Determining Mitigation Needs for NiSource Natural Gas Transmission Facilities - Implementation of the Multi-Species Habitat Conservation Plan (MSHCP)

Mitigation Site Report

Indiana Bat

Section 6 Cooperative Endangered Species Conservation Fund Grant
(IDFW Subtask 2.2)
Prepared by The Conservation Fund
DECEMBER 2010

INDIANA BAT MITIGATION SITE REPORT
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Mitigation Site Report Summary

The key task of the NiSource Multi-Species Habitat Conservation Plan (MSHCP) Section 6 grant is to identify potential mitigation opportunities for take species outlined in the MSHCP. The Conservation Fund (the Fund), in consultation with the US Fish and Wildlife Service (USFWS), NiSource, and state natural resource agencies, has prepared customized mitigation site reports, organized by species that provide selection criteria and an initial list of potential mitigation project opportunities that are likely to meet the requirements outlined in the MSHCP.

Additional information on individual projects will be required at the time of mitigation need as outlined in the Mitigation Proposal Requirements section of the MSHCP. Whether a mitigation proposal can be funded will depend on a number of factors, including but not limited to the species affected, the location of the mitigation activities compared to the location of the species impacts, the cost of the mitigation proposal, whether the proposal satisfies the mitigation proposal criteria, and the scientific justification for the mitigation proposal. This species report is a helpful resource in preparing the future applications for mitigation funding and should be used in conjunction with the Decision Support Framework for Evaluating and Ranking Mitigation Sites report.

Mitigation Project Criteria

Each take species has a set of project selection criteria that will be used to help evaluate and rank potential mitigation projects. The MSHCP currently includes nine take species where potential mitigation projects meeting specific requirements will need to be identified over the 50-year timeframe of the MSHCP (see table).

NiSource MSHCP Take Species Requiring Mitigation

Bog Turtle
Clubshell
Fanshell
Indiana Bat
James Spinymussel
Madison Cave Isopod
Nashville Crayfish
Northern Riffleshell
Sheepnose

The Fund generated an initial set of mitigation project selection criteria for each species based upon an analysis of the draft MSHCP. These criteria were reviewed and refined in detail during a series of webinars held by the Fund, NiSource, and USFWS in spring 2010. These criteria were then presented to the states during focus group meetings in summer 2010 where additional enhancements were made. The Fund synthesized the comments from the states in September 2010 and organized the criteria for each species into a hierarchical structure known as a 'decision tree'.

Each decision tree evaluates to what extent a potential mitigation project meets the particular take species mitigation needs and desires (including habitat quality, location, likely protection in perpetuity, and protection of other listed species) as well as how it supports the green infrastructure network design, advances state and regional planning goals, and leverages other financial and partnership resources. The Fund has included a copy of the decision tree as a reference in this report.

Each criterion spans a range of characteristics from most to least suitable in terms of meeting species mitigation requirements. Where each project falls within this range is represented numerically on a standard scale from 0-100 that describes how well it satisfies that particular criteria (100 being the highest). In addition to the score for each criterion, weights are assigned relative to other criteria within its 'branch of the tree' since some factors are more important than others in evaluating a potential project. In addition, criteria have a 'logic structure' that designates them as mandatory, sufficient, or desired based on their contribution to species protection. The Fund has included descriptions of the criteria and their values as reference in this report. The project selection criteria provide an applicant

with insight into project characteristics that make them more attractive for mitigation funding and hopefully will lead to well prepared applications that are responsive to the articulated goals of the mitigation effort.

The design of the decision trees is based on a state-of-the-art method known as 'logic scoring of preference' (LSP) to ensure that all criteria and weightings are designed to reflect fundamental properties of human reasoning and ensure that the benefits calculated accurately reflect the desired intent of decision makers (Dujmović, 2007). Dr. Jozo Dujmović, one of the world's pioneers in the use of LSP for decision making, has designed a customized desktop software package (ISEE) and a web-based application (LSPWeb) to support the ongoing refinement of the species decision trees as the MSHCP begins to be implemented in 2011. Instructions on the use of LSP software are found within the ISEE Users Manual- Integrated System Evaluation Environment V1.1. For web applications, refer to the LSP Methods for Evaluation over the Internet V1.

