed, and random chance. Also, this model assumes that turbines are spinning at all times, so survival probability can also be thought of as accounting for the chance that a blade is not spinning when it is encountered.

In many collision risk studies, survival probabilities (sometimes referred to as avoidance rates) are set at >0.90% (Cooper and Day 2004, Podolsky 2005, Chamberlain et al. 2006, Hatch and Brault 2007, Sanzenbacher and Cooper 2009), indicating a high chance of survival. For example, in the Cape Wind report (Hatch and Brault 2007), biological arguments were used to establish 2 possible survival probabilities for roseate terns (95.3% and 98.3%), with 2 additional probabilities (91% and 99%) used in a sensitivity analysis. The lowest survival probability to date, 75% (for rotating turbine blades), was used in a collision risk model estimating marbled murrelet mortality at a wind facility (Nations and Erickson 2009).

The actual chance of survival if an Indiana bat flies into the rotor swept zone of a turbine is unknown. Therefore, in the probability-based model presented here, the chance of survival is presented as a Beta probability distribution to reflect uncertainty. Three potential survival scenarios were created to both reflect uncertainty and to test the sensitivity of the model outcome to this parameter, based on the model framework, Indiana bat morphology, mortality patterns of *Myotis* bats at wind facilities, and survival rates used in available collision risk models. A graphic illustrating the 3 Beta distributions used is shown in Figure 2-6, where 1 represents the outcome that 100% of bats encountering a turbine would successfully avoid a collision and survive, and 0 represents the outcome that every bat encountering a turbine would be struck and killed. The full collision risk model was run 3 separate times, each time using a different survival scenario. In survival scenario 1 (blue), 90% of 100,000 Monte Carlo simulations had survival probabilities between 48% and 84% (representing the 10th and 90th percentiles of the Beta distribution). In survival scenario 2 (green), 90% of simulations had survival probabilities between 55% and 90%. In survival scenario 3 (red), 90% of simulations had survival probabilities between 68% and 97%.

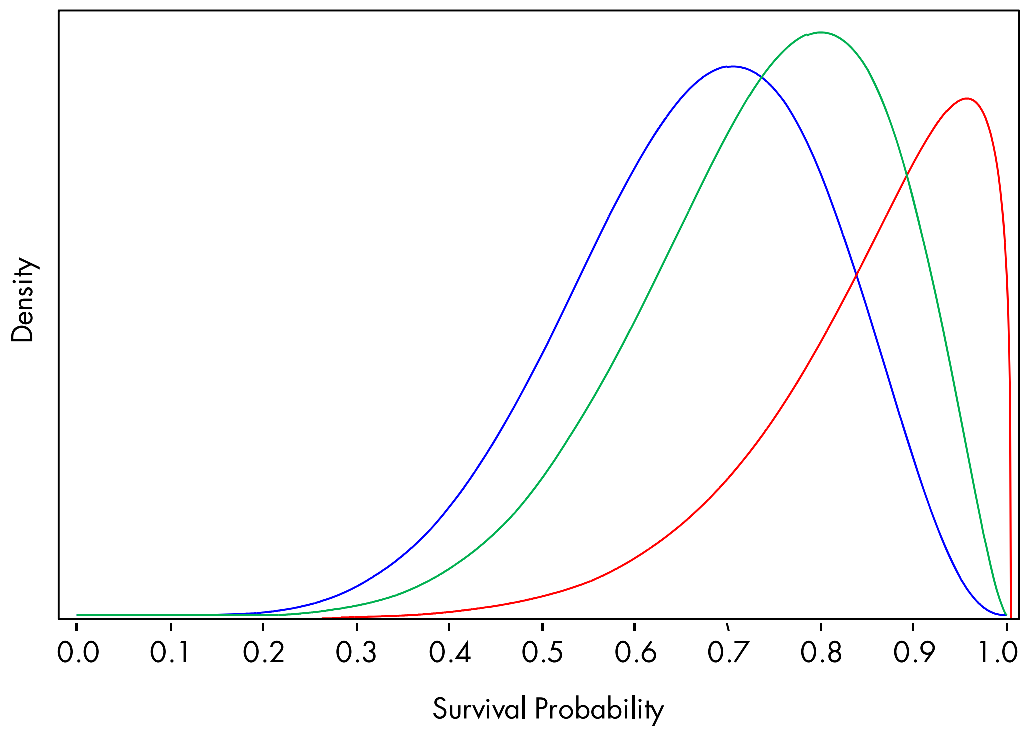

Figure 2-6. Survival probability distributions for Indiana bats, weighted toward 70% survival (blue), 80% survival (green) and 95% survival (red).

Most of the area below each survival scenario curve falls above 50%; therefore these distributions reflect a chance of surviving an encounter with a wind turbine blade that is most often above 50% for any Monte Carlo simulation; but each scenario also includes the possibility of choosing any survival probability from 0 to 1 during any simulation. It is important to reemphasize that factors leading to an Indiana bat surviving an encounter with a turbine (e.g., avoidance) are very poorly understood and are confounded even more by evidence that suggests that other bat species may be attracted to turbines (Cryan 2008, Cryan and Barclay 2009). By incorporating a distribution of survival probabilities over 3 different scenarios, it is expected that this method provides a reasonable and conservative estimation of the survival probability.

In addition to modeling a range of possible survival potentials, the approach taken is considered conservative because the Bolker et al. (2006) model assumes that turbine blades are spinning at all times. However, according to nightly wind speed data recorded from June 2007 through July 2010, 5.5% of nights in the spring, summer, and fall seasons have average nightly wind speeds below 3 m/s (Table 2-3); given these are averages across an entire night, there is likely a much higher amount of time during these seasons when turbines are not moving. Additionally, wind turbines will be curtailed (i.e., rotor blades will be feathered into the wind so that they cannot rotate) at varying wind speeds during the Indiana bat active period as a condition of the ITP. On these occasions, survival probabilities would likely be equal to 1 (or 100%).

Since the model assumes that turbine blades are spinning all the time, it underestimates Indiana bat survival probability during times when turbines will be curtailed and when wind speeds are too low for turbines to spin. Again, this conservative approach is appropriate given the uncertainty in conditions that could lead to an Indiana bat successfully surviving a turbine encounter. Furthermore, Indiana bat morphology (low aspect ratio and high wind loading) make this species agile and highly maneuverable flyers, which may indicate an ability to avoid turbines. Finally, relatively high rates of avoidance may be evidenced by the relatively low number of *Myotis* bats found in post-construction mortality facilities (Arnett et al. 2008, Kunz et al. 2007, Johnson et al. 2003) and the fact that only 2 Indiana bats have been confirmed to have been killed at a wind facility.

2.7 Turbine Design and Location

The model assumed the use of Nordex N100 turbines, although the final turbine model has not yet been selected. This turbine model was used because it represents the worst case scenario in terms of potential mortality of Indiana bats, given that it has the largest rotor swept zone of all turbine models considered and the lowest cut-in speed (or wind speed at which blades are pitched into the wind and blades begin rotating). Details on the characteristics of Nordex N100 2.5 MW turbines are provided in Table 2-8.

Table 2-8. Characteristics of Nordex N100 2.5 MW wind turbine generators.

Turbine Manufacturer and Type	Nordex N100
Power Generation	2.5 MW per turbine
Hub Height	100 m (328 ft)
Rotor Diameter	100 m (328 ft)
Total Tower Height (Hub + ½ Rotor)	150 m (492 ft)
Height of Lowest Rotor Blade Reach	50 m (164 ft)
Rotor Swept Area	7,823 m^2 (84,206 ft^2)
Rotor Speed (*range possible*)	9.6-14.9 rotations per minute (rpm)
Rotor Tilt Angle Blade Cone Angle	5° 3.5°
Wind Speed of Generator Initiation (Cut-in)	3 meters/second (m/s; 7 mile/hour [mph])
Wind Speed of Generator Cessation (Cut-out)	20 m/s (45 mph)
Maximum Tip Speed	77 m/s (172 mph)
Rated Wind Speed (Unit Reaches Maximum Output)	12.5 m/s (28 mph)

Each wind turbine will consist of 3 major components: the tower, the nacelle, and the rotor. The height of the tower, or "hub height" (height from foundation to top of tower) will be 100 m (328 feet [ft]). The nacelle sits atop the tower and the rotor hub is mounted to the front of the nacelle. The rotor diameter will be 100 m (328 ft). Thus, the total turbine height at the highest blade tip position (i.e., rotor apex) will be approximately 150 m (492 ft).

At the time of model development, 52 of 100 turbine locations were known. Random coordinates within the Action Area were generated for the remaining 48 turbines using a random number generator in order to account for the total number of proposed turbines at the facility (Figure 2-7). To ensure that random turbines were located in areas where turbines could potentially be placed, constraint parameters developed for compliance with Ohio Power Siting Board (OPSB) standards, as well as economic and feasibility factors, were used to delineate areas in which random turbine locations were generated (refer to Buckeye Wind Project Draft Environmental Impact Statement for more information on the constraints analysis process).

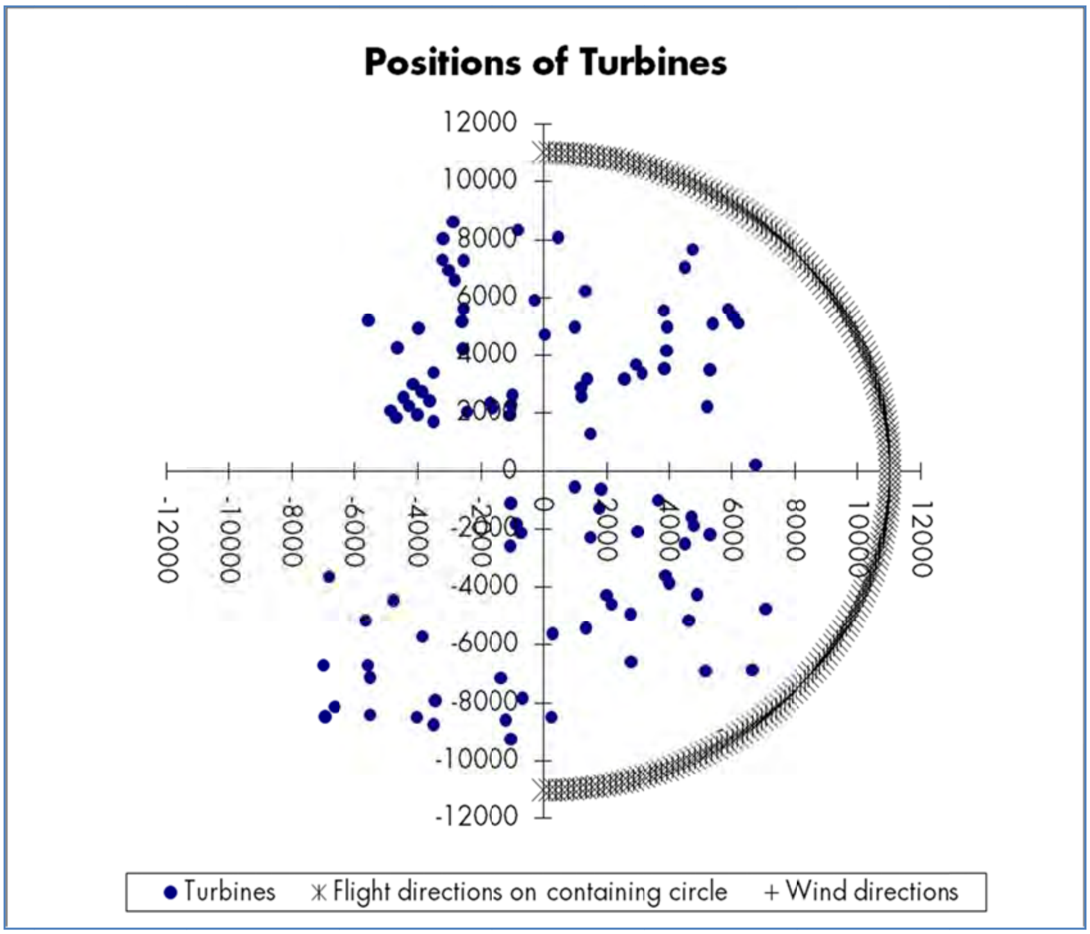

Figure 2-7. Graphic representation of the Buckeye Wind Power Project showing 52 known and 48 randomly generated turbine locations.

Nacelle height and rotor length were derived from the characteristics of Nordex N100 2.5 MW turbines (see Table 2-8). Bats flying at the nacelle height are assumed to have the highest chance of collision in the Bolker et al. (2006) model, while bats flying above or below the blade length are assumed to have no chance of collision. Until recently it was thought that bats were killed or injured by the impact from physically colliding with turbines (Johnson et al. 2004, Horn et al. 2008, as cited in by Kunz et al. 2007). However, the recent discovery that bats can be killed by passing through the rotor zone, but not striking turbines, demonstrated that bats do not have to experience physical impact to be at risk (Baerwald et al. 2008). Such mortality is the result of tissue damage to lungs caused by rapid or excessive pressure changes formed in the wake of rotating turbine blades, also known as barotrauma. Bats that experience barotrauma can die from internal bleeding as their blood vessels burst on exposure to the low pressure.

The Bolker et al. (2006) model was adjusted to account for mortality from both direct collisions and barotrauma by extending the length of the turbine blade by 3 m (9.8 ft). This distance was based on an article in which researcher E. Baerwald, University of Calgary, (Handwerk 2008) described the diameter of this "small zone of [dropping] pressure" as "a meter or so." Subsequent correspondence with R. Barclay (University of Calgary, personal communication, April 17 and April 23, 2010; E. Baerwald was unavailable for comment) and B. Thresher (National Renewable Energy Lab, personal communication) to provide further support for this distance was inconclusive, with neither researcher able to provide a specific estimate, and both stating that the length of the zone of decompression varies with respect to the rotational speed of turbines.

Because it was not possible to confirm the "meter or so" estimate, and because the size of the "zone of decompression" will vary based on several dynamic factors such as wind speed, the rotational speed of the turbine rotors, and the length, width, and shape of the turbine blades, among other things, 3 m was selected as a conservative estimate. Although the decompression zone extends along the entire length of the rotor blade edge, the rotor swept zone in this model was modeled as a solid disc with a radius equal to the rotor blade length. Thus, increasing the rotor blade length by 3 m effectively increased the size of the rotor swept zone, which in turn increased the number of turbine encounters possible during a given traverse of the turbine array. Since mortality probability is based on the average number of turbine encounters, increasing the rotor blade size resulted in an increase in the number of turbine encounters, and thus an increase in mortality probability. The model was run assuming the wind turbines rotated into the wind and the bats were flying parallel with the wind direction, which is the most conservative approach because it results in the highest number of possible collisions.

3.0 ESTIMATING MORTALITY

The collision risk model inputs are considered uncertain random parameters, whose sampling distributions were selected using a combination of expert judgment, empirical measurements, and literature references, as described in the above sections. Crystal Ball software (a Microsoft Excel add-on) was used to implement a Monte Carlo analysis in which the uncertainty in the model inputs was propagated through the model equation to describe the uncertainty in seasonal mortality. The mortality model can be succinctly written as follows:

$$M_s = Pop_s * W * C_s * M_c$$

where:

- M_s = seasonal mortality
- Pop_s = seasonal population size (Section 2.1)
- W = weather factor influencing the number of bats at risk of exposure (Section 2.2)
- C_s = number of complete or partial crossings as a function of total distance traveled within risk area of the wind facility (Section 2.3)
- M_c = probability of mortality as defined in Bolker et al. (2006) as $M_c = 1\text{-}p^E$ where p is the probability of surviving an encounter and E is the total number of encounters with the bat passing completely through the wind facility risk area (Section 3.1).

As described in preceding sections, the total number of bats at risk on any random day is a function of the seasonal population size (Pop_s; see Section 2-1) and weather conditions (W; see Section 2-2) thought to affect whether bats are actively flying. An empirical distribution derived from emergence counts at local Indiana bat roost trees was used to randomly select summer population size; a Beta distribution based on the population size of hibernating Indiana bats within migrating distance of the Action Area was used to randomly select spring and fall population sizes; an empirical distribution derived from frequency histograms of wind speed and temperature conditions in the Action Area was used to randomly select representative nightly weather conditions. The total number of bats at risk on any given night was further adjusted based on the number of times and the distance these bats were estimated to move within the turbine array (Cs; see Section 2-3). An empirical distribution derived from foraging telemetry data from local Indiana bats was used to randomly select a random distance an individual bat would travel across the turbine array. Note that the probability of survival is the only term in the model that does not effectively reduce the total mortality by reducing the number of individual bats that may be at risk (see above discussions on weather conditions, movements within the turbine array, and flight height).

The following sections describe how the number of turbines encountered (E), the probability of mortality (Mc), and estimated mortality were calculated. The model was run for 100,000 iterations independently for each season (with the seasonal runs reflecting the seasonal differences in population, weather, and flight height). The resulting distribution of mortality for a specific season represents the uncertainty in bat mortality, given the uncertainties in the variables influencing the mortality calculations.

3.1 Number of Turbine Encounters

A turbine encounter occurs if a bat's flight height is within the rotor swept zone and its flight path intersects a turbine location; effectively if it is within striking distance of a rotor blade. The Bolker et al. (2006) model calculates the average and maximum number of turbines encountered by an individual animal flying through the wind facility, conditional on the angle (θ) of movement relative to the radius of the turbine blade. Therefore, any path (T) given θ may or may not intersect with a turbine's rotor swept area. The chance of a collision is calculated as the average (or expected) number of turbine encounters over all possible flight paths with angle θ and the probability of surviving a turbine encounter (E. Bolker, University of Massachusetts, personal communication). To estimate the number of turbine encounters, the Bolker et al. (2006) model treats the rotor swept area as a vertically-mounted disc, without thickness, that may be oriented in any direction in response to the wind, and estimates the average number of collisions as a function of the following 6 factors:

1) Turbine location;
2) Height of turbine center (i.e., nacelle height);
3) Rotor length;
4) Angle of approach;
5) Probability of safe passage (i.e., survival); and
6) Flight height.

As discussed in previous sections, probable flight heights, flight directions, and survival probabilities are all uncertain for Indiana bats, while the remaining inputs into the Bolker et al. (2006) model (turbine location, nacelle height, rotor length) are known or can be estimated with confidence. Therefore, the Bolker et al. (2006) model was adjusted such that for every Monte Carlo simulation (n = 100,000), all possible flight heights and all possible flight directions were incorporated into a single estimate of the number of expected encounters. An open-source spreadsheet designed by Bolker et al (2006; http://www.cs.umb.edu/~eb/windfarm) was used to create a matrix of the average number of turbine encounters for each flight angle (0 to 180 degrees) within each flight height bin (< 47 m, 47 m to 153 m in 10 m bins, > 153 m). No turbines are encountered at flight heights below 47 m or above 153 m. Because each output of the Bolker et al. (2006) model is an average value, based on all possible flight paths through the turbine array for a given flight direction (where some will result in 0 turbine encounters), all estimated average number of encounters were less than 1.

A weighted estimate of the average number of turbine encounters for an individual bat, should it fly completely through the wind facility, was calculated using the following equation:

$$E = \sum_{i=1}^{k} C_{\theta_{i,j}} * PH_i \,; j = 1, 180 \; randomly\ selected\ angles\ equation\ 1$$

In the above equation, the weighted number of collisions (E) is a function of the possible flight heights (i =1 to k height bins, Table 2-7; with the chance of any flight height dependent upon the probability associated with each height bin), and the angle of flight (θ, j = angles 1 to 180 degrees). For each Monte Carlo simulation, the model selected a random angle for each possible flight height bin (Table 2-7). Based on the angle randomly chosen, the average number of turbine encounters for each flight height bin was selected from the matrix of all possible turbine encounters generated from the Bolker et al. (2006) model. To generate an adjusted number of encounters for each flight height bin, the average number of turbine encounters was then weighted by the probability that each flight height would be expected to occur. Finally, the adjusted number of turbine encounters was summed across all flight height bins to calculate the total number of expected encounters for the simulation. This resulting weighted number of encounters represents the possible number of collisions for a bat traveling through the wind facility.

3.2 Estimated Mortality

The final step in estimating total mortality was to combine the number of bats expected to encounter turbines with the probability of mortality. Mortality will occur when a bat encounters a turbine blade and does not survive. The probability of mortality is $M_c = 1\text{-}p^E$; where p is the probability of surviving an encounter and E is the total number of encounters, calculated as described above. For each Monte Carlo simulation, a random value for p was selected from one of the Beta distributions shown in Figure 2-6.

The probability of mortality was calculated using output from the Bolker et al. (2006) model, which assumes complete passage through the turbine array. Therefore, the probability was adjusted for partial movements through the turbine array by multiplying mortality probability by a random distance traveled (the chance of selecting each distance traveled dependent upon the probability associated with each distance bin; Table 2-5 and 2-6). A random population size, wind speed, and temperature were then chosen (the chance of selecting dependent upon the probability associated with each input, with the exception of summer population size, Table 2-1, 2-2, and 2-3, Figure 2-3). The process of selecting random values for each input was repeated 100,000 times.