Although the details of the application review process are not firm at this time, it is likely that the application reviewer(s) would enter the criteria values into the LSP software for each potential mitigation project. Next, the LSP software generates a numerical score on a 100-point scale that represents the percent satisfaction that the project meets the decision tree criteria. The *ISEE* desktop application is the tool that ensures the criterion scores, weights, and logic structure are structured properly and follow the scientifically rigorous techniques of the LSP method. A project's percent satisfaction, when combined with the costs of implementing the project, can be used to help evaluate and rank potential mitigation projects. When trying to select a single project to meet mitigation requirements, the *LSPWeb* application streamlines the selection process and helps clarify the tradeoffs involving benefits and costs for potential projects.

In situations where a large number of projects need to be selected concurrently within a relatively fixed budget constraint, tools using the concept of optimization are most suitable for helping to select multiple projects at a time. The Fund has collaborated with Dr. Kent Messer from the University of Delaware to develop the Optimization Decision Support Tool (*ODST*). The ODST is an Excel™ based application that allows users to evaluate mitigation opportunities based on a variety of evaluation techniques: (1) identifying an optimal set of mitigation projects within a fixed budget constraint, (2) exploring the relative cost effectiveness of mitigation projects and selecting the portfolio with the highest benefit: cost ratio, and/or (3) identifying the minimum cost required to achieve a defined benefit level. The details of the use of the software application are covered in the user manual "Optimization Decision Support Tool Reference Guide –Lite Version.

All mitigation project selection will be governed by the decision making process outlined in the MSHCP. A final MSHCP will not be available before the end of the Section 6 grant project. The weights and logic structure outlined in the enclosed decision trees are likely to be adjusted in the future by USFWS and NiSource, in consultation with the states.

With the above caveats in mind, this species mitigation site report summarizes each state's Wildlife Action Plan recommendations, Maxent models and mitigation opportunities; and provides a true landscape scale snap shot of the alternatives. This document hopefully will serve as a desk reference for mitigation needs and opportunities for the Indiana Bat.

Potential Indiana Bat Mitigation Opportunity Summary Table

The following table summarizes potential mitigation site opportunities for the Indiana Bat. The bulk of sites were contributed by state agency staff at two outreach meetings held in 2008 and 2010. Each site represents a general location for a potential mitigation opportunity, but the features in the associated GIS layer are not accurate to the parcel scale.

ID	Location	Type	Notes
PA98	PA State Gamelands	Spring, Summer, or Fall Habitat	Acquisition of land for PA Game Commission state game lands
PA102	PA State Gamelands	Spring, Summer, or Fall Habitat	Acquisition of land for PA Game Commission state game lands
PA106	PA State Gamelands	Spring, Summer, or Fall Habitat	Acquisition of land for PA Game Commission state game lands
MD508	Carroll County MD	Maternity Colony	Acquisition or easements on maternity habitat
MD506	Carroll County	Spring, Summer, or Fall Habitat	Habitat protection
MD522	Allegany County	Spring, Summer, or Fall Habitat	
MD678	Carroll County	Spring, Summer, or Fall Habitat	Habitat and population survey
IN731	Brown County	Spring, Summer, or Fall Habitat	Large forest block acquisition
IN746	Fish Creek	Spring, Summer, or Fall Habitat	Expand wetlands and forest around and along Fish Creek
IN750	Pokagon, Seven Sisters and east	Spring, Summer, or Fall Habitat	Expand around Pokagon, Seven Sisters and east to improve overall landscape
IN728	Jefferson County	Spring, Summer, or Fall Habitat	
KY862	Near Bat, Laurel, and Saltpeter Caves	Hibernacula	Increase buffer around critical habitat around known hibernacula
KY875	Henderson County	Spring, Summer, or Fall Habitat	Add forestland to nearby public land
KY28	Henderson County	Spring, Summer, or Fall Habitat	Add forestland to nearby public land, restoration and management opportunities
KY879	Ft. Knox	Maternity Colony	Add to public land near Ft. Knox for maternity colonies