3.3 Sex- and Age-Specific Adjustments to Mortality Estimates

As described in Section 2.1.1, summer population size was derived from emergence counts and home ranges associated with radio tagged female Indiana bats. As described in Section 2.1.1, emergence counts conducted before 15 July were multiplied by 1.9 to account for unborn or non-volant young and emergence counts conducted after this date were presumed to include approximately 1 volant juvenile per adult female. This is a conservative estimate because it assumes no pre-weaning mortality and that all females successfully give birth. Thus, summer mortality estimates can be assumed to include approximately 50% adult females and 50% juveniles. To account for adult males that could be killed by wind turbines, the summer population estimates for females and juveniles was increased by 8% (based on the male:female ratio observed during mist netting surveys in the tri-county area).

In terms of the migratory population, the methods used to estimate the size of the migratory population took into account differences in male and female migratory behavior. As described in Section 2.1.2, sex-specific population sizes from any given hibernaculum were explicitly defined (on average females comprised 73%, and males comprised 27% of the migratory population). However, estimates of the spring migratory population did not take into account the loss of juveniles that will occur if pregnant females are killed during this time. To adjust collision risk estimates to account for this additional mortality, the proportion of females in the spring migratory population (i.e., 73%; Section 2.1.2) was multiplied by 1.9. Using these methods, females, males, and juveniles were accounted for in the estimates of spring, summer, and fall mortality.

4.0 RESULTS

The following section presents the estimated mortality of female, male, and unborn or non-volant juveniles (prior to 15 Jul) Indiana bats under the high, moderate, and low flight height scenarios presented in Section 2.0, and for each of 3 survival scenarios (presented in Section 2.6). For each scenario, the median fatality estimate is presented, which indicates that 50% of the 100,000 resampled values were below this value and 50% were above. In other words, the 50th percentile represents the average estimated mortality of Indiana bats for the given scenario. The 30th and 70th percentile values are also presented to represent the lower and higher estimated values of mortality and to show the range of uncertainty in the model. The 30th and 70th percentile values should not be interpreted in terms of the usual confidence intervals in hypothesis testing. Given the degree of uncertainty in the model input parameters, the upper 70th percentile results are considered the extreme upper bound of the model output distribution and represent higher than expected values.

4.1 Sensitivity of Survival Probability

The 3 survival probability scenarios had variable impacts on estimated collision mortality, as expected. In summer, when little activity was expected within the rotor swept zone, changing the Beta distribution for survival had little effect on estimated mortality (Figure 3-1, Summer). The effect of survival probability was higher in the spring, as the amount of activity expected in the rotor swept zone increased (Figure 3-1, Spring). The effect of survival probability was most pronounced in the Fall, when the largest amount of activity (30% under the high flight height scenario) was estimated to be in the rotor swept zone (Figure 3-1, Fall).

4.2 Low Flight Height

The median (i.e., 50th percentile) fatality estimates (averaged over the 3 survival scenarios) for the low flight height scenario were 2.35, 0.07, and 4.43 bats for the spring, summer, and fall seasons respectively. The 30th percentile for the number of bats potentially killed was lowest in the summer at 0.03 bats; while the 70th percentile was highest in the fall at 11.24 bats. Thus, the range of uncertainty (i.e., range between the 30th and 70th percentiles) under the low flight height scenario in all seasons combined (i.e., annual mortality) ranged from 3.14 to 16.33, with the most likely estimated annual mortality of 6.86 Indiana bats, based on the cumulative seasonal mean values (Table 3-1).

4.3 Moderate Flight Height

As expected, the median fatality estimates under the moderate flight height scenario were higher than those estimated under the low flight height scenario, given the higher proportions of bats flying within the rotor swept zone, with estimated mortality of 6.79, 0.72, and 8.74 bats for the spring, summer, and fall seasons respectively. The 30th percentile value for the number of bats potentially killed was lowest in the summer, at 0.24 bats; while the 70th percentile value was highest in the fall at 22.10 bats. Thus, the range of uncertainty under the moderate flight height scenario in all seasons combined ranged from 7.51 to 38.12, with the most likely annual estimated mortality of 16.26 Indiana bats, based on the cumulative seasonal median values (Table 3-1).

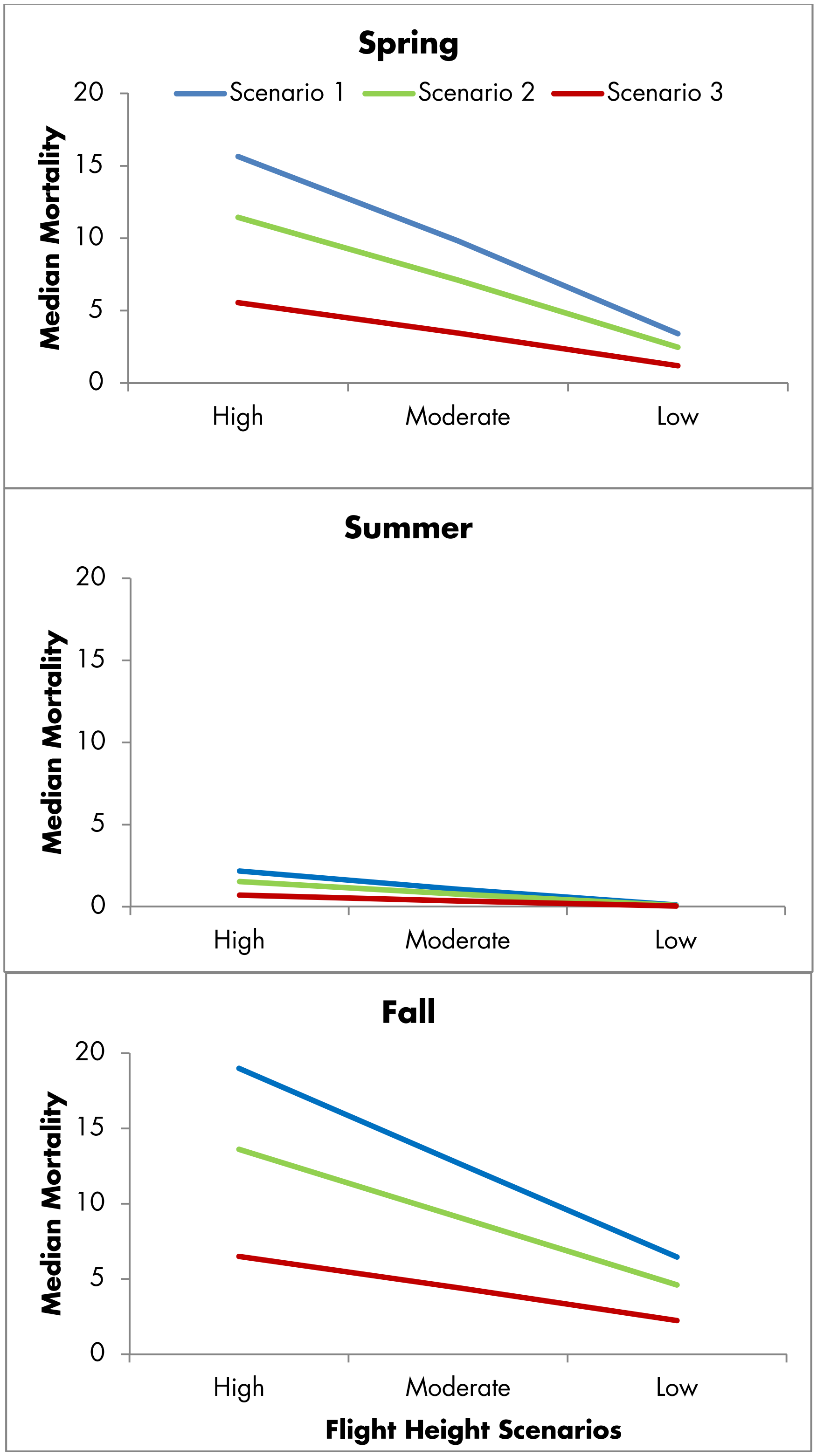

Figure 4-1. Median mortality estimates for 3 flight height scenarios (high, moderate, and low) under 3 survival scenarios (Beta distributions weighted toward 70% [blue], 80% [green], and 95% [red]), during the spring (April 1 to May 31), summer (June 1 to July 31), and fall (August 1 to October 31).

4.4 High Flight Height

As expected, the median fatality estimates were greatest under the high flight height scenario, at 10.88, 1.47, and 13.03 bats for the spring, summer, and fall seasons respectively. The 30th percentile value for the number of bats potentially killed was lowest in the summer, at 0.49 bats; while the 70th percentile value was highest in the fall at 33.07 bats. Thus, the range of uncertainty under the high flight height scenario in all seasons combined ranged from 11.69 to 59.66, with the most likely annual estimated mortality of 25.38 Indiana bats, based on the cumulative seasonal median values (Table 3-1).

Table 3-1. Estimated Indiana bat fatalities (median values) under 3 survival scenarios during the spring (1 Apr to 31 May), summer (1 Jun to 31 Jul), and fall (1 Aug to 31 Oct) periods, and annually, under high, moderate, and low flight height scenarios relative to the rotor swept zone.

Flight height scenario	Median estimated fatalities			
	Survival Scenario 1 (48 - 84% survival)			
	Spring	Summer	Fall	Annual
Low	3.40	0.11	6.46	9.97
Moderate	9.82	1.07	12.70	23.59
High	15.65	2.17	19.00	36.82
	Survival Scenario 2 (55 - 90% survival)			
	Spring	Summer	Fall	Annual
Low	2.47	0.08	4.60	7.15
Moderate	7.10	0.76	9.12	16.98
High	11.45	1.53	13.61	26.58
	Survival Scenario 3 (68 - 97% survival)			
	Spring	Summer	Fall	Annual
Low	1.19	0.04	2.23	3.46
Moderate	3.45	0.34	4.41	8.21
High	5.55	0.70	6.50	12.75
	Mean of 3 Survival Scenarios			
	Spring	Summer	Fall	Annual
Low	2.35	0.07	4.43	6.86
Moderate	6.79	0.72	8.74	16.26
High	10.88	1.47	13.03	25.38

5.0 DISCUSSION

The range of estimated mortality of Indiana bats reflects uncertainty around each of the model inputs: population size; flight height; the effect of temperature and wind speed on nightly activity; movements within the turbine array; and factors that lead to survival or mortality (e.g., avoidance or attraction). This uncertainty is evident in the disparity of values at the upper and lower edges of estimated mortality distributions (i.e., the 30^{th} and 70^{th} percentiles). A probabilistic approach was chosen for this model, using distributions for each model input derived from empirical data, derived data, or professional opinion to account for this uncertainty. This was preferred over using single-point estimates for each of the input parameters, which would have resulted in less variability, but also less confidence, in the model results.

Estimates of mortality relied heavily on the total population size and the proportion of the population exposed to risk as a function of flight height. Population size is essentially unknown for populations of migratory and summer resident bats in the Action Area. Although a relatively large site-specific dataset from was available which to base assumptions about the summer resident population, the data were not without limitations. Due to the sensitive nature of location data on endangered species, access to raw telemetry data was not provided and therefore, associated location error could not be estimated. Similarly, because data were collected by multiple consultants as part of pre-construction studies for multiple proposed wind power developments, multiple observers collected telemetry data and likely used varying methods with differing levels of experience. These factors could have affected the accuracy of home range estimates which influenced summer population estimates. However, sample sizes of radio telemetry locations used to derive home ranges were relatively large (93.7 locations ± 56.4 locations), which increases the reliability of these estimates.

Due to these limitations, each emergence count had to be treated as a separate estimate of maternity colony population size. Further, because home range estimates for multiple bats from the same maternity colony were not available in most cases, individual home ranges had to be treated as approximations of total maternity colony home range size. This likely overestimated the number of maternity colonies the Action Area to a large degree, since the size of an area used by all members of a maternity colony will likely be larger than that used by each individual colony member. Further, this method assumes that maternity colonies do not overlap and that all are occupied. These methods allowed for the highest numbers of maternity colonies to be present in the Action Area, which was appropriate given the limitations of the data and the inherent uncertainty in estimating maternity colony size based on emergence counts. However, there is likely higher variability in the estimated summer population sizes than actually occurs in the Action Area.

The annual mortality estimates were especially sensitive to the greater proportion of Indiana bats flying within the rotor swept zone during the fall migratory period, which affected the impact that survival probability had on model outcomes. Assumptions about the proportion of activity at different height bins were based in part on acoustic data; other sources included published and unpublished telemetry studies, visual observation, and published aircraft-bat collision information.

It is important to note that acoustic data indicated that a much lower percentage of *Myotis* bats would be expected to fly within the rotor swept zone than what was presented in all flight height scenarios (*Myotis* activity recorded at 50 m [164 ft] was approximately 3% of that recorded at 2 m [7ft]); this was particularly true for the moderate and high flight scenarios. However, relying solely on acoustic data to inform assumptions about Indiana bat flight height is questionable because data were not recorded throughout the rotor swept zone; the highest detectors were placed at the lower limit of the rotor swept zone, at 50 m (164 ft). Finally, acoustic detectors cannot be used to determine the number of individuals recorded, but rather to establish an index of relative activity. Due to these limitations, a conservative approach was taken, such that the proportions of bats flying within the rotor swept zone were assumed to be much higher than the 1% indicated by acoustic data alone (the maximum proportion of activity within the rotor swept zone was 30% under the high flight height scenario in the fall).

Another potential limitation of this model is that it was not able to directly incorporate the erratic, non-linear flight behavior of bats because a model was used that was created for birds, which presumably exhibit more direct and linear flight behavior. Furthermore, methods have not currently been developed for modeling non-linear flight. However, for Indiana bats, it is expected non-linear flight behavior would be exhibited primarily during active foraging that occurs most often at or below canopy height, which would not lead to risk of collision with spinning turbine blades that are placed well above canopy level. Instead, it was assumed that when Indiana bats were flying within the rotor-swept zone, they would exhibit direct and linear flight behavior that would be expected during traveling or commuting activity. Thus, the assumption of straight-line flight at heights within the rotor swept zone is appropriate and is not expected to violate the assumptions of the model framework.

The probabilistic approach used in this collision risk model represented a unique way of adapting the existing Bolker et al. (2006) model to fit the needs of a species whose behavior did not match that of migratory or nesting bird species. For each individual simulation (out of 100,000), the calculation of collision risk combined the average number turbine encounters for all possible flight directions and all possible flight heights (weighted by probability), along with a randomly-selected survival probability between 0 and 1 that varied among survival scenarios. By using distributions whose shapes were derived from available data on bats, *Myotis* species, or Indiana bats specifically, a reasonable range of uncertainty was encapsulated during each simulation, which likely captured the expected amount of mortality that would result from the proposed Project.

6.0 REFERENCES CITED

Adam, M. D., M. J. Lacki, and T. G. Barnes. 1994. Foraging areas and habitat use of the VA big-eared bat in KY. Journal of Wildlife Management 58:462-469.

Arnett, E. B., W. K. Brown, W. P. Erickson, J. K. Fiedler, B. L. Hamilton, T. H. Henry, A. Jain, G. D. Johnson, J. Kerns, R. R. Koford, C. P. Nicholson, T. J. O'Connell, M. D. Piorkowski, and R. D. Takersley Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72:61-78.

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

Avery, M. I. 1985. Winter activity of pipistrelle bats. Journal of Animal Ecology 54:721–738.

Baerwald, E. F., G. H. D'Amours, B. J. Klug, and R. M. R. Barclay. 2008. Barotrauma is a significant cause of bat fatalities at wind turbines. Current Biology 18(6). <http://www.wbwg.org/conservation/papers/BaerwaldetalCurrentBiology2008.pdf>. Accessed 6 April 2010.

Band, W. 2000. Guidance Windfarms and Birds: Calculating a theoretical collision risk assuming no avoiding action. Guidance notes series 2000. Scottish Natural Heritage (SNH). http://www.snh.org.uk/pdfs/strategy/renewable/COLLIS.pdf.

Band, W., M. Madders, and D.P. Whitfield. 2005. Developing field and analytical methods to assess avian collision risk at wind farms. In De Lucas, M., Janss, G. & Ferrer, M., eds. Birds and Wind Power. Barcelona., Spain: Lynx Editions.

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

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

Bolker, E. D., J. J. Hatch, and Catalin Zara. 2006. Modeling bird passage through a windfarm. < http://www.cs.umb.edu/~eb/windfarm>. Accessed January 2010.

Brack, V., Jr. 1983. The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, *Myotis sodalis.* Dissertation, Purdue University, West Lafayette, USA.

Britzke, E. R., A. C. Hicks, S. L. von Oettingen, and S. R. Darling. 2006. Description of spring roost trees used by female Indiana Bats (*Myotis sodalis*) in the Lake Champlain Valley of Vermont and New York. American Midland Naturalist 155:181-187.

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

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

Canham, C. D., J. J. Cole, and W. K. Lauenroth, eds. 2003. Models in EcoSystem Science. Princeton University Press. Princeton, New Jersey. 420 pps.

Chamberlain, D. E., M. R. Rehfisch, A. D. Fox, M. Desholm, and S. J. Anthony. 2006. The effect of avoidance rates on bird mortality predictions made by wind turbine collision risk models. Ibis 148:198-202.

Cooper, B. A. and R. H. Day. 2004. Modeling annual seabird use and fatality at the proposed Kaheawa Pastures Wind Energy Facility, Maui Island, Hawaii, fall 2004. Unpublished report prepared for Kahaewa Windpower LLC, Makawao, HI, and UPC wind Management LLC< Newton, MA, by ABR, Inc., Forest Grove, OR, and Fairbanks, AK.

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

Cryan, P. M. and R. M. R. Barclay. 2009. Causes of bat fatalities at wind turbines: hypotheses and predictions. Journal of Mammalogy 90:1130-1340.

Davis, W. 1964. Fall swarming of bats at Dixon Cave, Kentucky. National Speleological Society 26:83-3.

Desholm, M. and J. Kahlert. 2005. Avian collision risk at an offshore windfarm. Biology Letters 1:296-298.

Erickson, W. P., G. D. Johnson, D. M. Strickland, D. P. Young, K. Sernka, and R. Good. 2001. Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States. Washington, DC: Resolve, Inc.

Erickson, W., G. Johnson, D. Young, D. Strickland, R. Good, M. Bourassa, K. Bay and K. Sernka. 2002. Synthesis and comparison of baseline avain and bat use, raptor nesting and mortality information from proposed and existing wind developments: Final Report for Bonneville Power Administration. West, Inc., Cheyenne, Wyoming, USA.

Erkert, H. G. 1982. Ecological aspects of bat activity rhythms. Pages 201-242 *in* T.H. Kunz, editor. Ecology of Bats. Plenum Press, New York, USA.

Fiedler, J. K. 2004. Assessment of bat mortality and activity at Buffalo Mountain Windfarm, eastern TN. Thesis, University of TN, Knoxville, TN, USA.

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.

Fox, A. D., M. Desholm, J. Kahlert, T. K. Christensen, and I. B. K. Petersen. 2006. Information needs to support environmental impact assessment of the effects of European marine offshore wind farms on birds. Ibis 148:129-144.

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

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.

Garner, J. D. and J. E. Gardner. 1992. Determination of summer distribution and habitat utilization of the Indiana bat (*Myotis sodalis)* in Illinois. Illinois Department of Conservation Project E-3, Springfield, USA.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1989. A portable mist-netting system for capturing bats with emphasis on *Myotis sodalis* (Indiana bat). Bat Research News 30:1-8.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991. Summary of *Myotis sodalis* summer habitat studies in Illinois: with recommendations for impact assessment. Indiana/Gray bat Recovery Team Meeting, Columbia, USA.

Good, R. E., W. 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. Prepared for Fowler Ridge Wind Farm, 28 January 2011.

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

Handwerk, B. 2008. Wind Turbines Give Bats the "Bends," Study Finds. National Geographic News. August 25, 2008. <http://news.nationalgeographic.com/news/pf/61204214.html>. Accessed January 2010.

Harvey, M. J. 2002. Status and ecology in the southern United States. Pages 29-34 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Hatch, J. J., and S. Brault. 2007. Collision mortalities at Horseshoe Shoal of bird species of special concern. Prepared for Cape Wind Associates, 23 January 2007.

Hayes, J. P. 1997. Temporal variation in activity of bats andthe design of echolocation monitoring studies. Journal of Mammalogy 78:1-524.

Hogg, R. V. and A. T. Craig. 1978. Introduction to mathematical statistics. Macmillan Publishing Co., Inc., New York.

Horn, J. W., Edward B. Arnett, Thomas H. Kunz. 2008. Behavioral Responses of Bats to Operating Wind Turbines. Journal of Wildlife Management 72:123-132.

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

Jackson, D. A., and K. M. Somers. 1989. Are probability estimates from the permutation model of Mantel's test stable? Canadian Journal of Zoology 67:766-769.

Johnson, G. D., W. P. Erickson, M. D. Strickland, M. F. Shepherd, D. A. Shepherd, and S. A. Sarappo. 2003. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. American Midland Naturalist 150:332-342.

Johnson, G. D., M. K. Perlik, W. P. Erickson, and M. D. Strickland. 2004. Bat activity, composition, and collision mortality at a large wind plant in Minnesota. Wildlife Society Bulletin 32:1278-1288.

Kerns, J., W. P. Erickson, and E. B. Arnett. 2005. Bat and bird fatality at wind energy facilities in Pennsylvania and West Virginia. Pages 24–95 *in* E. B. Arnett, editor. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. Bats and Wind Energy Cooperative. Bat Conservation International, Austin, USA.

Kunz, T. H., E. B. Arnett, B. M. Cooper, W. P. Erickson, R. P. Larkin, T. Mabee, M. L. Morrison, M. D. Strickland, and J. M. Szewezak. 2007. Assessing impacts of wind-energy development on nocturnally active birds and bats: a guidance document. Journal of Wildlife Management 71:2449-2486.

Kurta, A. 1980. Status of the Indiana bat, *Myotis sodalis*, in MI. MI Academician 13:31-36.

Kurta, A. 2005. Roosting ecology and behavior of Indiana bats (*Myotis sodalis*) in summer. Pages 29-42 *in* K.C. Vories and A. Harrington, editors. Proceedings of the Indiana bat and coal mining: a technical interactive forum. Office of Surface Mining, U.S. Department of the Interior.

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

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

Kurta, A. and H. Rice. 2002. Ecology and management of the Indiana bat in Michigan. MI Academician 33:361–376.

Kurta, A., K. J. Williams, and R. Mies. 1996. Ecological, behavioural, and thermal observations of a peripheral population of Indiana bats (*Myotis sodalis*). Pages 102-117 in R. M. R. Barclay and R. M. Brigham, editors. Bats and Forests Symposium, British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

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

LaVal, R. and M. L. LaVal. 1980. Ecological studies and management of MO bats, with emphasis on cave-dwelling species. Terrestrial Report 8. MO Department of Conservation, Jefferson City, USA.

Madders, M. and Whitfield, D. P. 2006. Upland raptors and the assessment of wind farm impacts. Ibis, Vol. 148, pp. 43 56.

Manly, B. F. J. 2007. Randomization, Bootstrap and Monte Carlo Methods in Biology, third edition. Chapman & Hall/CRC, Boca Raton, FL.

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

Myers, R. F. 1964. Ecology of three species of myotine bats in the Ozark Plateau. Dissertation, University of MO, Columbia, USA.

Nations, C. S., and W. P. Erickson. 2009. Marbled murrelet wind turbine collision model for the Radar Ridge Wind Resource Area. Prepared for Energy Northwest, 4 September 2009.

Negraeff, O. E., and R. M. R. Brigham. 1995. The influence of moonlight on the activity of little brown bats. Zeitschrift für Saugertierkunde 60:330–336.

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

Peurach, S. C., C. J. Dove, and L. Stepko. 2009. A decade of U.S. Air Force bat strikes. Human-Wildlife Conflicts 3:199–207.

Podolsky, R. 2003. Avian Risk of Collision (ARC) Model. NWCC Biological Significance Workshop, November 17-18, 2003. Washington, DC. National Wind Coordinating Committee.

Podolsky, R. 2005. Peer review and avian risk of collision model for Kaheawa Pastures Wind Farm, Maui, HI. Prepared for UPC Wind Management, LLC, 19 February 2005.

Reynolds, D. S. 2006. Monitoring the potential impact of a wind development site on bats in the Northeast. Journal of Wildlife Management 70: 1219–1227.

Russell, A. L., C. M. Butchkoski, L. Saidak, G. F. McCracken. 2008. Road-killed bats, highway design and the commuting ecology of bats. Endangered Species Research. doi: 10.3354/esr00121. <http://amyrussell.net/docs/RussellEtAl2008ESR.pdf>. Accessed 10 June 2010.

Russo, D. and G. Jones. 2003. Use of foraging habitats by bats in a Mediterranean area determined by acoustic surveys: conservation implications. Ecography 26:197–209

Rydell, J. 1991. Seasonal use of illuminated areas by foraging northern bats *Eptesicus nilssoni*. Holarctic Ecology 14: 203–207.

Sanzenbacher, P. M. and B. A. Cooper. 2009. Radar and visual studies of seabirds at the proposed KWP II Wind Energy Facility, Maui Island, Hawaii: use of 2008 data to model annual collision fatalities at proposed wind turbines. Final report prepared for First Wind, Newton, MA, January 2009.

Saunders, M.B., and R.M.R. Barclay. 1992. Ecomorphology of insectivorous bats: A test of predictions using two morphologically similar species. Ecology 73:1335-1345.

Shiel, C.B. and J. S. Fairley. 1998. Activity of Leisler's bat *Nyctalus leisleri* in the field in south-east County Wexford, as revealed by a bat-detector. Biology and Environment 98:105-112.

Sparks, D. W., C. M. Ritzi, J. E. Duchamp, and J. O. Whitaker, Jr. 2005. Foraging habitat of the Indiana bat, (*Myotis sodalis*) at an urban-rural interface. Journal of Mammalogy 86:713-718.

Thornthwaite, C.W. 1940. Atmospheric moisture in relation to ecological problems. Ecology 21:17-28.

Tucker, V. A. 1996*a*. A mathematical model of bird collisions with wind turbine rotors. Journal of Solar Energy Engineering. 118: 253–262.

Tucker, V.A. 1996*b*. Using a collision model to design safer wind turbine rotors for birds. Journal of Solar Energy Engineering. 118: 263–269.

Turner, G.G. 2006. Bat Migratory Behaviors and Routes in Pennsylvania and Maryland. Proceedings NWCC Wildlife Workgroup Research Planning Meeting VI, San Antonio, Texas November 14-15, 2006 http://www.nationalwind.org/assets/blog/WindWildlife_Research_Mtg_VI_Proceedings_FINAL.pdf

U.S. Department of the Interior, Fish and Wildlife Service. 2005a. Biological Opinion on the construction, operation, and maintenance of the U.S. 24 New Haven, Indiana to Defiance, Ohio project for the federally-listed endangered Indiana bat (*Myotis sodalis*) submitted to the Federal Highway Administration; September, 2005. Ohio Ecological Services Field Office, Reynoldsburg, Ohio.

U.S. Department of the Interior, Fish and Wildlife Service. 2005b. Biological Opinion on the construction, operation, and maintenance of the U.S. 33 Nelsonville Bypass for the federally-listed endangered Indiana bat (*Myotis sodalis*) submitted to the Federal Highway Administration; September, 2005. Ohio Ecological Services Field Office, Reynoldsburg, Ohio.

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

U.S. Fish and Wildlife Service [USFWS]. 2010. U.S. Fish and Wildlife Service and Wind Farm Owners Work Together. <http://www.fws.gov/midwest/News/release.cfm?rid=177>. Accessed 9 February 2010.

Vaughan, N., G. Jones, S. Harris. 1996. Effects of sewage effluent on the activity of bats (Chiroptera: Vespertilionidae) foraging along rivers. Biological Conservation 78:337–343.

Warren-Hicks, W. J., D. Moore. eds. 1998. Uncertainty Analysis in Ecological Risk Assessment: Pellston '95. SETAC Press, Florida.

Warren-Hicks, W. J., and Hart, A. eds. 2010. Application of Uncertainty Analysis to Ecological Risks of Pesticides. Taylor & Francis, New York, New York.

Warren-Hicks, W.J. 1999. Formal Methods for Risk-Based Decision-Making. HERA 5(2):225-229.

Whitaker, J. O., Jr. and V. Brack, Jr. 2002. Distribution and summer ecology in Indiana. Pages 48-54 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Winhold, L., E. Hough, and A. Kurta. 2005. Long-term fidelity by tree-roosting bats to a home area. Bat Research News 46:9-10.

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

Appendix B

Habitat Suitability Model

Summer Habitat Suitability Model for Indiana Bats at the Buckeye Wind Power Project in Champaign County, Ohio

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EXECUTIVE SUMMARY

Section 10 of the ESA of 1973 (7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.) allows for the incidental take of listed species via an Incidental Take Permit (ITP), as long as an associated Habitat Conservation Plan (HCP) demonstrates that incidental take has been avoided, minimized, and mitigated to the maximum extent practicable. To avoid and minimize take of Indiana bats at the Buckeye Wind Power Project (the Project) during the summer maternity season, a turbine curtailment strategy was developed in which operational adjustments will be based on the suitability of habitat in which turbines are placed. The proposed Project includes up to 100 turbines that will generate up to 250 megawatts of energy. Turbines will be situated within a 32,395-ha (80,051 ac) area in Champaign County, Ohio. The Project area is dominated by agricultural lands and is comprised of approximately 9% forested habitat.

Indiana bat habitat suitability was based on data supplied by the Ohio Department of Natural Resources (ODNR) for 17 adult Indiana bats (n=15 females, n= 2 males) captured in 2008 and 2009 during pre-construction mist netting surveys for various proposed wind power projects (including the proposed Project) in Champaign, Logan, and Hardin Counties. Sampled locations for the 17 Indiana bats included 1,124 telemetry points that were collected during nighttime foraging and traveling activities, and 43 roost trees.

A partitioned Mahalanobis D^2 technique was used to predict suitable Indiana bat habitat across the Project area. This multivariate technique measures the spatial distance (D^2) between a collection (or vector) of environmental variables measured at locations where the target species was identified, and a vector of those same environmental variables measured at unsampled locations. Environmental variables which are consistent across locations where the species was identified are considered more important and are given more weight in the model than variables which vary widely across known locations. A high probability of occurrence is assigned to sites at which conditions are most similar to the conditions where the species was detected.

We used a Geographic Information System (GIS) to consider 13 environmental variables thought to influence Indiana bat habitat selection (see Table 3-1), based on literature review and professional judgment. The program FRAGSTATS manipulated the 2001 National Land Cover Database (30-m resolution) to generate spatial metrics for 7 of the 13 environmental variables. The additional 6 variables were obtained from existing data sources.

Separate predictive maps were created for Indiana bat roosting suitability (using the 43 roost tree locations) and foraging suitability (using the 1,124 telemetry locations) because sample size and location error was significantly larger for the telemetry dataset, and with unequal sample sizes, a model containing both data types would not properly identify potential roosting habitat. Using the 1,124 telemetry locations, a predictive map for foraging suitability was created based on all 13 environmental variables. A separate predictive map based on only 7 of the environmental variables was created for Indiana bat roosting suitability so that roost suitability was properly mapped, and so that the smaller roost tree data set did not result in an overfitted model. We determined the distance (D^2) between the vector of environmental conditions measured at each pixel and the mean vector of environmental conditions derived from known Indiana bat roosting or foraging locations. These D^2 values were then rescaled using a chi-squared (χ^2) distribution and converted to p-values to determine probability of occurrence in each 30-m pixel in the Project area. P-values were divided into four quantiles, representing most to least suitable for Indiana bat roosting and foraging activities. Roosting and foraging suitability maps were then combined into a single predictive map by retaining the highest suitability category assigned to each pixel in either predictive map when a discrepancy occurred. A turbine curtailment strategy will be derived in which turbine operation will

vary during the summer maternity season based on turbine location in relation to predicted suitable summer Indiana bat habitat.

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1.0 INTRODUCTION

Since its description as a separate species, Indiana bat (*Myotis sodalis*) populations have experienced marked population declines. The species was listed as being in danger of extinction in 1967 under the Endangered Species Preservation Act of 1966 (32 FR 4001, March 11, 1967) because of large decreases in population size and an apparent lack of winter habitat (Clawson 2002; USFWS 1983, 1999). It was later listed as federally endangered under the Endangered Species Act (ESA) when it was enacted in 1973.

Section 10 of the ESA of 1973 (7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.) allows for the incidental take of listed species via an Incidental Take Permit (ITP), as long as an associated Habitat Conservation Plan (HCP) demonstrates that incidental take has been avoided, minimized, and mitigated to the maximum extent practicable (among other issuance criteria described in detail in the HCP). To avoid and minimize take of Indiana bats at the Buckeye Wind Power Project (the Project), a turbine curtailment strategy will be derived in which turbine operation will vary during the summer maternity season based on turbine location in relation to predicted suitable Indiana bat foraging and roosting habitat.

Suitable habitat is thought to be more restrictive for female Indiana bats, which congregate in maternity colonies during the summer months, than for males or nonreproductive females (Rommé et al. 1995, Farmer et al. 2002, Carter 2005). Maternity colonies can use between 10 and 20 different roost trees per year, although usually only 1 to 3 of these are considered primary roosts which are used more consistently by a larger number of individuals in the colony (Callahan 1993, Callahan et al. 1997). Indiana bats roost underneath bark or in cracks or crevices of trees, so roosts are most often found in trees which are dead or dying; although live trees with exfoliating bark are also used (Kurta 2005). In an analysis of 393 roost trees from 11 states, Kurta (2005) found that 87% were ash (*Fraxinus*), elm (*Ulmus*), hickory (*Carya*), maple (*Acer*), poplar (*Populus*) and oak (*Quercus*). Although most trees used by reproductive females are deciduous, hemlock (*Tsuga* spp.) and pitch pine (*Pinus rigida*) have been used in western NC and eastern TN, and eastern white pine (*Pinus strobes*) has been used in VT (Britzke et al. 2003, Watrous et al. 2006). The large number of tree species identified as roosts (> 30 species; Kurta 2005) may indicate that tree location and structure are more important than the species of tree itself.

Numerous foraging habitat studies have been completed for the Indiana bat throughout much of the species range. Indiana bats forage in closed to semi-open forested habitats and forest edges located in floodplains, riparian areas, lowlands, and uplands (Humphrey et al. 1977, LaVal et al. 1977, Brack 1983, Garner and Garner 1992, Carter 2003). Forest edges are often used as protective travel corridors. In fragmented habitat, bats typically use hedge rows and other features of the landscape that provide cover and serve as travel corridors between foraging areas and roosts (Murray and Kurta 2004). While visual observations suggest that foraging over open fields or bodies of water more than 50 m (150 ft) from a forest edge do occur, it appears to be less common than foraging within forested sites or along edges (Brack 1983, Menzel et al. 2001).

1.1 Review of Existing Habitat Suitability Index Models

Three habitat suitability index (HSI) models have been developed to evaluate the suitability of Indiana bat maternity sites in the Midwest (Rommé et al. 1995, Farmer et al. 2002, Rittenhouse et al. 2007). An Indiana bat HSI was developed for the Indiana Department of Natural Resources (Rommé et al. 1995) that used known roosting and foraging characteristics determined by studies in the Indiana bat's "core area" of

Indiana, Illinois, Missouri, southern Michigan, and western Ohio. Five roost tree variables were used to assess suitability of roosting habitat including: 1) percent overstory canopy cover, 2) diameter of overstory trees, 3) density of potential live roost trees by class > 22 cm (8.7 in) diameter at breast height (dbh), 4) density of snags by class > 22 cm (8.7 in) dbh, and 5) percent cover of understory from 2.0 m (6.6 ft) to the base of overstory canopy. Two variables were identified to evaluate the suitability of foraging habitat: 1) percent overstory canopy cover, and 2) percent of trees 5 to 12 cm (2 to 4.7 in) dbh. Each variable had an associated suitability index curve so that the average values collected in the field could be transformed into an index value between 0 and 1, with higher values representing more suitable habitat. The minimum of the roosting or foraging index value was then multiplied by the mean index values for 2 landscape variables (distance to water and the amount of forested area) to determine the overall HSI for the site (Rommé et al. 1995).

The Farmer et al. (2002) model condensed the Romme et al. (1995) model down to only three variables: number of land cover types covering > 10% of the study area, density of suitable roost trees, and the percent of landscape in forest. Similar to the Rommé et al. (1995) HSI model, implementation of the Farmer et al. (2002) model requires that input values be measured at the site and transformed into an index value using curves developed from known roosting and foraging characteristics. Performance of the model, using various combinations of index values, was assessed by comparing HSI values calculated for locations where Indiana bats had been previously detected in mist netting studies in Missouri to values calculated for locations where Indiana bats were deemed absent. Higher index values were found at locations where Indiana bats were found; however, results were driven solely by the density of suitable roost trees. Farmer et al. (2002) were careful to point out that sound empirical support was lacking for various components of their model.

Rittenhouse et al. (2007) developed an HSI model based on reported ecological relationships for Indiana bats in the Central Hardwoods region of Indiana. The Rittenhouse et al. (2007) HSI model differed from the previous two models in that it used information derived in a Geographic Information System (GIS) to evaluate Indiana bat roosting and foraging habitat suitability. The Rittenhouse et al. (2007) model was most similar to the Farmer et al (2002) model, but differed in that it used Forest Inventory Analysis data and estimates of snag density by tree age class to identify potential roost trees, and it accounted for solar radiation of roost trees. Four variables measured summer habitat suitability: 1) roost tree dbh and snag density as functions of tree age, 2) suitability of open habitat and early successional forest (thought to indicate suitable foraging habitat) based on tree age, 3) distance to water, and 4) solar exposure. The final habitat suitability value was the maximum of the composite roost site suitability or the foraging suitability. While this model allows for predictions of suitable habitat to be made over larger areas, it relies on arbitrary suitability index curves to assess the suitability of roost tree and landscape information, similar to the Rommé et al. (1995) and Farmer et al. (2002) HSI models.

1.1.1 Model Limitations

While these models attempt to quantitatively predict suitable habitat, there are several drawbacks to their methods. These studies relied on limited (Rommé et al 2005, Farmer et al. 2002) or no empirical data (Rittenhouse et al. 2007) to develop suitability index curves. Because these models have rarely been tested with empirical data to validate their underlying assumptions, the scope of inference is restricted to areas in which the studies were conducted. Carter (2005) used data collected in Illinois in a post-hoc test of both the Rommé et al. (1995) and Farmer et al. (2002) HSI models and found contradicting results. Although Carter believed an appropriate HSI for his study area should have been well above average (0.8 to 0.9), the Rommé et al. (1995) model resulted in an HSI value of only 0.42, while the Farmer et al. (2002) model predicted an HSI of up to 0.8, suggesting that it might be more useful. However, until these various models are validated through field studies that are designed and implemented specifically to test the predictions of the models at multiple sites, these HSI models will be of questionable value.

Another limitation to the aforementioned HSI models is that they assume that all variables are equally important in assessing habitat suitability and that no unimportant variables have been included. Additionally, implementation of the Rommé et al. (1995) and Farmer et al. (2002) HSI models require extensive field work to derive values for each roost tree variable in the model, but the optimal number of samples required and the proper scale at which each model operates are not known. As a result, these models cannot be applied to a large landscape. Similarly, none of these models addressed landscape-scale spatial patterns of habitat configuration such as fragmentation and connectedness of forested habitat. Yet, Indiana bat foraging studies have consistently shown that bats use linear features such as forest edges, hedge rows, road corridors, streams, and other features on the landscape that provide cover as travel corridors between foraging areas and roosts (Gardner et al. 1991b, Kurta et al. 2002, Carter 2003, Murray and Kurta 2004, Kurta 2005, Winhold et al. 2005), indicating that the spatial configuration of forested habitat may be as important as other features such as the density of suitable roost trees.

1.2 Selected Model Framework

In order to predict suitable Indiana bat habitat across the Project area, a model was needed that would allow for predictions over a large landscape based on site-specific, empirical data on Indiana bat habitat features. Two examples of such models were developed by Carter et al. (2002) and Miller et al. (2002). Carter et al. (2002) used a GIS model to compare habitat characteristics measured at roosting areas with the same characteristics measured at random points in Illinois. Roosting habitats had less urban development, larger patches of closed-canopy deciduous forest, more patches of water, and less agricultural area (although more individual patches), than random locations. In comparison, Miller et al. (2002) did not find any difference in 5 of 7 landscape characteristics measured at locations where Indiana bats had been captured in mist nets and locations where mist netting had not resulted in capture (and the authors believe the 2 significant characteristics would not strongly influence Indiana bat occurrence).

Common statistical techniques (e.g., logistic regression, discriminant function analysis, canonical correlation analysis) often used to identify suitable habitat are based on comparison of sampled locations where the target species was determined to be present, with random or surveyed locations where the species was presumed to be absent. However, assigning "absence" can be difficult for rare and elusive species such as the Indiana bat, since the species could be present but not detected. For example, if the random locations used in the Carter et al. (2002) model, or the mist net locations where Indiana bats were not captured in the Miller et al. (2002) model did not truly represent unoccupied habitat, the outcome of these models would not accurately predict Indiana bat habitat suitability.