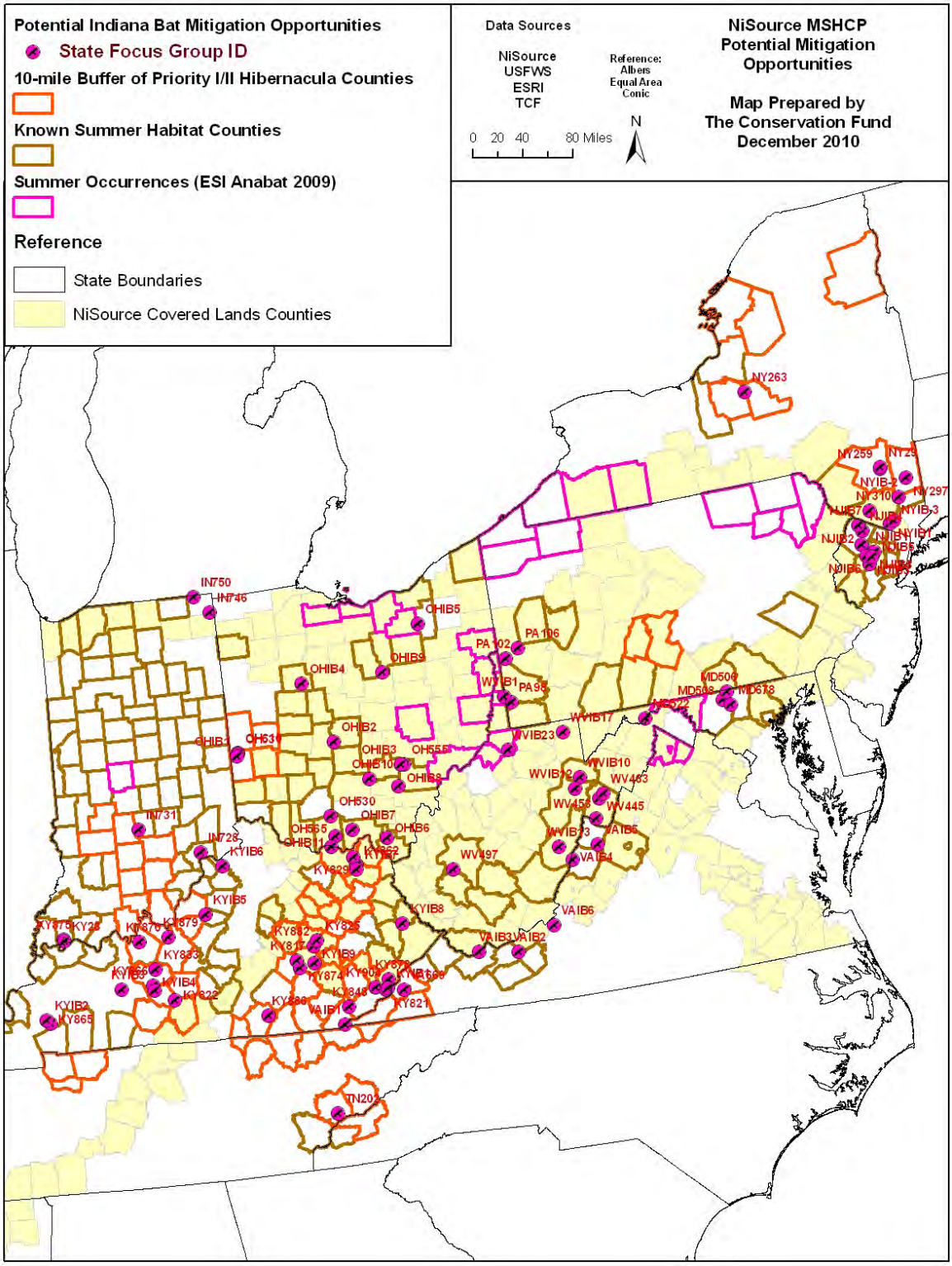
KY904	Near Green and Line Fork Caves	Spring, Summer, or Fall Habitat	Protection of interior forest species from mining, logging, etc.
KY848	Pine Mtn Pike to Bell County	Spring, Summer, or Fall Habitat	Pine Mtn Pike to Bell County
KY866	Coach/ James Caves	Hibernacula	Acquisition or cons. easement - Coach/ James Caves
KY874	Jackson/ Rockcastle	Hibernacula	Acquisition or cons. easement - of P2 Caves in Jackson/ Rockcastle
KY886	Wind Cave Wayne County	Hibernacula	Acquisition or cons. easement - Wind Cave Wayne County
KY870	Breckinridge County	Hibernacula	Acquisition of cons. easement - of P2 caves in Breckinridge County
KY878	Pine Mt	Hibernacula + Summer Habitat	Acquisition or cons. easement - of P2 caves on Pine Mt + surrounding habitat summer habitat in area
KY882	Morton's Cave in Estill County	Hibernacula	Acquisition or cons. easement - of Morton's Cave in Estill County
KY865	Cool Spring Cave	Hibernacula	Acquisition or cons. easement of Cool Spring Cave
KY817	Near Smokehole Cave	Spring, Summer, or Fall Habitat	Land acquisition partnership: KSNPC, TNC, KDFWR and DBNF
KY821	Near State Parks	Hibernacula	Expand State parks and establish nature program to protect hibernacula
KY825	Near Cave Hollow and Stillhouse Cave	Hibernacula	Important karst area plus rare species protection
KY829	Near Bat, Laurel, and Saltpeter Caves	Hibernacula	Protect cave watershed area
KY833	Grayson County	Hibernacula	Protect cave
KY822	Congs cave	Hibernacula	Protect cave
KYIB1	821 Pine Mountain caves	Hibernacula	Protect cave
KYIB2	865 Cool Springs Cave	Hibernacula	Protect cave
KYIB3	Peabody WMA	Spring, Summer, or Fall Habitat	
KYIB4	866 Jesse James/ Coach Caves	Hibernacula	Protect cave
KYIB5	Spencer Co. maternity	Maternity Colony	
KYIB6	Carroll Co., maternity	Maternity Colony	