Models based solely on presence data, such as Mahalanobis D^2, avoid misclassification of absence. This multivariate technique measures the spatial distance (D^2) between a collection (or vector) of environmental variables measured at locations where the target species was identified, and a vector of those same environmental variables measured at unsampled locations. A high probability of occurrence is assigned to sites that have small distance (D^2) values; i.e., sites at which conditions are most similar to conditions where the species was detected. Low probabilities of occurrence are assigned to sites that are distant (i.e., large D^2 values) from the vector derived from occupied sites. An additional benefit to the Mahalanobis D^2 technique is that it is appropriate for use within a GIS, which allows for analysis of environmental conditions across large landscapes, such as areas used for foraging and roosting activities by Indiana bats. Furthermore, multivariate statistical models account for interactions between variables while making no assumptions on variable distributions; therefore, environmental variables need not be normally distributed across sites in order to be included.

This technique has been used to predict suitable summer habitat for Indiana bats in the Lake Champlain Valley, Vermont (Watrous et al. 2006), where predicted suitable habitat was located in areas that had diverse land cover types, predominantly characterized by agriculture, isolated forest patches, and water sources. Within a 0.5 km (0.3 mi) buffer, forest patch area (mean ± SD = 36 ha ± 12.79 ha [89.0 ac ± 31.6 ac]), elevation (110 m ± 44 m [361.0 ft ± 144.4 ft]), aspect (90.6° ± 2.3°), and Shannon's diversity index (0.6 ± 0.1) were strong predictors of suitable habitat. Traditional and modified Mahalanobis D^2 techniques have also been used to predict suitable habitat for black bear (*Ursus americanus*; Clark et al. 1993*a,b*), black-tailed jackrabbit (*Lepus californicus*; Knick and Dyer 1997), gray wolf (*Canis lupus*; Corsi et al. 1999), sage sparrows (*Amphispiza belli*; Knick and Rotenberry 1998, Rotenberry et al. 2002), Acadian flycatcher (*Empidonax virescens*; Dunn and Duncan 2000, Duncan and Dunn 2001), timber rattlesnake (*Crotalus horridus*; Duncan and Dunn 2001, Browning et al. 2005), California gnatcatcher (*Polioptila californica*; Rotenberry et al. 2006), and sagebrush ecosystems (*Artemisia* spp., Meinke et al. 2009).

1.2.1 Model Limitations

While GIS-based models can be used to predict suitable habitat over large landscapes, they require model inputs that are measureable on a landscape scale. Several roost tree factors, such as tree species, dbh, the amount of solar exposure, or the amount of peeling bark are of known importance to Indiana bats, but cannot be mapped on a landscape scale. The density of suitable roost trees was the most important component of previous habitat suitability index models developed by Rommé et al. (1995), Farmer et al. (2002), and Rittenhouse et al. (2004). Roost tree suitability was determined either in the field (Rommé et al. 1995, Farmer et al. 2002), or using surrogate measures, such as the combination of tree age and size class (Rittenhouse et al. 2007). Indeed, Rittenhouse et al. (2007) was able to create a landscape-scale predictive map using those surrogate tree-scale characteristics. However, the variables in the model estimated the number of suitable roosts based on snag density, and not all snags will be suitable roost trees due to differences in species, size, and bark characteristics (Menzel et al. 2001), and not all roost trees will be snags (Kurta 2005). Further, the relationship between the density of potential roost trees and the suitability of an area has not been well established (Menzel et al. 2001). Miller et al. (2002) found that stands where Indiana bats had been captured in mist nets had a higher number of medium and large diameter trees than stands where no Indiana bats had been captured; however, it is not stated whether the trees measured were considered suitable roost trees.

Because Indiana bats are rare, it is difficult to collect a sufficiently large data set of independent samples. Due to the sensitive nature of information for this endangered species, and the sensitive nature of investigations at proposed wind facilities, precise locations for roost trees or telemetry points were not available for this analysis. Instead, environmental characteristics at sampled locations were provided by the ODNR. These data were collected by multiple observers and did not include estimates of telemetry error. Thus, issues related to sampling independence or spatial autocorrelation were not able to be addressed. However, the effects of spatial autocorrelation were likely minimized as a function of tracking fast-moving bats.

Tracking bats typically involves multiple observers taking simultaneous bearings at a specified time interval (often every 5 minutes) and then triangulating those bearings to derive a location or "fix". Because bats move rapidly while flying (Indiana bats have been documented flying between approximately 13 km/hr and 20 km/hr [8 mph and 12mph]; Patterson and Hardin 1969, Butchkoski and Turner 2005), and due to other issues inherent in tracking animals across varied landscapes (e.g., signal bounce, blocked signals), bearings are often collected that do not cross other bearings (i.e., cannot be triangulated). Thus, usable triangulations are often separated in time, increasing the independence of successive radio locations.

Another limitation of this model is that the number of unique maternity colonies in the dataset was not able to be identified because all roost trees used by each tracked individual were not identified. Mist netting surveys from which data were derived were designed to establish presence or likely absence of Indiana bats; more rigorous study would have been required to determine primary and secondary roost trees and colony membership of tracked individuals. However, because the 17 radio tagged individuals were each tracked to at least 1 roost tree (the average number of roost trees identified per individual was 2; range = 1 to 5 roost trees identified per individual), the sample of roost trees was representative of roosting activity by the entire group. In other words, a small percentage of radio tagged individuals did not account for an unusually high percentage of identified roost trees.

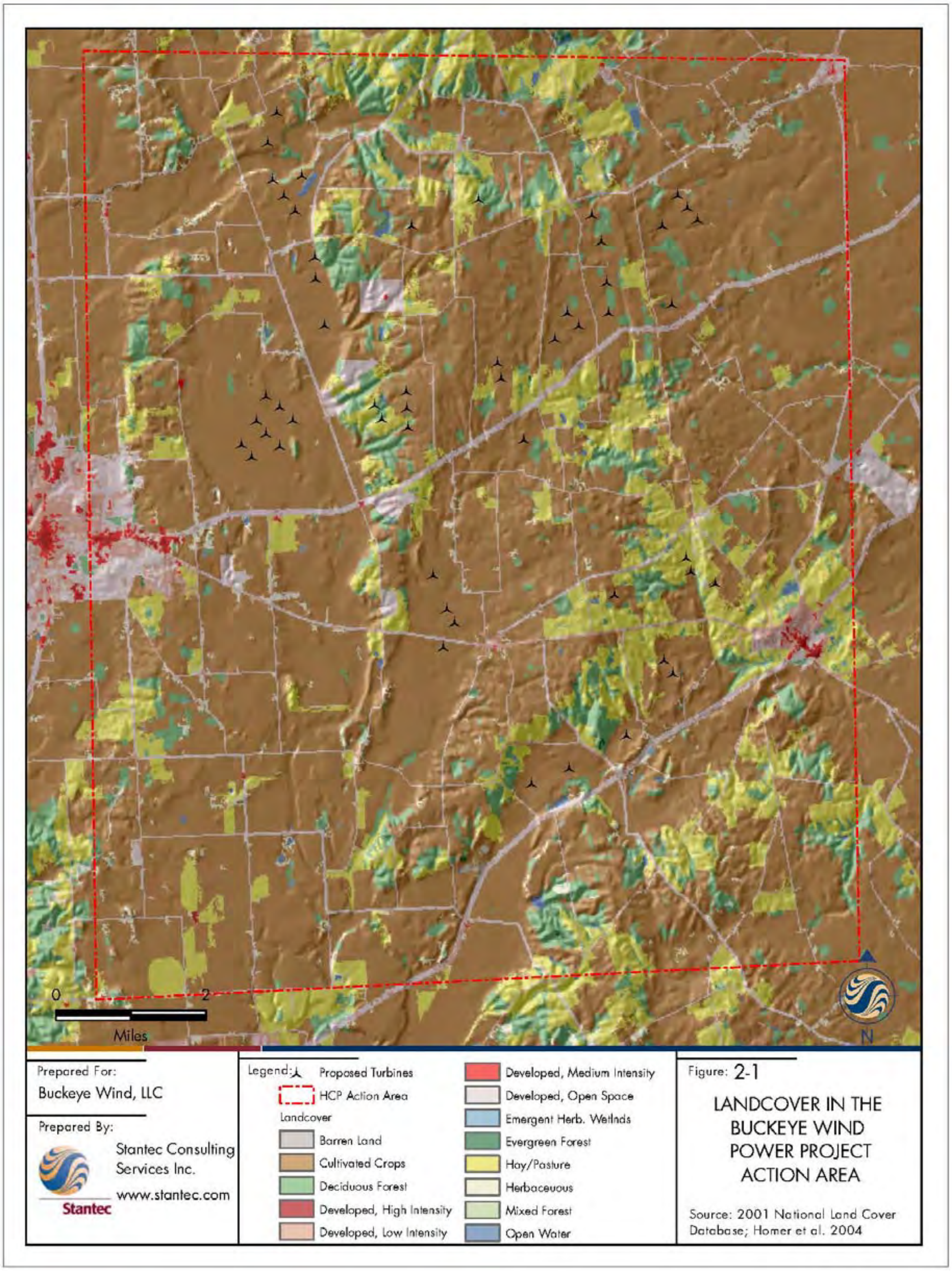
Finally, the accuracy of the model is dependent on the accuracy of the spatial layers used to derive model inputs. Although the most current GIS data was used to develop spatial layers, the resolution and accuracy of some spatial data may have resulted in inaccuracy of model predictions. Because the NLCD (Homer et al. 2001) land cover data that were used had a minimum mapping unit of 30-m (98-ft), habitat features that occupied a smaller area may not have been accurately mapped. For example, tree-lined hedgerows may not have been accurately identified as forested habitat even though they contained deciduous trees. If a radio location were recorded for an Indiana bat that was using such a hedgerow, the GIS analysis would not have accurately identified this individual as occurring at a forest edge; rather, it would be identified as occurring some distance from the nearest forest patch. Because we did not have access to the original data and a ground-based accuracy assessment of the NLCD data was outside of the scope of this assessment, we were not able to identify how often this may have occurred. However, based on a desktop assessment comparing the forested habitat identified in the NLCD dataset to a current (2009) aerial image, the spatial accuracy of mapped forested habitat, even in the case of narrow stream corridors and hedgerows, appeared accurate except in cases where trees became very sparse.

2.0 PROJECT AREA DESCRIPTION

The proposed Project will be situated within an area that encompasses approximately 32,395 ha (80,051 ac) within portions of Union, Wayne, Urbana, Salem, Rush, and Goshen Townships in Champaign County, Ohio, hereafter referred to as the "Action Area". The Action Area is characterized by flat and rolling terrain with elevations ranging from 396 to 548 m (1,300 to 1,800 ft) above mean sea level.

2.1 Land Cover

The Action Area is comprised largely of active agricultural lands (producing mostly corn and soybean crops), interspersed with scattered stands of deciduous forest (Figure 2-1). Based on the 2001 National Land Cover Database ([NLCD; Homer et al. 2004), the majority (69%) of vegetation in the Action Area is comprised of the *Cultivated Crop* landcover type, 13% is comprised of *Pasture/Hay*, 9% is comprised of *Deciduous Forest*, and 6% is comprised of *Developed Open Spac*e (Homer et al. 2004). Remaining native land cover types, such as *Grassland/Herbaceous* (i.e., old fields, Conservation Reserve Program [CRP] lands) and *Developed, Low Intensity* each makes up approximately 1% of the Action Area, while *Evergreen Forest*, *Mixed Forest*, and *Emergent Herbaceous Wetlands*, each make up 0.1% or less of the Action Area (Table 2-1, Figure 2-1).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Proposed Turbines
HCP Action Area
Landcover
Barren Land
Cultivated Crops
Deciduous Forest
Developed, High Intensity
Developed, Low Intensity
Developed, Medium Intensity
Developed, Open Space
Emergent Herb. Wetlnds
Evergreen Forest
Hay/Pasture
Herbaceuous
Mixed Forest
Open Water
Figure: 2-1
LANDCOVER IN THE BUCKEYE WIND POWER PROJECT ACTION AREA
Source: 2001 National Land Cover Database; Homer et al. 2004

Table 2-1. 2001 National Land Cover Database landcover types and size (ha and ac) identified in the Buckeye Project Action Area, Champagne County, OH.

Landcover type	Hectares	Acres	Percent of action area
Cultivated crops	22,408	55,372	69.2%
Hay/pasture	4,163	10,287	12.9%
Deciduous forest	2,744	6,779	8.5%
Developed, open space	1,962	4,849	6.1%
Grassland/herbaceous	445	1,099	1.4%
Developed, low intensity	422	1,042	1.3%
Open water	84	208	0.3%
Developed, medium intensity	55	135	0.2%
Emergent herbaceous wetlands	40	100	0.1%
Evergreen forest	31	76	0.1%
Developed, high intensity	26	65	0.1%
Barren land (rock/sand/clay)	13	33	<0.1%
Mixed forest	2	6	<0.1%
Totals	32,395	80,051	100%

Source: Homer et al. 2004

Based on the 2001 NLCD, there are approximately 766 distinct forest patches in the Action Area[1] that average 3.6 ha ± 10.0 ha (9.0 ac ± 24.7 ac) in size and vary from 0.1 ha to 106.47 ha (0.2 ac to 263.09 ac). Eighty-two percent of the forest patches were 4 ha (10 ac) or smaller and only 2% (n=13) were 40 ha (100 ac) or more. The deciduous forest habitat in the Action Area includes mature stands and early-successional scrub-shrub, primarily bordered by agricultural fields, generally even-aged, and dominated by oaks (*Quercus* spp.), maples (*Acer* spp.), hickories (*Carya* spp.), and ash (*Fraxinus* spp.) as determined during the course of 2008 bat mist-netting surveys in the Action Area (Stantec 2008) and during ground-based habitat assessments conducted by Buckeye Wind in conjunction with the USFWS in November 2010.

2.2 Hydrology

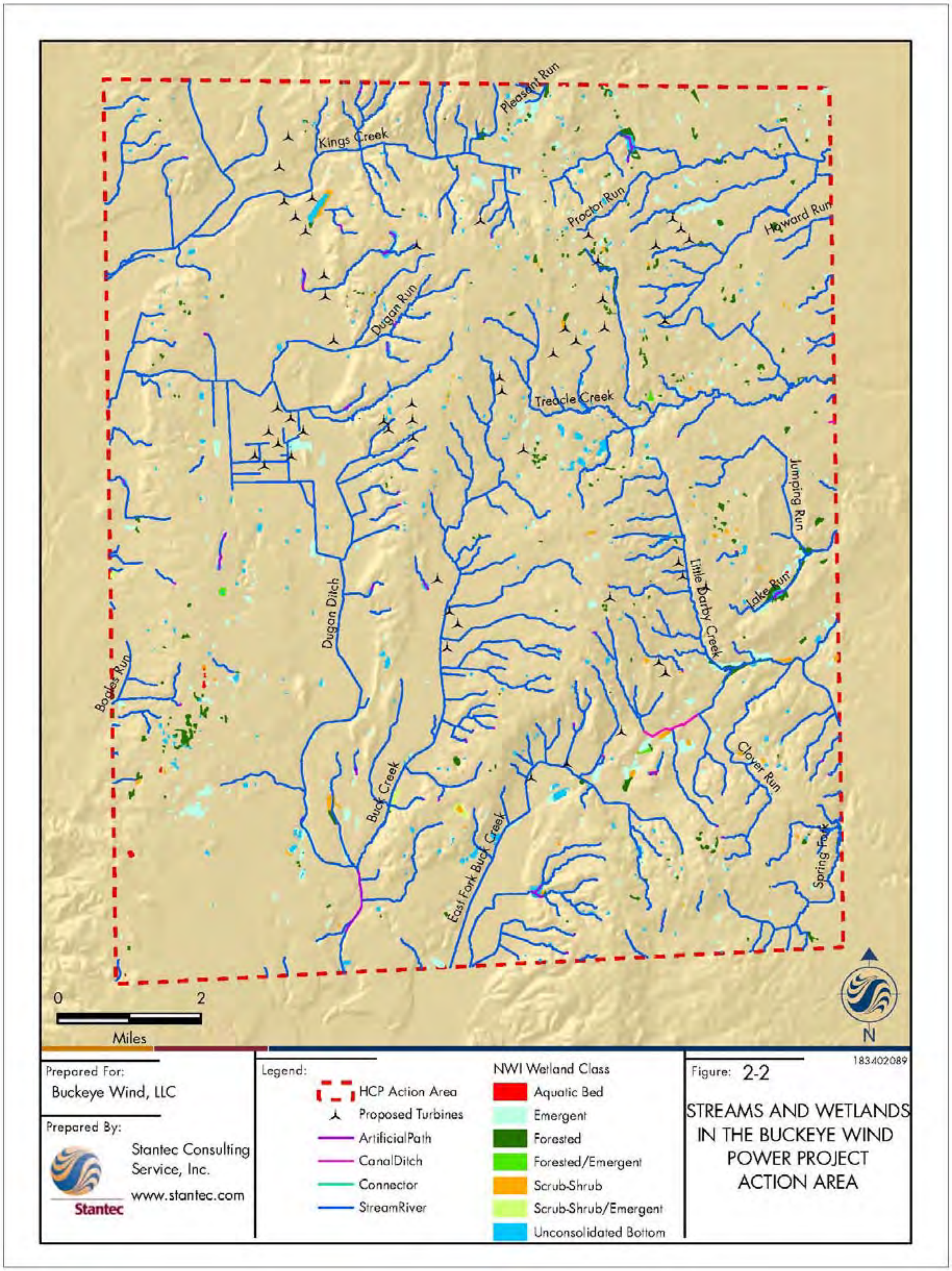
The Action Area lies within the Upper Scioto River and Upper Great Miami River drainages, both of which drain to the Ohio River (USGS 2003). These drainage basins are divided into smaller watersheds and sub-watersheds in the USGS hydrologic classification system in which hydrologic units are divided and sub-divided into successively smaller hydrologic units. Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of 2 to 12 (or more) digits based on tiered levels of classification in the hydrologic unit system. Table 2-2 presents the hydrologic units in the Action Area at the watershed and sub-watershed levels. Named perennial streams or ditches within these watersheds include Bogles Run, Buck Creek, Clover Run, Dugan Ditch, Dugan Run, East Fork Buck Creek, Howard Run, Jumping Run, Kings Creek, Lake Run, Little Darby Creek, Pleasant Run, Proctor Run, Spring Fork, and Treacle Creek (Figure 2-2).

[1] Excluding portions of 6 forest patches that only partially overlap the Action Area, totaling 0.4 ha (0.9 ac).

Table 2-2. Watersheds and subwatersheds within the Buckeye Wind Project, Champaign County, Ohio[a].

12-Digit HUC Number	Watershed (10-digit HUC)	Subwatershed (12-digit HUC)	Streams
50800011702	Buck Creek	Headwaters Buck Creek	
50800011705	Buck Creek	Clarence J Brown Lake-Buck Creek	
50800011701	Buck Creek	East Fork Buck Creek	
50800011801	Donnels Creek-Mad River	Moore Run	
50600011902	Headwaters Big Darby Creek	Spain Creek-Big Darby Creek	
50800011503	Headwaters Mad River	Kings Creek	
50600012003	Little Darby Creek	Headwaters Little Darby Creek	Little Darby Creek to Big Darby Creek to Scioto River
50600012001	Little Darby Creek	Headwaters Treacle Creek	Little Darby Creek to Big Darby Creek to Scioto River
50600012002	Little Darby Creek	Proctor Run-Treacle Creek	Little Darby Creek to Big Darby Creek to Scioto River
50600012004	Little Darby Creek	Spring Fork	Little Darby Creek to Big Darby Creek to Scioto River
50800011602	Nettle Creek-Mad River	Dugan Run	Big Darby Creek to Scioto River
50800011607	Nettle Creek-Mad River	Bogles Run	Buck Creek to Mad River to Great Miami River

[a]All watersheds drain into the Ohio River.



Pleasent Run
Kings Creek
Proctor Run
Howard Run
Dugan Run
Treacle Creek
Jumping Run
Little Darby Creek
Lake Run
Dugan Ditch
Bodes Run
Clover Run
Buck Creek
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HCP Action Area
Proposed Turbines
ArtificialPath
CanalDitch
Connector
StreamRiver
NWI Wetland Class
Aquatic Bed
Emergent
Forested
Forested/Emergent
Scrub-Shrub
Scrub-Shrub/Emergent
Unconsolidated Bottom
183402089
Figure: 2-2
STREAMS AND WETLANDS IN THE BUCKEYE WIND POWER PROJECT ACTION AREA

The Action Area also contains a number of wetlands identified in the National Wetlands Inventory (NWI) database that was updated based on current (2005 to 2007) aerial photos by Ducks Unlimited (DU) in 2009 in draft format (DU 2009; Table 2-3). The DU update to the NWI database was recommended for use by the ODNR as the most accurate source for wetlands information in Ohio at the desktop level (Keith Lott, ODNR, personal communication). The largest wetland in the Action Area is a 10.0 ha (24.7 ac) palustrine (i.e., non-tidal, inland wetland which lacks flowing water), emergent, seasonally flooded wetland located in the west central portion of the Action Area (Figure 2-2). The largest open water wetland is a 9.2 ha (22.7 ac) lacustrine/limnetic (i.e., freshwater lake or pond), unconsolidated bottom, permanently flooded, excavated pond in the northwest portion of the Action Area.