KYIB7	Carter Caves State Resort Park	Spring, Summer, or Fall Habitat	
KYIB8	Robinson Forest	Spring, Summer, or Fall Habitat	
KYIB9	USFWS KY Field Office Ibat Mitigation Layer	Spring, Summer, or Fall Habitat	
NJIB1	Mt. Hope Mines	Hibernacula	Acquisition of Mt. Hope Mines and surrounding forest
NJIB2	Tracking Ibats from hibernacula to summer habitat	Maternity Colony	
NJIB3	Protect known maternity colonies through cons. Eas	Maternity Colony	
NJIB4	Sussex County	Spring, Summer, or Fall Habitat	
NJIB5	Hibernia Mine	Hibernacula	Replace Hibernia Mine bat gate
NJIB6	Mt. Hope East mine	Hibernacula	Gate Mt. Hope East mine hibernacula site
NJIB7	Land acquisition within Wall Kill River NW R acqui	Spring, Summer, or Fall Habitat	
NJIB8	Morris County	Hibernacula	Habitat acquisition adjacent to known hibernacula
NY310	Orange County	Spring, Summer, or Fall Habitat	Intense land development pressure
NY259	Near Hotel Mine	Hibernacula	Habitat protection and fix collapse at Hotel Mine
NY297	Dutchess County	Spring, Summer, or Fall Habitat	
NY29	Williams Mine	Hibernacula	Williams Mine protection
NY263	Near Jamesville Quarry Cave	Spring, Summer, or Fall Habitat	
NYIB1	Orange County	Spring, Summer, or Fall Habitat	
NYIB-2	Putnam County	Spring, Summer, or Fall Habitat	
NYIB-3	Bull Mine hibernaculum	Spring, Summer, or Fall Habitat	
OH555	Wayne NF	Spring, Summer, or Fall Habitat	Public land acquisition inside Wayne NF boundary
OH565	DNAP, TNC Highlands Karst area of Ohio The Edge Highlands Region + Caves	Hibernacula	Protect DNAP, TNC Highlands Karst area of Ohio, The Edge Highlands Region + Caves

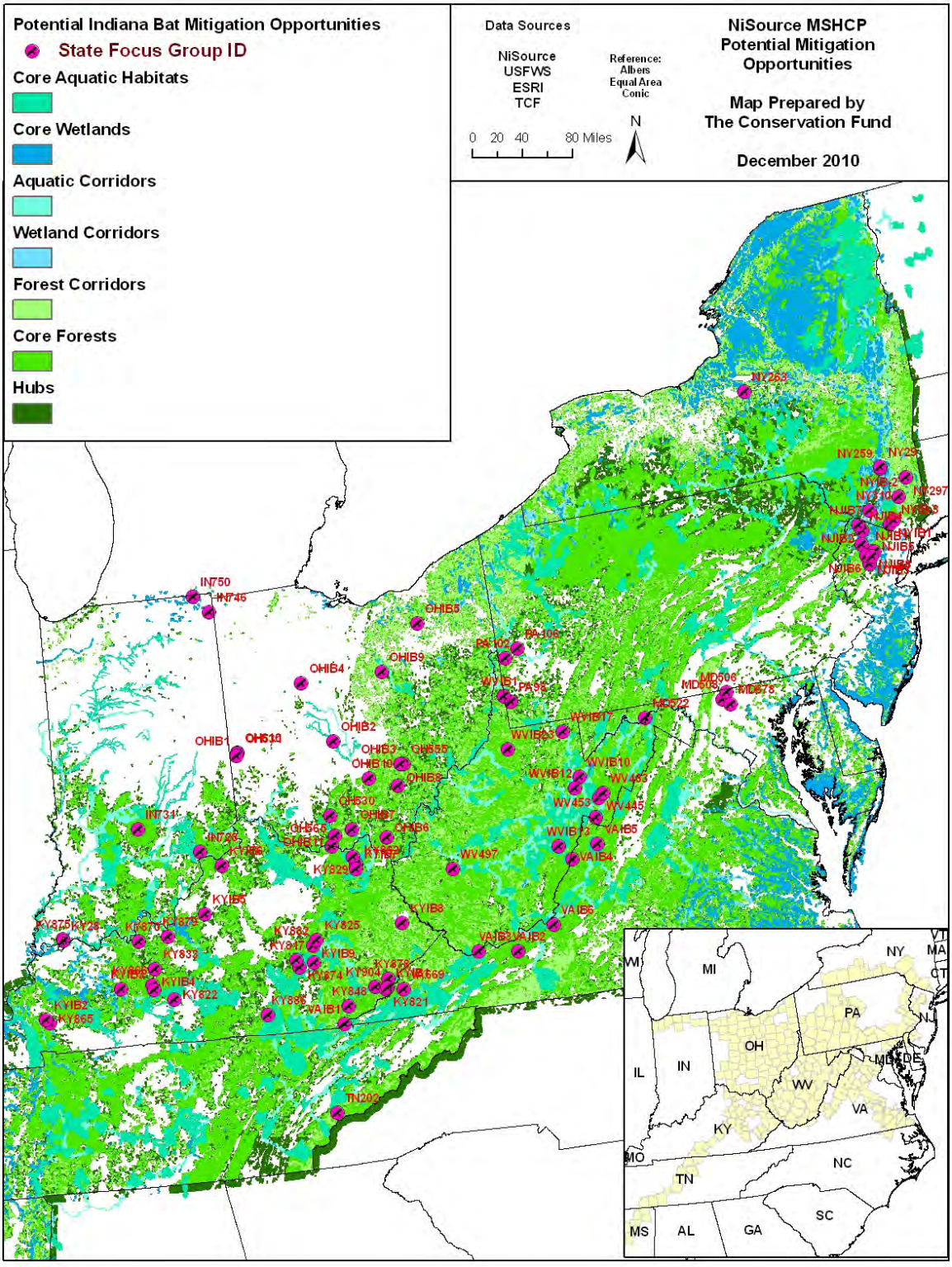
OH530	Highlands Nature Sanctuary	Hibernacula	Protect Highlands Nature Sanctuary and caves
OH610	Preble Mine	Hibernacula	
OH531	Lewisburg Mine in Preble Co	Hibernacula	Purchase Lewisburg Mine in Preble Co, or conservation easement
OHIB1	Preble County Mine	Hibernacula	
OHIB2	Darby Creek	Spring, Summer, or Fall Habitat	
OHIB3	Wayne National Forest	Spring, Summer, or Fall Habitat	
OHIB4	Lawrence Woods	Spring, Summer, or Fall Habitat	
OHIB5	Metro parks serving Summit counties	Spring, Summer, or Fall Habitat	
OHIB6	Wayne National Forest	Spring, Summer, or Fall Habitat	
OHIB7	Wayne National Forest	Spring, Summer, or Fall Habitat	
OHIB8	Zaleski State Forest	Spring, Summer, or Fall Habitat	
OHIB9	Mohican Memorial State Forest	Spring, Summer, or Fall Habitat	
OHIB10	Tar Hollow State Park	Spring, Summer, or Fall Habitat	
OHIB11	Edge of Appalachia	Spring, Summer, or Fall Habitat	
TN202	White Oak Blowhole Cave	Hibernacula	
WV445	Pendleton County	Spring, Summer, or Fall Habitat	Ridge protection for migration of local bats and connectivity