Table 2-3. Description and total area (ac and ha) of NWI wetland categories identified in the Buckeye Wind Project Action Area by the Ducks Unlimited 2009 update to the National Wetlands Inventory database.

NWI System/Class Code	Wetland description	Acres	Hectares
PAB	Palustrine Aquatic Bed	11.4	4.6
PEM	Palustrine Emergent	718.3	290.7
PFO	Palustrine Forested	377.2	152.6
PFO/PEM	Palustrine Forested/Emergent	12.0	4.9
PSS	Palustrine Scrub-Shrub	106.3	43.0
PSS/PEM	Palustrine Scrub-Shrub/Emergent	21.1	8.6
PUB	Palustrine Unconsolidated Bottom	383.1	155.0
L1UB	Lacustrine/Limnetic Unconsolidated Bottom	22.7	9.2
Total		1652.2	668.6

2.3 Indiana Bat Distribution In and Near the Action Area

Although the summer distribution of Indiana bats has historically been poorly documented, recent summer mist netting efforts in OH related to pre-permitting activities for proposed wind power projects have resulted in a number of newly documented Indiana bat maternity colonies in previously undocumented portions of their summer range (M. Seymour, USFWS, personal communication). Indiana bat summer records in western OH were known from Greene, Montgomery, Miami, and Preble Counties prior to 2008. Additional summer reproductive records were documented in Champaign, Hardin, and Logan Counties, OH (hereafter "tri-county area") in 2008 and 2009.

Based on data provided by the ODNR, 26 Indiana bats (24 adult females and 2 adult males) were captured during pre-construction mist netting surveys for various proposed wind power projects (including the proposed Project) in the tri-county area (Stantec 2008, K. Lott, ODNR, personal communication). Of these 26 Indiana bats, 19 (17 females and 2 males) were radio-tagged and 17 (15 females and 2 males) were successfully tracked to 36 day-roost trees. Seven additional day-roost locations were estimated using triangulation, for a total of 43 day-roost locations. A total of 1,124 radio telemetry locations were collected for the 19 radio-tagged bats. Refer to Section 4.2.2 of the HCP for additional information on Indiana bats in the Action Area and tri-county area.

3.0 METHODS

3.1 Environmental Variables

Research has shown that the spatial relationships of forest habitat, water resources, and topography are important predictors of Indiana bat habitat (Menzel et al. 2001, Carter 2002). Using the 2001 National Land Cover Database (NLCD; Homer et al. 2004), we assessed forest class and landscape variables produced by FRAGSTATS (McGarigal et al. 2002) for their ability to discriminate areas of expected Indiana bat presence in the Action Area. Environmental variables were measured within a 2-km (1.2-mi) buffer of each 30-m pixel in the Action area, based on the average distance (mean ± standard deviation [SD]; 1.1 km ± 0.9 km [0.7 mi ± 0.5 mi]) between roost trees and foraging locations identified for 17 radio-tagged Indiana bats (n=15 females, n= 2 males) captured in the tri-county area in 2008 and 2009. Forty-three roost tree and 1,124 telemetry locations were collected for the 17 bats during pre-construction mist netting surveys for various proposed wind power projects (including the proposed Project).

We used a Geographic Information System (GIS) to consider 13 environmental variables thought to influence Indiana bat habitat selection (see Table 3-1), based on literature review and professional judgment. These environmental variables include forest patch attributes related to size, connectivity to other wooded areas, amount of forest edge, percentage of the landscape, and dispersion across the landscape. Each pixel in the Action Area was also evaluated for its distance to the nearest forest edge or water resource (stream, wetland, or forested stream). Although there is overlap within distance to streams, forested streams, wetlands, and forest, all were included in the analysis because we did not know which of these measures would be most discriminating, and because they were developed from different data sources. The Mahalanobis D^2 approach scales deviations by the variance-covariance matrix, thereby standardizing variables and incorporating their correlations (Rotenberry et al. 2002). We used Shannon's diversity index to measure the overall heterogeneity in the landscape; elevation and slope were used to assess vertical relief (Table 3-1).

Table 3-1. Environmental variables used in Habitat Suitability Model for Indiana bats at the Buckeye Wind Power Project in Champaign County, Ohio.

Variable (abbreviation)	Unit	Description (data source)
Forest patch area (AREA_MN)[a]	ha	Mean patch area of forest (codes 41, 42, and 43 in 2001 National Land Cover Database [NLCD; Homer et al. 2004]; 30-m resolution) within 2-km buffer
Patch cohesion index (COHSN) [a]	--	Cohesion of forest patches (codes 41, 42, and 43 in 2001 NLCD) within 2-km buffer
Elevation (ELEV)	m	Elevation (30-m digital elevation model - DEM; National Elevation Dataset [Gesch et al. 2009])
Euclidean nearest neighbor (ENN_AM) [a]	m	Area-weighted mean distance to the nearest neighboring forest patch (codes 41, 42, and 43 in 2001 NLCD)
Distance to forest (FOR_D)	m	Distance to nearest forest pixel (codes 41, 42, and 43 in 2001 NLCD)
Distance to forested stream (FORSTRM_D)	m	Distance to nearest stream (high resolution linear water features; National Hydrography Dataset [Simley and Carswell 2009]) intersecting forest pixels (codes 41, 42, and 43 in 2001 NLCD)
Perimeter-area ratio (PARA_AM) [a]	--	Perimeter to area ratio (area-weighted) of forest patches (codes 41, 42, and 43 in 2001 NLCD) within 2-km buffer
Percentage of landscape (PLAND) [a]	percent	Percentage of 2-km buffer comprised of forest patches (codes 41, 42, and 43 in 2001 NLCD)
Shannon's diversity index (SHDI) [a]	--	Proportional abundance of forest patches (codes 41, 42, and 43 in 2001 NLCD) within 2 km buffer
Slope (SLP)	degrees	Slope (derived from 30-m DEM)
Distance to stream (STRM_D)	m	Distance to nearest stream (high resolution linear water features; National Hydrography Dataset [Simley and Carswell 2009])
Total core area (TCA) [a]	ha	Amount of forest (codes 41, 42, and 43 in 2001 NLCD) core area (defined by 100-m threshold from forest edge) within 2-km buffer
Distance to wetland (WET_D)	m	Distance to nearest wetland (National Wetlands Inventory [NWI] updated by Ducks Unlimited [2009])

[a] Analyzed using FRAGSTATS (McGarigal et al. 2002)

3.2 Presence Data Set

The ODNR provided Stantec with values of environmental variables measured at each of the 43 identified Indiana bat roost trees and 1,124 telemetry points used in the model. Field methods used to derive these data varied and were conducted by multiple environmental consultants during 2008 and 2009. We prepared predictive models for foraging telemetry and roost tree data set separately for the following reasons:

1. Sample size was significantly larger for the telemetry dataset.

2. While roost trees can occur in foraging habitat, not all foraging occurs in roosting habitat. With unequal sample sizes, a model containing both data types would not properly identify potential roosting habitat.
3. There was disparity in the level of accuracy associated with roost and telemetry locations. Error is an inherent part of telemetry data and no consistent error estimation method was applied to telemetry data. However, there is much less or no error associated with roost tree locations because the presence of the tree is confirmed based on visual confirmation of the emerging radio-tagged bat.

3.3 Standard and Partitioned Mahalanobis D² Models

The standard Mahalanobis D^2 method measures the spatial distance between a vector of environmental variables measured at unsampled locations and the mean vector of the same environmental variables derived from all occupied locations (Clark et al. 1993a, Dunn and Duncan 2000, Rotenberry et al. 2002, Browning et al. 2005, Rotenberry et al. 2006). This distance is measured as (Rotenberry et al. 2002):

$$D^2(\boldsymbol{y}) = (\boldsymbol{y} - \boldsymbol{\mu})' \boldsymbol{\Sigma}^{-1} (\boldsymbol{y} - \boldsymbol{\mu})$$

where

H = a matrix of *p* variables measured at *n* points where a species was detected;
$\boldsymbol{y}$ = a p X 1 vector of measurements on any point (occupied or unsampled);
$\boldsymbol{\mu}$ = a p X 1 vector of mean measurements derived from **H;**
$\boldsymbol{y} - \boldsymbol{\mu}$ = a vector of deviations between a point and the mean vector;
$\boldsymbol{\Sigma}^{-1}$ = the inverse of the variance-covariance matrix of **H;**
D^2 = the squared standardized distance.

Thus, any location can be defined by its distance from the average environmental conditions associated with occupied Indiana bat habitat. As the distance between the vector at a location and the mean vector increases, the habitat at the location becomes less suitable.

This measurement of a standard D^2 assumes that **H**, the matrix derived from occupied locations, includes the full range of habitat variation in which the species can be found and that no unnecessary variables are included (Rotenberry et al. 2002, Browning et al. 2005, Rotenberry et al. 2006). In essence, we assume that **H** represents an optimum range of habitat configurations. These assumptions are not violated when the landscape from which **H** was derived is the same landscape where suitability is to be estimated (Rotenberry et al. 2002). However, these assumptions are often violated when the model is applied to areas not included in the original sample, or in changing landscapes (Rotenberry et al. 2002). It is also possible to violate the assumptions of the model if the selected environmental conditions are not truly representative of variables that influence species presence.

The standard D^2 model considers all habitat characteristics equally and limits suitability based on the average values of each variable in the model; it compares all points in a landscape to an *optimum* set of conditions. However, within a group of occupied sites, some environmental measures may remain relatively constant across all locations, while other measures are highly variable. Characteristics that are highly variable are less likely to be informative because they seemingly do not restrict species distribution in any way. Conversely, characteristics that are relatively constant across occupied sites presumably indicate features that are important to the species (Rotenberry et al. 2002, Rotenberry et al. 2006).

Rotenberry et al. (2002) presented a partitioned Mahalanobis D^2 model as an alternative to the standard Mahalanobis D^2 model. The partitioned D^2 model gives more weight to those characteristics that are constant across occupied sites, while allowing variation to occur for the remaining variables; it compares all points in a landscape to a basic, or *minimum* set of habitat requirements. Characteristics which are constant across occupied sites are thought to be more limiting to a species distribution and thus more informative (Rotenberry et al. 2002). Instead of measuring the distance between the vector at an unsampled location and the mean vector, as in the standard D^2 method, the partitioned D^2 distance is measured to a vector of minimum habitat characteristics, which restricts variability for important variables and allows flexibility for the remaining, less important variables.

For a species to occur at a given location (or point), the partitioned D^2 model assumes that the values of some combination of a subset of environmental variables measured at that point satisfies the basic requirements for the species. Using a principal components analysis (PCA), the standard D^2 distance can be partitioned into separate components, each explaining an incrementally smaller amount of variability in the model (Rotenberry et al. 2002):

$$D^2(\boldsymbol{y}) = d_j^2/\lambda_j + \ldots + d_k^2/\lambda_k + \ldots + d_p^2/\lambda_p$$

where

d_j = the difference between a point and the mean vector $(\boldsymbol{y} - \boldsymbol{\mu})$ multiplied by the eigenvector associated with the *jth* component; and

λ_j = the eigenvalue associated with the *jth* component.

The number of components produced by the PCA is equal to *p*, the total number of variables used in the model. Each component contains a vector of coefficients ("eigenvector"). The number of coefficients in each eigenvector is also equal to *p*, the total number of variables used in the model; thus, the sum ("linear combination") of each coefficient in the eigenvector multiplied by the value of its corresponding environmental variable measured at that location will return a partial D^2 distance. Within each component, the absolute value of each coefficient ("eigenvector values") indicates how important each variable is, with larger absolute values indicating more important variables.

In addition, each component has an associated "eigenvalue" (the amount of variability explained by the eigenvector). Each component is numbered 1 through *p*, with the first principal component ("PC 1") explaining the most variability and the last component ("PC *p*") explaining the least amount of variability. Environmental variables that are constant among occupied points, and therefore are assumed to represent basic habitat requirements, are emphasized in the last components (those explaining the least amount of variability). These variables will have the largest eigenvector values in components with the smallest eigenvalues. Environmental variables that exhibit a wide range of variability across occupied points are emphasized in the first components with the largest eigenvalues; i.e., they have the largest eigenvector values in components with the largest eigenvalues.

The partitioned distances are additive with the sum of all components equal to the standard D^2 measurement (Rotenberry et al. 2006). However, for the partitioned D^2 model, only a subset (or *k*, where $1 \leq k \leq p$) of components with the smallest eigenvalues are included in the sum, such that the predicted suitability emphasizes the most important (i.e., most constant) variables within each included component. Including only the components with the smallest eigenvalues (those explaining the least amount of variability) allows for less important variables to be included in the model, but have only a minimal effect on the prediction of suitable habitat (Rotenberry et al. 2002, Rotenberry et al. 2006).

D^2 values can range from zero to near infinity, and therefore are difficult to interpret. However, a D^2 distribution approximates a chi-squared (χ^2) distribution, and can therefore be scaled to range between 0 and 1(Rotenberry et al. 2002):

$$\text{p-value for } D^2(\boldsymbol{y};\boldsymbol{k}) = 1 - \text{prob}\left(\chi^2_{(\mathrm{p}+1-\mathrm{k})}\right)$$

Resulting "p-values" can be interpreted as the probability that a given location represents suitable habitat, with a value of 1 representing environmental conditions identical to those measured at occupied sites.

3.4 Model Development

We conducted a PCA on the correlation matrix derived from p = 13 possible environmental variables (Table 3-1) measured at telemetry (n = 1,124) and roosting (n = 43) locations. We used SAS procedure PRINCOMP (SAS Institute Inc., Cary, North Carolina) to generate eigenvalues and eigenvectors. We considered variables with the highest absolute eigenvector value in the last component to be the most important habitat characteristics for each dataset (Dunn and Duncan 2000). Since a low ratio of observations to variables can result in an overfitted model (Rotenberry et al. 2006) and the roost tree dataset had a lower number of observations (n=43), we reduced the number of variables in the roosting model by selecting the top-ranking variables in the last component of the full, 13-variable model for further analysis. There is no quantitative way to determine the cut-off between important and unimportant variables (Rotenberry et al. 2006). However, there is often a demarcation between zero and nonzero eigenvector values (Dunn and Duncan 2000), which can be used to select variables by graphing the eigenvector values in the last component and noting the change in slope of the resulting line. We assumed that variables above the demarcation point were the best variables to use for the roosting habitat model.

We used SAS procedure SCORE to calculate linear combinations of the vector of environmental variables measured at each 30-m pixel in the Action Area and each eigenvector produced in the PCA. Using a SAS macro (Dunn and Duncan 2000, Rotenberry et al. 2006), we squared each linear combination and divided by the appropriate eigenvalue to calculate p partitioned D^2 distances for each pixel. Starting with the partitioned D^2 associated with the smallest eigenvalue, then the 2 smallest, then the 3 smallest, and so on, we sequentially summed partitioned D^2 values. When all partitioned D^2 values were included in the sum, the result was the standard D^2 value for the pixel. We rescaled $D^2(\boldsymbol{y};\boldsymbol{k})$ values into p-values using a χ^2distribution with $p + 1 - k$ degrees of freedom.

Choosing k, or the number of components to include in the calculation of a partitioned D^2 distance, is a subjective process (Dunn and Duncan 2000, Rotenberry et al. 2006). We assessed the magnitude and relative spacing of eigenvalues, and the success of the model in predicting areas of presence (Dunn and Duncan 2000) to choose k. We used 4 techniques for choosing k in order to create predictive maps for the telemetry and roost tree data sets:

1. All components (standard D^2 distance; the most restrictive model);
2. Only components with eigenvalues less than 1 (Rencher 2002);
3. Only components with eigenvalues below a demarcation point (Dunn and Duncan 2000); and
4. Only the last component (the least restrictive model).

Model outcomes for k components were imported into ArcMap 9.2 (Environmental Systems Research Institute, Redlands, CA). Models were evaluated based on site-specific knowledge of likely Indiana bat use of the area from mist netting surveys and Indiana bat habitat assessments conducted by Stantec in association with U.S. Fish and Wildlife Service (USFWS) biologists in the Action Area in 2008. Although Stantec was not provided with the specific locations of all roost and telemetry locations, the preparers of this document were familiar with their general locations based on ongoing consultation with the ODNR and USFWS from 2008 to 2010. Using this site-specific knowledge, we qualitatively assessed p-values at known Indiana bat locations in order to evaluate how well each model performed.

The full range of χ^2 values was converted into quartiles[2] (Meinke et al. 2009), which resulted in 4 categories that represented most to least suitable habitat for Indiana bat roosting and foraging activities. The final roosting and foraging (telemetry) models were combined into a single predictive map by retaining the highest suitability category assigned to each pixel in either predictive map when a discrepancy occurred.

Turbines were each assigned a risk category based on their location relative to the 4 habitat suitability categories in the final predictive map of the Action Area. Category 1 represented the most suitable habitat for Indiana bats, while Category 4 represented the least suitable habitat for Indiana bats during the summer maternity season.

4.0 RESULTS

4.1 Roost Tree and Foraging Locations Relative to Forested Habitat

Roosts were located in 21 forest stands (only 6 roost trees were not located within a forest stand), with an average patch size of 100.5 ha ± 71.8 ha (248.3 ac ± 177.4 ac]; range 4.0 ha to 197.6 ha [9.9 ac to 488.3 ac]). The average forest stand size in the general tri-county (Champaign, Logan, Hardin) area was 4.2 ha ± 13.9 ha (10.4 ac ± 34.3 ac; range 0.1 ha to 360.4 ha [0.2 ac to 890.6 ac]). Similarly, the proportion of forested habitat within the 2-km buffer area surrounding roost locations was 23% ± 8% compared to an average of 9% for the tri-county area as a whole. The majority (30 roosts or 70%) were located within 182.9 m (600 ft) of a stream, within 182.9 m (600 ft) of a wetland (74%), and within 182.9 m (600 ft) of a forest associated with a stream (70%).

All roosts, whether located within or outside a forest patch, were located within 182.9 m (600 ft) of the nearest forest stand edge. The average distance from nighttime foraging locations to a forest edge was 60 m ± 110 m (198 ft ± 361 ft), which includes foraging distances from within or beyond the forest stand (Figure 4-1). Thus, 85% of telemetry locations were <170 m (559 ft; mean + 1 SD) from a forest patch edge. All 1,124 telemetry locations were within 701 m (2,300 ft) of a forest edge.

4.2 Environmental Variables Selected

Mahalanobis D^2 distances were calculated for every 30-m pixel in the Action Area. Seven FRAGSTATS variables (AREA_MN, COHSN, ENN, PARA, PLAND, SHDI, TCA; Table 3-1) were measured across the 2-km buffer surrounding each 30-m pixel. Six additional variables summarizing distances to several landscape elements (FOR_D, FORSTRM_D, STRM_D, WET_D; Table 3-1) and topographic features (ELEV, SLP; Table 3-1) were measured for each individual pixel in the Action Area.

All 13 environmental variables listed above were used in the foraging habitat model. Since a low ratio of observations to variables leads to an overfitted model (Rotenberry et al. 2006) and the roost tree data set

[2] A quartile is one of three points that divide a data set into four equal groups, each representing a fourth of the distributed sampled population.

had only 43 roost trees, the number of variables was reduced in the roosting habitat model. We identified the most important variables by first running a PCA with all 13 variables included, and selecting those variables which were most consistent across known locations. There were 7 variables in the last component with eigenvector values above a demarcation point: AREA_MN, COHSN, ELEV, FORSTRM_D, FOR_D, SHDI, and STRM_D.

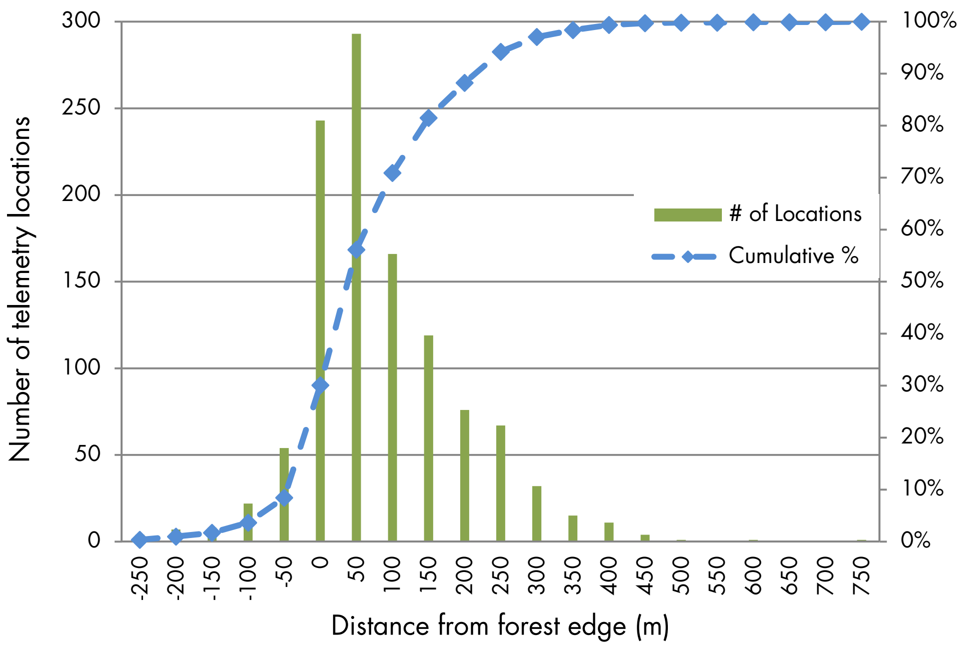


Figure 4-1. Number of telemetry locations within 50-m distance bins of the forest edge. Note negative distances indicate telemetry locations within a forest patch; positive distances inidicate locations outside of a forest patch.

4.3 Foraging Habitat Suitability Model

Results from the PCA analysis of 13 environmental variables measured at 1,124 telemetry points (Table 4-1) indicated that the first 3 principal components explained more than two-thirds (69.5%) of the total variation in the telemetry dataset (Table 4-2). The degree of forest fragmentation (PARA_AM) and the connectedness of forest patches (COHSN) were the 2 most important variables in the last component (with the highest absolute eigenvalues in the eigenvector), followed in order of importance by total core area (TCA), Shannon's diversity index (SHDI), forest patch area (AREA_MN), distance to forested stream (FORSTRM_D), percentage of landscape (PLAND), elevation (ELEV), distance to wetland (WET_D), distance to stream (STRM_D), distance to forest (FOR_D), Euclidean nearest neighbor (ENN_AM), and slope (SLP) (Table 4-3). The last 6 components (principal components [PCs] 6 through 13) had eigenvalues < 1; the same components had eigenvalues below a demarcation point (Table 4-2). We created predictive maps using PCs 1-13 ($D^2_{(k=13)}$), PCs 6-13 ($D^2_{(k=8)}$), and PC 13 ($D^2_{(k=1)}$). We selected the partitioned D^2 map using PCs 6-13 for the final foraging suitability model (Figure 4-2[3]); this model predicted high suitability at the most known roosting and foraging locations, as well as areas suspected of potential habitat.

[3] The grey area in the southwest corner of the map, that also occurs in subsequent suitability maps, is a byproduct of the spatial analysis process and results from not having data from one or more of the environmental variable data layers in that area.

Table 4-1. Mean and standard deviations (SD) for 13 environmental variables measured at 1,124 Indiana bat telemetry points in Champaign, Logan, and Hardin Counties, Ohio, 2008-2009

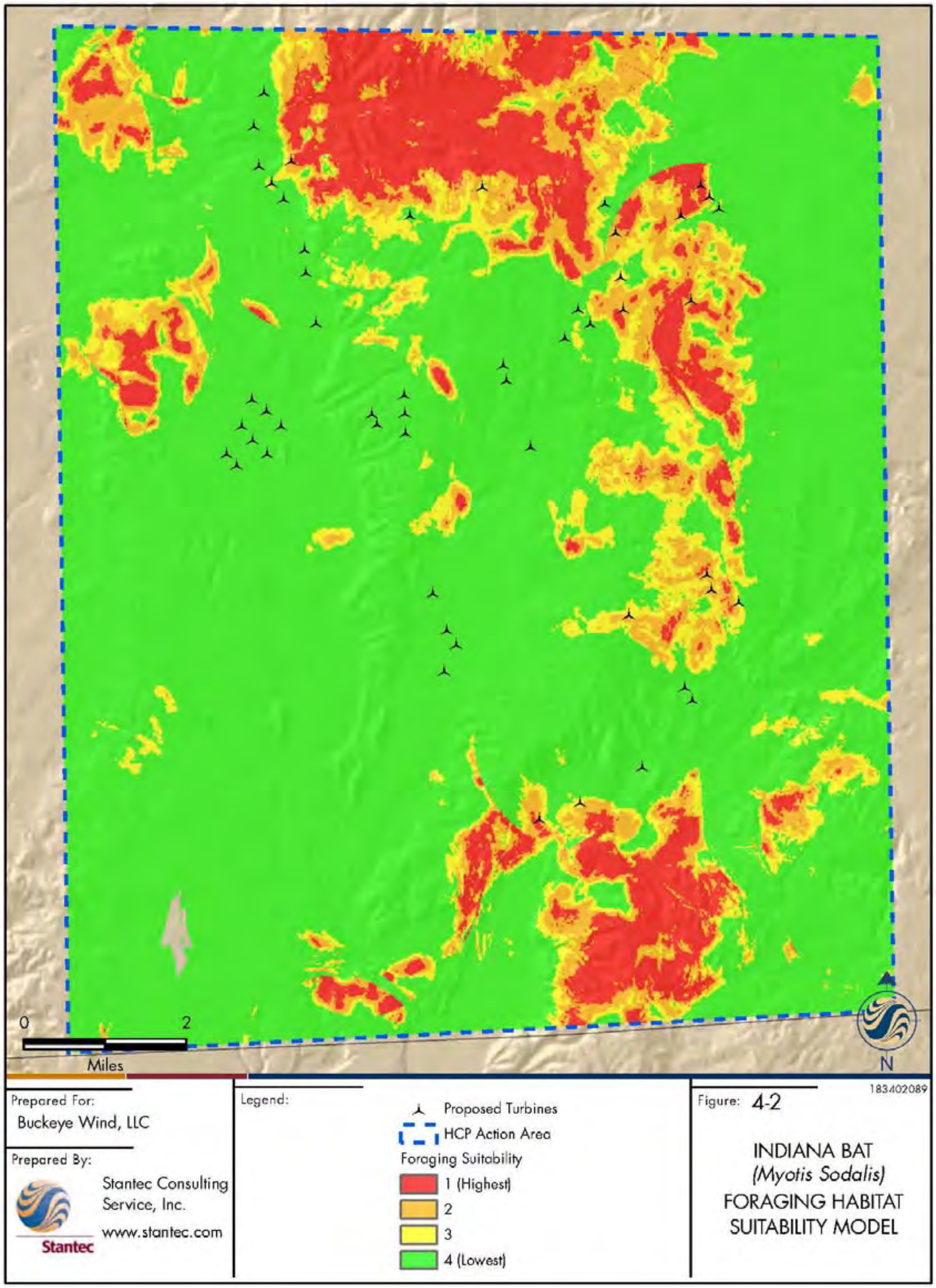
Variable	Mean	SD
Forest patch area (AREA_MN)	11.48	6.23
Patch cohesion (COHSN)	94.50	2.79
Elevation (ELEV)	376.48	29.63
Euclidean nearest neighbor (ENN_AM)	104.28	36.63
Distance to forested stream (FORSTRM_D)	295.63	216.52
Distance to forest (FOR_D)	86.80	98.26
Perimeter to area ratio (PARA)	212.46	52.78
Percentage of landscape (PLAND)	23.72	7.56
Shannon's Diversity Index (SHDI)	1.14	0.14
Slope (SLP)	2.84	2.50
Distance to stream (STRM_D)	192.64	163.59
Total core area (TCA)	66.45	48.88
Distance to wetland (WET_D)	205.40	139.55

Table 4-2. Results of principal components analysis of 13 environmental variables measured at 1,124 Indiana bat telemetry points in Champaign, Logan, and Hardin Counties, Ohio 2008-2009.

Principal Component (PC)	Eigenvalue	Proportion of total variance
13	0.026	0.002
12	0.05	0.004
11	0.076	0.006
10	0.088	0.007
9	0.221	0.017
8	0.314	0.024
7	0.396	0.03
6	0.637	0.049
5	1.035	0.08
4	1.122	0.086
3	1.42	0.109
2	2.095	0.161
1	5.522	0.425

Table 4-3. Eigenvectors for principal components 6 through 13 using 13 environmental variables measured at 1,124 Indiana bat telemetry points in Champaign, Logan, and Hardin Counties, Ohio, 2008-2009. Results for principal components 1 through 5 are not shown. Bold values indicate the most important variables.

Variable	PC 6 k 8	PC 7 k 7	PC 8 k 6	PC 9 k 5	PC 10 k 4	PC 11 k 3	PC 12 k 2	PC 13 k 1
Forest patch area (AREA_MN)	0.019	0.237	0.055	0.192	0.407	0.721	0.054	-0.133
Patch cohesion (COHSN)	0	0.091	0.007	0.168	0.489	0.18	0.332	**0.623**
Elevation (ELEV)	0.323	0.162	0.775	0.022	0.017	0.019	0.145	-0.051
Euclidean nearest neighbor (ENN_AM)	0.018	0.693	0.236	0.101	0.077	0.132	0.213	0.013
Distance to forested stream (FORSTRM_D)	0.059	0.062	0.282	0.633	0.228	0.115	0.007	0.079
Distance to forest (FOR_D)	0.657	0.029	0.104	0.359	0.031	0.038	0.01	-0.015
Perimeter to area ratio (PARA_AM)	0.023	0.131	0.112	0.101	0.451	0.109	0.046	**0.68**
Percentage of landscape (PLAND)	0.021	0.053	0.026	0.056	0.417	0.535	0.577	-0.061
Shannon's Diversity Index (SHDI)	0.032	0.565	0.006	0.118	0.318	0.077	0.015	-0.167
Slope (SLP)	0.451	0.066	0.381	0.053	0.036	0.004	0.004	-0.013
Distance to stream (STRM_D)	0.389	-0.09	-0.17	0.591	0.169	0.062	0.034	-0.034
Total core area (TCA)	0.051	0.256	0.111	0.086	0.165	0.328	0.696	**0.297**
Distance to wetland (WET_D)	0.317	0.078	0.224	0.091	0.034	0.008	0.004	-0.038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HCP Action Area
Foraging Suitability
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4 (Lowest)
Figure: 4-2
INDIANA BAT
(Myotis Sodalis)
FORAGING HABITAT
SUITABILITY MODEL

4.4 Roosting Habitat Suitability Model

Results from the PCA analysis of 7 environmental variables measured at 43 Indiana bat roost locations (Table 4-4) indicated that the first 2 principal components explained more than two-thirds (70.5%) of the total variation in the dataset (Table 4-5). The distance to forested streams (FORSTRM_D) and the distance to streams (STRM_D) were the two most important variables in the last component (with the highest absolute eigenvalues in the eigenvector), followed in order of importance by distance to forest (FOR_D), Shannon's diversity index (SHDI), forest patch area (AREA_MN), patch cohesion index (COHSN), and elevation (ELEV) (Table 4-6).

The last 4 components (PCs 4 through 7) had eigenvalues less than 1; the same components had eigenvalues below a demarcation point (Table 4-5). We created predictive maps using PCs 1-7 ($D^2_{(k=7)}$), PCs 4-7 ($D^2_{(k=4)}$), and PC 7 ($D^2_{(k=1)}$). We selected the partitioned D^2 map using PCs 4-7 for the final roosting suitability model (Figure 4-3); this model predicted high suitability at the most known roosting locations, as well as areas suspected of potential habitat.

Table 4-4. Mean and standard deviations (SD) for 7 environmental variables measured at 43 Indiana bat roosts in Champaign, Logan, and Hardin Counties, Ohio, 2008-2009.

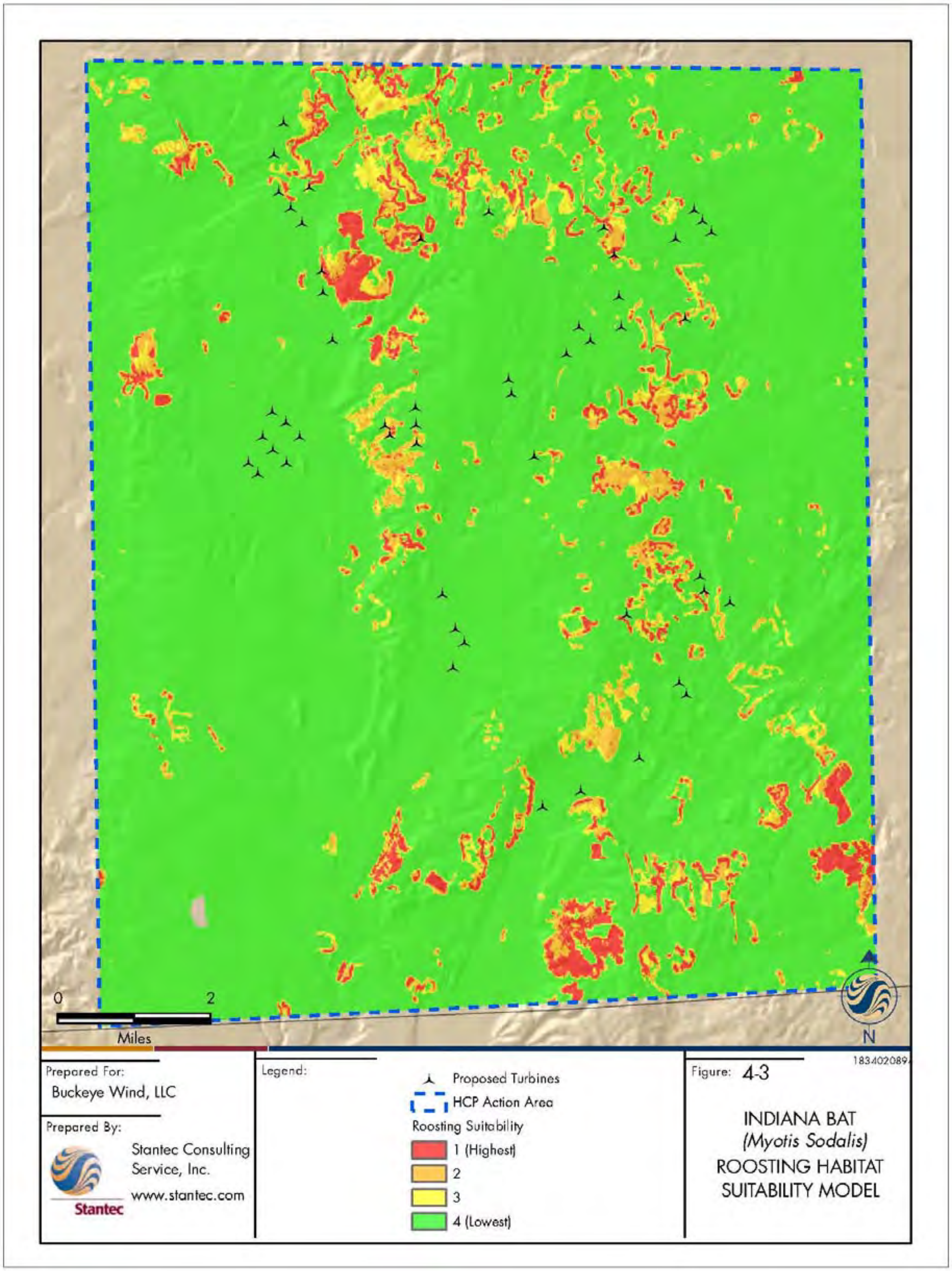
Variable	Mean	SD
Forest patch area (AREA_MN)	12.37	5.42
Patch cohesion (COHSN)	95.15	2.77
Elevation (ELEV)	362.65	29.44
Distance to forested stream (FORSTRM_D)	179.99	204.69
Distance to forest (FOR_D)	11.99	31.78
Shannon's Diversity Index (SHDI)	1.04	0.21
Distance to stream (STRM_D)	155.80	180.14

Table 4-5. Results of PCA analysis of 7 environmental variables measured at 43 Indiana bat roosts in Champaign, Logan, and Hardin Counties, Ohio, 2008-2009.

Principal Component (PC)	Eigenvalue	Proportion of total variance
7	0.008	0.001
6	0.067	0.010
5	0.304	0.043
4	0.560	0.080
3	1.127	0.161
2	1.564	0.223
1	3.371	0.482

Table 4-6. Eigenvectors for principal components 4 through 7 using 7 environmental variables measured at 43 Indiana bat telemetry points in Champaign, Logan, and Hardin Counties, Ohio, 2008-2009. Results for principal components 1 through 3 are not shown. Bold values indicate the most important variables.

Variable	PC 4 k 4	PC 5 k 3	PC 6 k 2	PC 7 k 1
Forest patch area (AREA_MN)	0.653	0.32	-0.447	-0.065
Patch cohesion (COHSN)	0.165	-0.098	0.798	0.05
Elevation (ELEV)	-0.434	0.588	-0.057	0.023
Distance to forested stream (FORSTRM_D)	0.149	-0.041	0.092	**-0.714**
Distance to forest (FOR_D)	0.561	0.143	0.23	0.088
Shannon's Diversity Index (SHDI)	-0.007	-0.712	-0.307	-0.067
Distance to stream (STRM_D)	0.147	-0.112	-0.062	**0.686**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INDIANA BAT
(Myotis Sodalis)
ROOSTING HABITAT
SUITABILITY MODEL

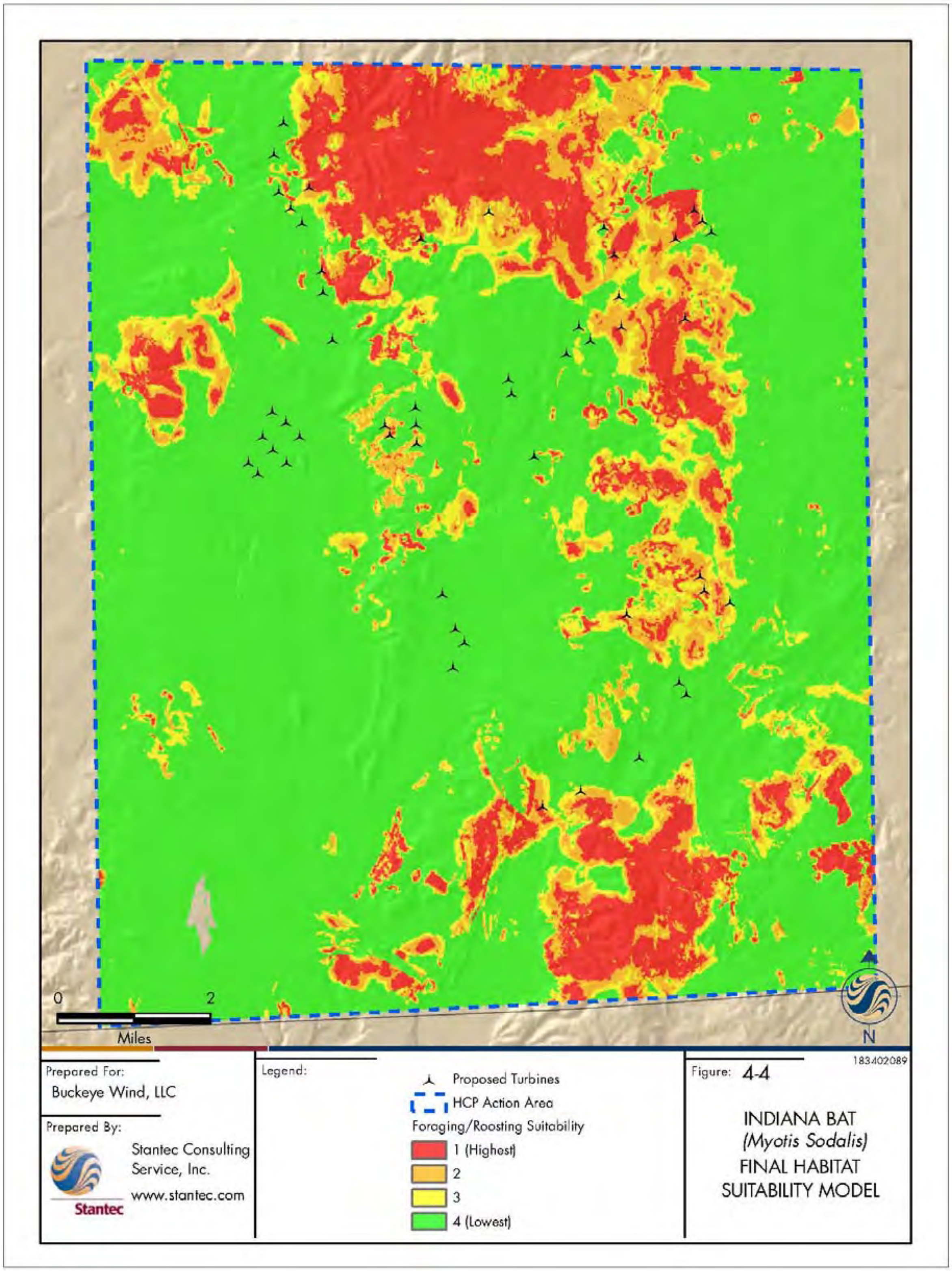
4.5 Final Habitat Suitability Model

The roosting and foraging (telemetry) models were combined into a single predictive map by retaining the highest suitability category assigned to each pixel in either predictive map when a discrepancy occurred (Figure 4-4). The roosting model classified 3% of the Action Area as having the highest roosting suitability, and the foraging model classified 10% of the Action Area as having the highest roosting suitability. While some areas ranked high for both roosting and foraging, most suitable habitat did not overlap between the two predictive maps. Therefore, when combined, 12% of the Action Area (4,016.1 ha [9,923.9 ac]) was categorized as having the highest suitability for Indiana bat roosting and foraging activities (Table 4-7).

Indiana bat foraging habitat suitability was strongly associated with the configuration and spatial relationships of forested patches; the 3 most important variables in the foraging habitat model were the degree of forest fragmentation (PARA_AM), the connectedness of forest patches (COHSN), and the total core area of forested habitat (TCA). The habitat diversity (SHDI), the amount of forested area (AREA_MN), and the distance to forested streams (FORSTRM_D) were also relatively important. This differed somewhat from roosting habitat suitability, which was driven largely by distance to forested streams (FORSTRM_D), distance to streams (STRM_D), and distance to the nearest forest edge (FOR_D), which were the 3 most important variables. Similar to foraging habitat suitability, habitat diversity (SHDI) and amount of forest area (AREA_MN) were also relatively important. When considering both foraging and roosting suitability, the spatial arrangement of forest patches, proximity to water sources, and amount of forested area were the most important habitat components.

Based on the 2001 NLCD, there are approximately 766 distinct forest patches in the Action Area[4] that average 3.6 ha ± 10.0 ha (9.0 ac ± 24.7 ac) in size and vary from 0.1 ha to 106.47 ha (0.2 ac to 263.09 ac). As reported previously, 82% of the forest patches in the Action Area were 4 ha (10 ac) or smaller and only 2% (n=13) were 40 ha (100 ac) or more. When the final Indiana bat habitat suitability map is overlaid by forest patches and streams (Figure 4-5), it is apparent that areas that were dominated by smaller (4 ha [10 ac] or less), isolated forest patches tended to be classified in the lowest habitat suitability category, while areas with relatively large forest patches (15 to 40 ha [37 to 100 ha] or more) that were in close proximity to other larger forest patches were most suitable for Indiana bats. While streams were fairly ubiquitous on the landscape, streams located in highly fragmented areas or large expanses on non-forested area were not classified as being highly suitable, while streams that intersected forested habitat were highly suitable.

[4] Excluding portions of 6 forest patches that only partially overlap the Action Area, totaling 0.4 ha (0.9 ac).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Foraging/Roosting Suitability
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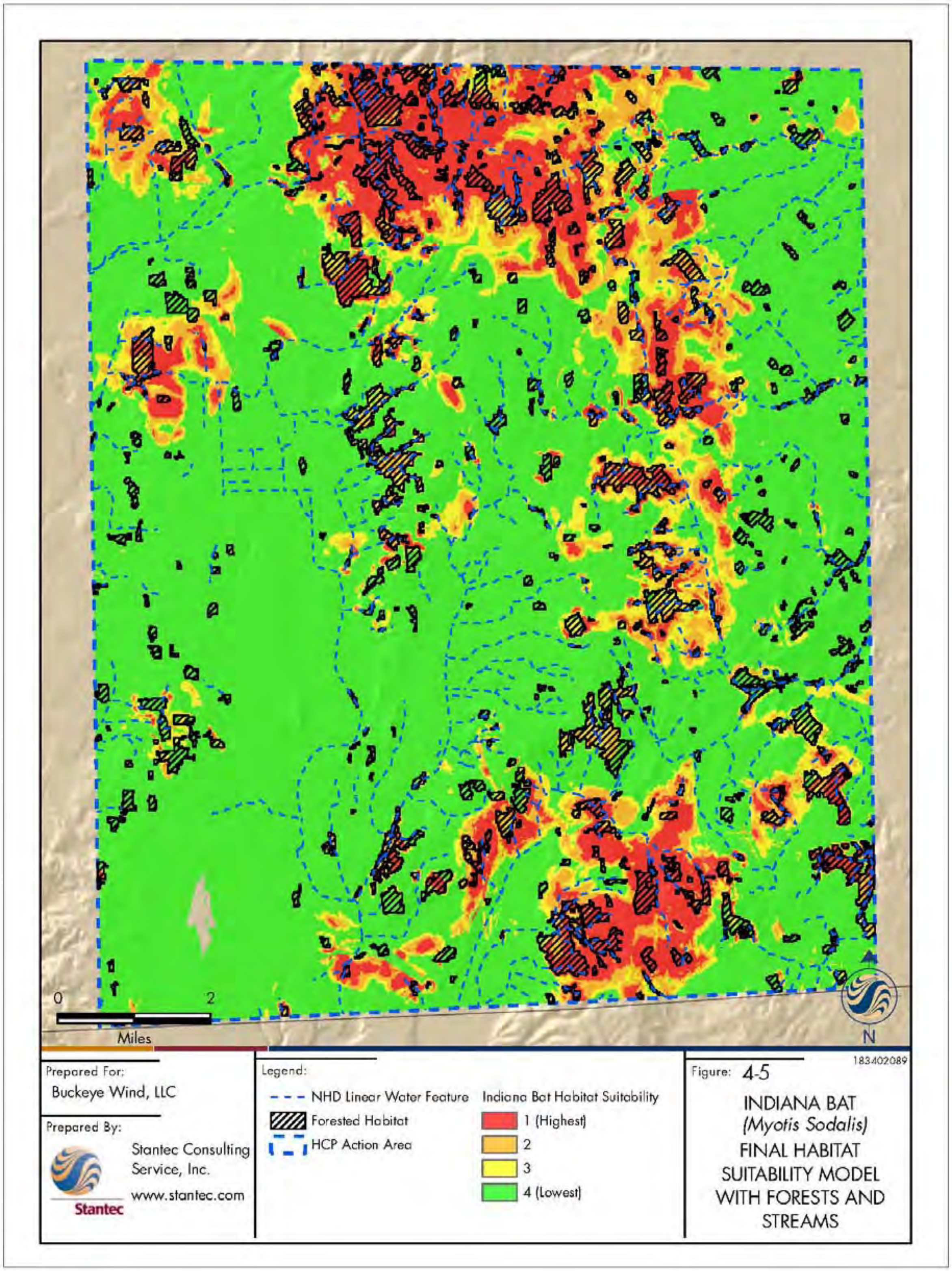
4 (Lowest)
Figure: 4-4
INDIANA BAT
(Myotis Sodalis)
FINAL HABITAT
SUITABILITY MODEL

Table 4-7. Areas classified as being most to least suitable in the roosting, foraging, and final habitat suitability models for Indiana bats in the Buckeye Wind Project Action Area.

Suitability Category	Hectares	Acres	Percent of Action Area
Roosting Habitat Suitability Model			
1 (Highest)	1,094.30	2,704.10	3%
2	1,213.90	2,999.70	4%
3	1,460.80	3,609.70	5%
4 (Lowest)	28,614.60	70,708.20	88%
Foraging Habitat Suitability Model			
1 (Highest)	3,087.50	7,629.30	10%
2	2,701.10	6,674.50	8%
3	2,631.00	6,501.30	8%
4 (Lowest)	23,932.40	59,138.30	74%
Final Habitat Suitability Model			
1 (Highest)	4,016.10	9,923.90	12%
2	2,973.90	7,348.60	9%
3	2,856.60	7,058.80	9%
4 (Lowest)	22,505.40	55,612.10	69%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Indiana Bat Habitat Suitability
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INDIANA BAT (Myotis Sodalis) FINAL HABITAT SUITABILITY MODEL WITH FORESTS AND STREAMS

5. DISCUSSION

Partitioned Mahalanobis D^2 methods allow for prediction of suitable habitat across large landscapes using environmental variables located at nearby Indiana bat roosting and foraging locations. A larger area of suitable foraging habitat was identified than roosting habitat, which was not unexpected given that foraging areas typically extend over greater areas than those in which roost trees are located. This may also be associated to some extent with greater location error associated with telemetry points compared with roost tree locations. A larger area was included in the combined final habitat suitability map, indicating that not all areas of suitable habitat for roosting and foraging overlapped. This combined model therefore represents the maximal estimate of suitable Indiana bat habitat within the Action Area.

Similar to other studies of Indiana bat habitat use during summer foraging and commuting activities (Humphrey et al. 1977, LaVal et al. 1977, Brack 1983, Garner and Garner 1992, Carter 2003), telemetry data collected in the tri-county area indicated that Indiana bats used areas that could be characterized as closed to semi-open forested habitats and forest edges. These findings are consistent with other studies in fragmented habitats that have shown Indiana bats use forest edges, hedge rows, and other features on the landscape that provide cover as travel corridors between foraging areas and roosts (Gardner et al. 1991b, Kurta et al. 2002, Carter 2003, Murray and Kurta 2004, Kurta 2005, Winhold et al. 2005).

Spatial configuration of forested habitat has not been addressed in previous predictive Indiana bat habitat suitability models for the midwest (Rommé et al 2005, Farmer et al. 2002, Rittenhouse et al. 2007). Our model emphasized spatial pattern of forested habitat, rather than fine scale attributes such as roost tree dbh and canopy closure that are difficult to accurately estimate over large areas. Indiana bat foraging habitat suitability was most strongly associated with the spatial arrangement of forested areas including fragmentation, connectedness of forest patches, and the amount of forest core area. This makes sense, given that other studies have shown that Indiana bats typically do not cross large, open areas and instead follow tree lines or other linear habitat features that provide protective cover. For example, Murray and Kurta (2004) found that bats increased their commuting distance by 55% to follow tree-lined paths rather than flying over large agricultural fields, some of which were at least 1 km (0.6 mi) wide. Further studies by Kurta (2005) and Winhold et al. (2005) found that this colony used the same wooded fenceline as a commuting corridor that connected forested areas situated in largely agricultural area for at least 9 years.

Carter (2003) found that Indiana bat roost selection in southern Illinois in a large, open swamp was dependent on roost tree proximity to the forest edge. Indiana bats rarely used trees more than 50 m (164 ft) from the forest edge and once bats emerged at dusk, they flew directly into the forest and were not seen flying in the more open portion of the swamp (Carter 2003). Two radio telemetry studies in IL and IN assessed the types of habitats used by adult females while foraging compared to available habitat. Floodplain forest was the most preferred habitat in IL (Gardner et al. 1991*b*, Garner and Gardner 1992), and woodlots were used more often than other available habitats in IN (Sparks 2003; Sparks et al. 2005*a*, 2005*b*). Although it was difficult to document due to the errors inherent in conducting radio telemetry on a rapidly moving species, it appeared that bats likely were foraging most often along forest-field edges rather than in the interior of fields when they used open habitats (Sparks et al. 2005*b*). While visual observations suggest that foraging over open fields or bodies of water more than 50 m (150 ft) from a forest edge does occur, it appears to be less common than foraging within forested sites or along edges (Brack 1983, Menzel et al. 2001).

These findings are consistent with distances between roost tree and telemetry locations recorded for the 17 radio-tagged bats in this study (i.e., 85% of telemetry locations were <170 m (559 ft) from a forest edge). It is important to note that features such as a tree-lined hedgerow often do not show up as a forested pixel on a land cover spatial layer, and therefore a bat located at this spot would not be recognized as foraging at a forest edge; rather, it would be deemed some distance from the nearest forest patch. Furthermore, we did not have information on triangulation error, which also may have skewed the measured distances to forest edges.

While distance to forest edge was one of the three most important variables in the roosting suitability model, proximity to streams was most important. Water is important as a drinking source as well as for the insect populations found in and near water sources, both important elements in meeting the energetic demands of pregnant and nursing females with dependant young (Kurta 2001). Insectivorous bats typically obtain 20% to 26% of their daily water from drinking (Kurta et al. 1989, 1990). Trees used by an Indiana bat maternity colony in Illinois were closer to intermittent streams than to perennial streams, although no comparison was made with randomly selected points (Gardner et al. 1991b). In Michigan, Indiana bat roost trees were closer to perennial streams than random locations, but there was no difference between roosts and random points in distance to lakes/ponds (Kurta et al. 2002).

Although Indiana bat roosting suitability was strongly associated with proximity to forested streams and streams, neither suitable roosting or foraging habitat were strongly associated with proximity to wetlands identified by the NWI, which included several small ponds in the Action Area. The extent to which proximity to water features affects selection of roosting habitat is likely related to the availability of water within the larger landscape. Water sources tend to be ubiquitous in areas where Indiana bat maternity roosts have been found (Kurta 2001). This was also true for the Buckeye Action Area. Although distance to water features such as wetlands and ponds may not play a large role in day-to-day roost selection in areas where water is not limiting, it may influence habitat suitability for maternity colonies on a broader, landscape level (Carter et al. 2002). Further, not all wetland types may be useful as water sources, and an analysis which included separate variables for various wetland types may have resulted in higher importance for some types. However, we were limited by a small sample size and therefore could not increase the number of variables in the model without risking overfitting the model.

Some studies have also found roosts located in closer proximity to unpaved roads than paved roads (Gardner et al. 1991). Our roosting model did not address distance to roads. However, since our model accounted for the shape and configuration of forest habitat, which is largely influenced by road corridors in fragmented habitats such as the Action Area, many of our variables, such as the perimeter to area ratio of forest patches, likely captured important features related to road corridors.

Like all wildlife, Indiana bats require food, water, and shelter during the active portion of their annual cycle and the conditions at foraging areas, which provide food and water, and at roost trees, which provide shelter, are of interest when predicting the suitability of unsampled habitat. Indiana bats are opportunistic foragers, feeding on a variety of small insects. The diet of Indiana bats varies depending upon habitat, geographic location, season, sex, and age of the foraging bat (Belwood 1979, Brack and LaVal 1985, Kurta and Whitaker 1998; Murray and Kurta, 2002). Diets of Indiana bats may also vary from year to year within the same colony, and bats may take advantage or be "selectively opportunistic" when other types of insects are plentiful (Murray and Kurta 2002). The ephemeral nature of insect populations and the variation in Indiana bat diet make food requirements a difficult factor to include in a static, remotely developed habitat suitability model. However, a relationship exists between land cover types and the insects that inhabit them, and it is likely that a diversity of land cover is ideal, providing a continuous supply of asynchronously emerging insects throughout the summer months (Farmer et al. 2002). Thus, prey availability was indirectly assessed by including a measure of land cover diversity (SHDI) in the predictive model. SHDI was only moderately important in both the roosting and foraging models, indicating that other conditions such as the configuration of forest patches and water availability were more important in predicting suitability.

Although we were not able to incorporate measures of roost tree suitability and density in the Action Area, our model highlights areas that contain the same stand-level conditions as those found at identified roost trees. Like every statistical model, we are limited by the scale at which modeling occurs: for example, if a large forest patch is devoid of suitable roost trees, then it will be unsuitable for roosting. However, we felt that this model was the best way to balance the needs of using empirical data collected nearby to make suitability assessments across a large area. Furthermore, our model provides strong support for the importance of the spatial configuration of forested habitat. In areas where suitable roost trees are not limiting, landscape features such as fragmentation and the connectedness of forest patches may be as important or more important as other fine-scale differences in roost tree characteristics.

6. REFERENCES CITED

Belwood, J. J. 1979. Feeding ecology of an Indiana bat community with emphasis on the endangered Indiana bat, *Myotis sodalis*. Thesis, University of Florida, Gainesville, USA.

Brack, V., Jr. 1983. The nonhibernating ecology of bats in Indiana with emphasis on the endangered Indiana bat, *Myotis sodalis*. Dissertation, Purdue University, West Lafayette, USA.

Brack, V., Jr. and R.K. LaVal. 1985. Food habits of the Indiana bat in Missouri. Journal of Mammalogy 66:308-315.

Browning , D. M., S. J. Beaupre, and L. Duncan. 2005. Using partitioned Mahalanobis $D^2(K)$ to formulate a GIS-based model of timber rattlesnake hibernacula. Journal of Wildlife Management 69:33-44.

Callahan, E. V. 1993. Indiana bat summer habitat requirements. Thesis, University of Missouri, Columbia, USA.

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

Carter, T. C. 2003. Summer habitat use of roost trees by the endangered Indiana bat (*Myotis sodalis*) in the Shawnee National Forest of southern Illinois. Dissertation, Southern Illinois University, Carbondale, USA.

Carter, T. C. 2004. Summer Habitat Assessment. Pages 81-86 *in* K. C. Vories and A. Harrington, editors. Proceedings of Indiana Bat & Coal Mining: A Technical Interactive Forum. Coal Research Center, Southern Illinois University, Carbondale, Illinois, USA and Office of Surface Mining, Alton, Illinois, USA.

Carter, T. C, S. K. Carroll, J. E. Hofmann, J. E. Gardner, and G. A. Feldhamer. 2002. Landscape analysis of roosting habitat in Illinois. Pages 160-164 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Clark, J. D., J. E. Dunn, and K. G. Smith. 1993a. A multivariate model of female black bear habitat use for a geographic information system. Journal of Wildlife Management 57:519-526.

Clark, J. D., K. G. Smith, and J. E. Dunn. 1993b. Modeling wildlife habitat requirements from environmental radiotelemetry data using GIS. Pages 523-528 *in* GIS '93 Symposium, February 1993, Vancouver, British Columbia, Canada.

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, USA.

Corsi, F., E. Pupre, and L. Boitani. 1999. A large-scale model of wolf distribution in Italy for conservation planning. Conservation Biology 13:150–159.

Duncan, L. and J. E. Dunn. 2001. Partitioned Mahalanobis D^2 to improve GIS classification. Paper 198-26, Proceedings SAS Users Group International No. 26. SAS Institute, Cary, North Carolina, USA.

Ducks Unlimited. 2009. Updating the National Wetlands Inventory (NWI) for Ohio Final Report Submitted to: Ohio Department of Natural Resources. Great Lakes/ Atlantic Regional Office. Ann Arbor, Michigan. USA. <http://www.ducks.org/Conservation/GLARO/3822/ GISNWIData.html#oh>. Accessed January 2010.

Dunn, J. E. and L. Duncan. 2000. Partitioning Mahalanobis D^2 to improve GIS classification. Pages 195-204 *in* C. A. Brebbia and P. Pascolo, editors. Management Information Systems 2000: GIS and Remote Sensing. WIT Press, Boston, USA.

Farmer, A. H., B. S. Cade, and D. F. Staufer. 2002. Evaluation of a habitat suitability index model. Pages 172-179 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: biology and management of an endangered species. Bat Conservation International, Austin, USA.

Gesch, D., Evans, G., Mauck, J., Hutchinson, J., Carswell Jr., W.J., 2009, The National Map—Elevation: U.S. Geological Survey Fact Sheet 2009-3053, 4 p.

Gardner, J. E., J. D. Garner, and J. E. Hofmann. 1991. Summer roost selection and roosting behavior of *Myotis sodalis* (Indiana bat) in Illinois. Indiana/Gray bat Recovery Team Meeting, Columbia, USA.

Garner, J. D. and J. E. Gardner. 1992. Determination of summer distribution and habitat utilization of the Indiana bat (*Myotis sodalis)* in Illinois. Illinois Department of Conservation Project E-3, Springfield, USA.

Homer, C. C. Huang, L. Yang, B. Wylie and M. Coan. 2004. Development of a 2001 National Land Cover Database for the United States. Photogrammetric Engineering and Remote Sensing 70:829-840.

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

Knick, S. T. and D. L. Dyer. 1997. Distribution of black-tailed jackrabbit habitat determined by GIS in southwestern Idaho. Journal of Wildlife Management 61:75-85.

Knick, S. T. and J. T. Rotenberry. 1998. Spatial distribution of breeding passerine bird habitats in a shrubsteppe region of southwestern Idaho. Studies in Avian Biology 19:104-111.

Kurta, A. 2001. Bats on the surface: The need for shelter, food, and water. Pages 197-204 *in* K. C. Vories and D. Throgmorton, editors. Bat Conservation and Mining. Office of Surface Mining, U. S. Department of the Interior, Alton, Illinois, USA.

Kurta, A. 2005. Roosting ecology and behavior of Indiana bats (*Myotis sodalis*,) in summer. Pages 29-42 *in* K.C. Vories and A. Harrington, editors. The Indiana bat and coal mining. Office of Surface Mining, U. S. Department of the Interior, Alton, Illinois, USA.

Kurta, A. and J. O. Whitaker, Jr. 1998. Diet of the endangered Indiana bat (*Myotis sodalis*) on the northern edge of its range. American Midland Naturalist 140:280-286.

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

McGarigal K, S. A. Cushman, M. C. Neel, and E. Ene. 2002. FRAGSTATS: Spatial pattern analysis program for categorical maps. University of Massachusetts, Amherst, USA. <www.umass.edu/landeco/research/fragstats/fragstats.html>. Accessed February 2010.

Meinke, C. W., S. T. Knick, and D. A. Pyke. 2009. A spatial model to prioritize sagebrush landscapes in the intermountain west (U.S.A.) for restoration. Restoration Ecology 17:652-659.

Menzel, M. A., J. M. Menzel, T. C. Carter, W. M. Ford, and J. W. Edwards. 2001 Review of the forest habitat relationships of the Indiana bat (*Myotis sodalis*). U.S. Department of Agriculture, Forest Service, General Technical Report NE-284, Newton, Pennsylvania, USA.

Miller, N. E., R. D. Drobney, R. L. Clawson, and E. V. Callahan. 2002. Summer habitat in northern Missouri. Pages 165-171 *in* A. Kurta and J. Kennedy, editors. The Indiana bat: Biology and Management of an Endangered Species, Bat Conservation International, Austin, Texas, USA.

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

Nixon, A. E., J.C. Gruver, R.M. Barclay. 2009. Spatial and temporal patterns of roost use by western long-eared bats (*Myotis evotis*). The American Midland Naturalist 162(1):139-147. 2009

Rencher, A. C. 2002. Methods of multivariate analysis. Second edition. John Wiley and Sons, New York, USA.

Rittenhouse, C. D., W. D. Dijak, F. R. Thompason, III, J.J. Millspaugh. 2007. Development of landscape-level habitat suitability models for ten wildlife species in the central hardwoods region. General Technical Report NRS-4. United States Forest Service, Northern Research Station, Newton Square, Pennsylvania, USA.

Romme, R.C., K. Tyrell, and V. Brack, Jr. 1995. Literature summary and Habitat Suitability Index model: components of summer habitat for the Indiana bat, *Myotis sodalis*. Indiana Department of Natural Resources, Bloomington, Indiana, USA.

Rotenberry, J. T., S. Knick, and J. E. Dunn. 2002. A minimalist approach to mapping species' habitat: Pearson's planes of closest fit. Pages 281-289 *in* J. M. Scott, P. J. Heglund, and M. L. Morrison, editors. Predicting species occurrences: Issues of accuracy and scale. Island Press, Washington, D.C., USA.

Rotenberry, J. T., K. L. Preston, and S.T. Knick. 2006. GIS-based niche modeling for mapping species' habitat. Ecology 87:1458–1464.

Simley, J.D., and W.J. Carswell Jr. 2009, The National Map—Hydrography: U.S. Geological Survey Fact Sheet 2009-3054, 4 p.

U.S. Fish and Wildlife Service [USFWS]. 1983. Recovery Plan for the Indiana Bat. Washington, D.C., USA.

U.S. Fish and Wildlife Service [USFWS]. 1999. Agency Draft Indiana Bat (*Myotis sodalis*) Revised Recovery Plan. Fort Snelling, Minnesota, USA.

Watrous, K. S., T. M. Donovan, R. M. Mickey, S. R. Darling, A. C. Hicks and S. L. Von Oettingen. 2006. Predicting minimum habitat characteristics for the Indiana bat in the Champlain Valley. Journal of Wildlife Management 70:1228-1237.

Appendix C

USFWS Template Language to be Included in Easement and Fee Simple Conveyances

APPENDIX C

USFWS TEMPLATE LANGUAGE
TO BE INCLUDED IN EASEMENT AND FEE SIMPLE CONVEYANCES

Real property deeds, transfers, and conservation easements take a variety of forms. To provide uniformity and consistency when implementing the Habitat Conservation Plan and Incidental Take Permit (HCP/ITP) mitigation requirements, this Template presents the legal text to be included when drafting those conveyance documents. Where indicated, there may be flexibility in terms of the language used or the content of a particular provision.

This Template reflects the organization and content of a standard conveyance document in that it includes recitals, purpose, rights, interpretation and miscellaneous provisions. Restrictions on uses and reserved rights appear at the end.

****

The following legal recitals must be included in any legal document conveying a real property interest over conservation lands. Due to variations in state law and the type of conveyance that may be used, and the preferences of the parties as to the format of their documentation, the wording of these recitals may need to change, but must remain substantially similar in content. The parties are entitled to include other recitals that are not contradictory.

RECITALS

WHEREAS, this _____________ [insert type of conveyance] is conveyed this _______ day of _______, from _______ [name], a _______ [description of entity], Grantor, with an address of_______, to _______ [name], a _______ [description of entity], Grantee, with an address of _______; and

WHEREAS, the Grantor is [the owner in fee simple of][current holder of an easement or lease, over, through and across] certain real property, hereinafter called the "Protected Property," which has ecological, scientific, educational and aesthetic value in its present state as a natural area which has not been subject to development or exploitation [or describe status with respect to development or exploitation] , which property is located in _______ and is more particularly described in Exhibit A, attached hereto and incorporated by this reference; and

(If applicable) WHEREAS, the Grantee, is a nonprofit corporation incorporated under the laws of [State, Commonwealth, or District] as a tax-exempt public charity under Section 501(c)(3) and/or 509(a)(1) of the Internal Revenue Code of 1986, as amended, and the regulations promulgated pursuant thereto (“IRC”); Grantee, whose purpose is to preserve natural areas for scientific, charitable, educational and aesthetic purposes, is qualified under section 170(h) of the IRC to receive qualified conservation contributions; and

APPENDIX C

(If applicable) WHEREAS, the Protected Property is a significant natural area which qualifies as a "...relatively natural habitat of fish, wildlife, or plants, or similar ecosystem," as that phrase is used in P.L. 96-541, 26 USC 170(h)(4)(A)(ii), as amended, and in regulations promulgated thereunder; specifically, the Protected Property is habitat for the _______ [ESA listed species for which mitigation is required]; and

WHEREAS, the Protected Property consists of _______ [general description of habitat] and conservation of the Protected Property will protect and enhance _______ [describe habitat values to be conserved], particularly as it relates to the [ESA listed species] with regard to _______ [discuss species needs and behaviors (e.g., breeding, feeding, sheltering, migration, etc.]; the Protected Property's_______ [describe habitat values] provides [or will provide] suitable ______ habitat for the_______ [ESA listed species]; and

WHEREAS, the United States Fish and Wildlife Service (the "USFWS") within the United States Department of the Interior, is authorized by federal law to administer the federal Endangered Species Act (hereinafter "ESA"), 16 U.S.C. § 1531 et seq., and other laws and regulations; and

WHEREAS, the _______ [ESA listed species] has been listed as _______ [insert species listing status; e.g., endangered or threatened] by the USFWS under the ESA; and

WHEREAS, ______ applied to the USFWS for the issuance of an Incidental Take Permit (the "ITP"), submitted a Habitat Conservation Plan ("HCP") pursuant to ESA Section 10 regarding its ______________, and was issued an ITP on _______ [insert date]; and

WHEREAS, ______ is required to mitigate for take of ESA listed species, including _______ [species to be conserved through this conveyance], in a manner and amount consistent with the terms of its HCP, and intends to accomplish said mitigation through acquisition and permanent preservation of the Protected Property, and implementation of mitigation measures on the Protected Property, if necessary; and

WHEREAS, the specific conservation values of the Protected Property are documented in an Easement Documentation Report, prepared by _______ [insert name of entity preparing report] and signed and acknowledged by the Grantor, establishing the baseline condition of the Protected Property at the time of this grant and including reports, maps, photographs, and other documentation; and

WHEREAS, the Grantor and Grantee have the common purpose of conserving the above-described conservation values of the Protected Property in perpetuity; and

[If through a conservation easement] WHEREAS, the State [or Commonwealth] of _______has authorized the creation of Conservation Easements pursuant to _______ [insert citation to state law] and Grantor and Grantee wish to avail themselves of the provisions of that law;

NOW, THEREFORE, the Grantor, for and in consideration of the facts above recited and of the mutual covenants, terms, conditions and restrictions herein contained and as an absolute and unconditional gift [or consideration of $1], does hereby give, grant, bargain, sell and convey unto the Grantee, a _______ [insert type of conveyance] in perpetuity over the Protected Property of the nature and character and to the extent hereinafter set forth.

****

The following provisions should be incorporated in their entirety. Any deviation must be both substantially similar and approved by U.S. Fish and Wildlife USFWS, in consultation with its Solicitor, prior to execution and recording.

PURPOSE

It is the primary purpose of this _______ [insert type of conveyance] to assure that the Protected Property will be retained forever in its _______[insert type of habitat] as suitable for the_______ [insert ESA listed species], irrespective of the federal listing status of the species; *[**optional, depending on Grantor interest:** and also to the extent consistent with the primary purpose, to protect any other rare plants, animals, or plant communities on the Protected Property, and to ensure the Protected Property remains permanently in a natural, scenic and _____ [describe habitat , e.g., forested, etc.] condition*; and to prevent any use of the Protected Property that will significantly impair or interfere with the conservation values or interests of the Protected Property described above. Grantor intends that this _______ [insert type of conveyance] will confine the use of the Protected Property to such activities as are consistent with the purpose of this _______ [insert type of conveyance].

THE USFWS AS THIRD-PARTY BENEFICIARY: ENFORCEMENT AND REMEDIES

1. The parties hereto agree that, because of the USFWS's duties and powers arising under the ESA and consistent with _________'s commitments to its HCP and ITP, the USFWS has a clear and substantive interest in the preservation and enforcement of this_______ [insert type of conveyance]. Therefore, the parties grant to the USFWS, its agents, successors and assigns, the rights and standing to be noticed, to enter the Protected Property, to approve or disapprove requests, and to enforce this _______ [insert type of conveyance] as described in this section and according to its terms.

2. Grantor or Grantee, as appropriate, shall notify the USFWS in writing of the names and addresses of any party to whom the Protected Property, or any part thereof, is to be granted, conveyed or otherwise transferred, said notice to be provided at or prior to the time said transfer is consummated.

3. This _______ [insert type of conveyance] does not convey a general right of access to the public, except that the USFWS, its agents, contractors, and assigns, may enter onto the Protected Property at any time upon 24 hours notice to Grantor or Grantee, as appropriate, for the purpose of conducting inspections to determine compliance with the terms contained herein, for the purpose of assessing the _______ [ESA listed species] population status and vegetative habitat suitability, in accordance with the terms of the ITP, HCP and the ESA implementing regulations at 50 C.F.R. Parts 13, Subparts C and D, or for the purpose of conducting _______ [specific management or monitoring activities] in accordance with the terms of the HCP. This right of entry does not include a right to enter any buildings on the property that serve as residences or places of business.

4. In addition to any other rights and remedies available to the USFWS at law or in equity, the USFWS shall have the right, but not the obligation to enforce this _______ [insert type of conveyance] and is entitled to exercise the same remedies available to Grantee, identified in paragraph _______ [paragraph that lists Grantee enforcement rights]. The USFWS may do so upon the written request of Grantee or if Grantee fails to enforce the_______ [insert type of conveyance]. Prior to taking any enforcement action, the USFWS shall notify Grantee in writing of its intention and shall afford Grantee a reasonable opportunity to negotiate a remedial action and settlement with Grantor or commence its own enforcement action. No failure on the part of the USFWS to enforce any term, condition, or provision hereof shall discharge or invalidate such term, condition, or provision to affect its right or that of Grantee or Grantor to enforce the same.

OTHER MANDATORY PROVISIONS

Assignment. The parties hereto recognize and agree that the benefits of this _______[insert type of conveyance] are in gross and assignable, and the Grantee hereby covenants and agrees that in the event it transfers or assigns _______ [property interest], it shall obtain written concurrence of the USFWS, and the organization receiving the interest will be a qualified organization as that term is defined in Section 170(h)(3) of the IRC (or any successor section) and the regulations promulgated thereunder, which is organized and operated primarily for one of the conservation purposes specified in Section 170(h)(4)(A) of the IRC, and Grantee further covenants and agrees that the terms of the transfer or assignment will be such that the transferee or assignee will be required to continue to carry out in perpetuity the conservation purposes which the contribution was originally intended to advance.

Subsequent Transfers. The Grantor agrees that the terms, conditions, restrictions and purposes of this grant or reference thereto will be inserted by Grantor in any subsequent deed or other legal instrument by which the Grantor divests any retained, reserved or reversionary interest and by Grantee if Grantee subsequently transfers any fee simple title or possessory interest in the Protected Property; and Grantor and Grantee further agree to notify Grantee or Grantor, as appropriate, and the USFWS of any pending transfer at least thirty (30) days in advance.

Government Permits and Approvals. The conveyance of this _______ [insert type of conveyance] by the Grantor to the Grantee does not replace, abrogate, or otherwise set aside any local, state or federal laws, requirements or restrictions applicable to the Protected Property and shall not relieve Grantor of the obligation and responsibilities to obtain any and all applicable federal, state, and local governmental permits and approvals, if necessary, to exercise Grantor's retained rights and uses of the Protected Property even if consistent with the conservation purposes of this_______ [insert type of conveyance].

Eminent Domain. Whenever all or part of the Protected Property is taken in exercise of eminent domain by public, corporate, or other authority so as to abrogate the restrictions imposed by this_______ [insert type of conveyance], the Grantor and the Grantee shall join in appropriate actions at the time of such taking to recover the full value of the taking and all incidental or direct damages resulting from the taking, which proceeds shall be divided_______ [insert method], and _______ [discuss how proceeds will be spent]. All expenses incurred by the Grantor and the Grantee in such action shall be paid out of the recovered proceeds.

Interpretation. This _______ [insert type of conveyance] shall be interpreted and performed pursuant to the laws of the State in which it is recorded, the federal Endangered Species Act, and other applicable federal laws.

Severability. If any provision in this instrument is found to be ambiguous, an interpretation consistent with the purposes of this _______ [insert type of conveyance] that would render the provision valid shall be favored over any interpretation that would render it invalid. If any provision of this _______ [insert type of conveyance] or the application thereof to any person or circumstance is found to be invalid, the remainder of the provisions of this _______ [insert type of conveyance] and the application of such provisions to persons or circumstances other than those as to which it is found to be invalid shall not be affected thereby.

Successors and Assigns. The term "Grantor" shall include the Grantor and the Grantor's successors and assigns and shall also mean the masculine, feminine, corporate, singular or plural form of the word as needed in the context of its use. The term "Grantee" shall include _______ and its successors and assigns.

Notices. Any notices, consents, approvals or other communications required in this _______ [insert type of conveyance] shall be sent by registered or certified mail to the appropriate party or its successor in interest at the following address or such address as may be hereafter specified by notice in writing:

Grantor:
Grantee:
USFWS:
[Others:]

Counterparts. The parties may execute this instrument in two or more counterparts, which shall, in the aggregate, be signed by both parties; each counterpart shall be deemed an original instrument as against any party who has signed it. In the event of any disparity between the counterparts produced, the recorded counterpart shall be controlling.

Captions. The captions herein have been inserted solely for convenience of reference and are not a part of this _______ [insert type of conveyance] and shall have no effect upon construction or interpretation.

****

Additionally, each conveyance must include provisions to address the following topics. The contents of these provisions must be negotiated by the parties. They may therefore differ considerably depending on the property, values to be conserved, and the intensity of management and monitoring required. There is no prescribed template for the following provisions. But the USFWS has recommended language it can provide the parties if desired:

Monitoring and Management;
Endowment [if applicable];
Cost and Liabilities;
Taxes;
Title;
Standing;
Extinguishment;
Merger;
Parties subject to the conveyance; and,
Grantee Rights of Entry and Enforcement [which must include, at a minimum, the right to: 1) prevent any activity on or use of the Protected Property that is inconsistent with the purpose of the conveyance and to require the restoration of such areas or features of the Protected Property that may be damaged by any inconsistent activity or use; 2) bring an action at law or equity in a court of competent jurisdiction to enforce the terms of the conveyance; 3) require the restoration of the Protected Property to its previous condition; 4) enjoin non-compliance by ex parte temporary or permanent injunction in a court of competent jurisdiction; and/or, 5) recover any damages arising from such noncompliance.]

****

Also, each conveyance *must* include the following text regarding force majeure. This text may be revised only to reflect any binding contingencies for adaptive management and changed circumstances, if any, memorialized in the HCP or ITP. But any changes must first be reviewed and approved by the USFWS in consultation with its Solicitor.

Neither absence of [ESA listed species] from the Protected Property nor a loss of or significant injury to conservation values for the _______ [ESA listed species] due to circumstances including, but without limitation, fire, flood, storm, disease, or seismic events, shall be construed to render the purpose of this ______________ [insert type of conveyance] impossible to accomplish and shall not terminate or extinguish this ____________ [insert type of conveyance] in whole or in part. In the case of loss of or significant injury to any of the conservation values for the [ESA-listed species] due to fire, flood, storm, disease, seismic events or similar circumstances, the Grantor or Grantee may, but shall not be required to, seek to undertake measures in consultation with the USFWS to restore such conservation values, subject to the terms of the HCP/ITP.

APPENDIX C

INDIANA BAT (SUMMER/SWARMING HABITAT) USE RESTRICTIONS AND RESERVED RIGHTS[1]

RESTRICTIONS

General Description	Legal Description to be included in Conveyance
No Industrial Use	No industrial activities, including but not limited to the construction or placement of buildings or parking areas, shall occur on the Protected Property
No New Residential Use	No new residential structures or appurtenances, including but not limited to the construction or placement of new homes, mobile homes or storage sheds, shall be constructed on the Protected Property.
No Commercial Use	No commercial activities shall occur on the Protected Property, except for the low impact recreational uses explicitly identified under Reserved Rights.
No Agricultural Use	No new agricultural activities that were not previously documented as part of the baseline conditions shall occur on the Protected Property, including the use of the Protected Property for cropland, waste lagoons, detention or collection ponds, or pastureland.
No Vegetative Clearing	No forestry or timbering activities shall occur on the Protected Property, except that 1) Grantee maintains the right to conduct silvicultural modifications with the intent to improve listed species habitat within the Protected Property through reforestation, afforestation or silvicultural management to improve the health of the Indiana bat habitat; and 2) limited vegetative clearing may occur as described under Reserved Rights only.
Development Rights Extinguished	No development rights which have been encumbered or extinguished by this _________ [insert type of conveyance] shall be transferred pursuant to a transferable development rights scheme or cluster development arrangement or otherwise.
No Subdivision	The Protected Property may not be divided or subdivided. Further, the Protected Property may not be divided, partitioned, nor conveyed except in its current configuration as an entity, without USFWS and Grantee's written approval. All terms and conditions of this easement will apply to each subdivided portion.

[1]USFWS acknowledges that there may be limited or extenuating circumstances that may warrant a deviation from this required boilerplate. The nature of the restrictions and consideration of allowable uses will necessarily depend on the land to be protected. Grantors or Grantees who wish to alter the language of these provisions bear the burden of demonstrating to the satisfaction of _____ and USFWS that doing so would not diminish or interfere with the conservation of Indiana bats and their habitat. Any such change(s) must be approved by USFWS in writing, after consulting with agency counsel, and prior to execution of the conveyancing document.

APPENDIX C

Appendix D

Suggested Native Tree Species for Indiana Bat Habitat and Example Native Seed Mix Species for Ground Disturbance Restoration

Suggested Native Tree Species for Indiana Bat Habitat[1]

Species Name	Scientific Name
^River Birch	*Betula nigra*
*^Eastern Cottonwood	*Populus deltoids*
^American Elm	*Ulmus Americana*
Slippery Elm	*Ulmus rubra*
^Bitternut Hickory	*Carya cordiformis*
^Shagbark Hickory	*Carya ovate*
^Shellbark Hickory	*Carya laciniosa*
Black Locust	*Robinia pseudoacacia*
^Red Maple	*Acer rubrum*
^Silver Maple	*Acer saccharinum*
Sugar Maple	*Acer saccharum*
*Black Oak	*Quercus velutina*
Post Oak	*Quercus stellate*
Red Oak	*Quercus rubra*
*Shingle Oak	*Quercus imbricaria*
*White Oak	*Quercus alba*
Sassafras	*Sassafras albidum*
*Sycamore	*Plantanus occidentalis*
*Black Willow	*Salix nigra*

^Indicates bottomland or mesic species; suitable for planting near rivers and streams

*Species most likely to survive on reclaimed mine land

[1] It is recommended that no more than 25% of the trees planted are one species. This will provide diversity necessary for wildlife habitat

Example Native Seed Mix Species for Ground Disturbance Restoration

Species Name	Scientific Name	Percentage of Mix
Little Bluestem	*Schizachyrium scoparium*	20
Switchgrass	*Panicum virgatum*	20
Indiangrass	*Sorghastrum nutans*	17
Virginia Wildrye	*Elymus viginicus*	15
Big Bluestem	*Andropogon gerardii*	10
Partridge Pea	*Chamaecrista fasciculata*	6
Beaked Panicgrass	*Panicum anceps*	5
Black-eyed Susan	*Rudbeckia hirta*	3
Fowl Bluegrass	*Poa palustris*	3
Plains Coreopsis	*Coreopsis tinctoria*	1