WV453	Pendleton County	Hibernacula	Protection of habitat near hibernacula
WV463	Pendleton County	Spring, Summer, or Fall Habitat	Habitat enhancement and land purchase to protect ridge and valley critical habitat sites and hibernacula
WV497	Boone Co.	Maternity Colony	Maternity habitat protection in Boone Co.
WVIB1	Ohio County	Maternity Colony	Protection of maternity colony
WVIB23	Wetzel County	Unknown	Capture surveys

WVIB10	Cave Hollow	Hibernacula	Protection of private lands around Cave Hollow/Arbogast
WVIB12	Rich Mountain	Spring, Summer, or Fall Habitat	Foraging habitat and migration corridors
WVIB13	Gate mines	Hibernacula	Gating unprotected hibernacula in states as opportunities arise
WVIB17	Cornwell Cave, Preston County	Hibernacula	Protection of Cornwell Cave
VAIB1	Cumberland Gap National Park and private land surrounding	Spring, Summer, or Fall Habitat	
VA669	Rocky Hollow Cave	Spring, Summer, or Fall Habitat	
VAIB3	Higgenbotham Cave	Hibernacula	
VAIB2	Skydusky Hollow	Spring, Summer, or Fall Habitat	
VAIB6	Shire's Cave	Hibernacula	
VAIB4	Starr Chapel Cave vicinity	Spring, Summer, or Fall Habitat	
VAIB5	Huppman's Cave	Hibernacula	

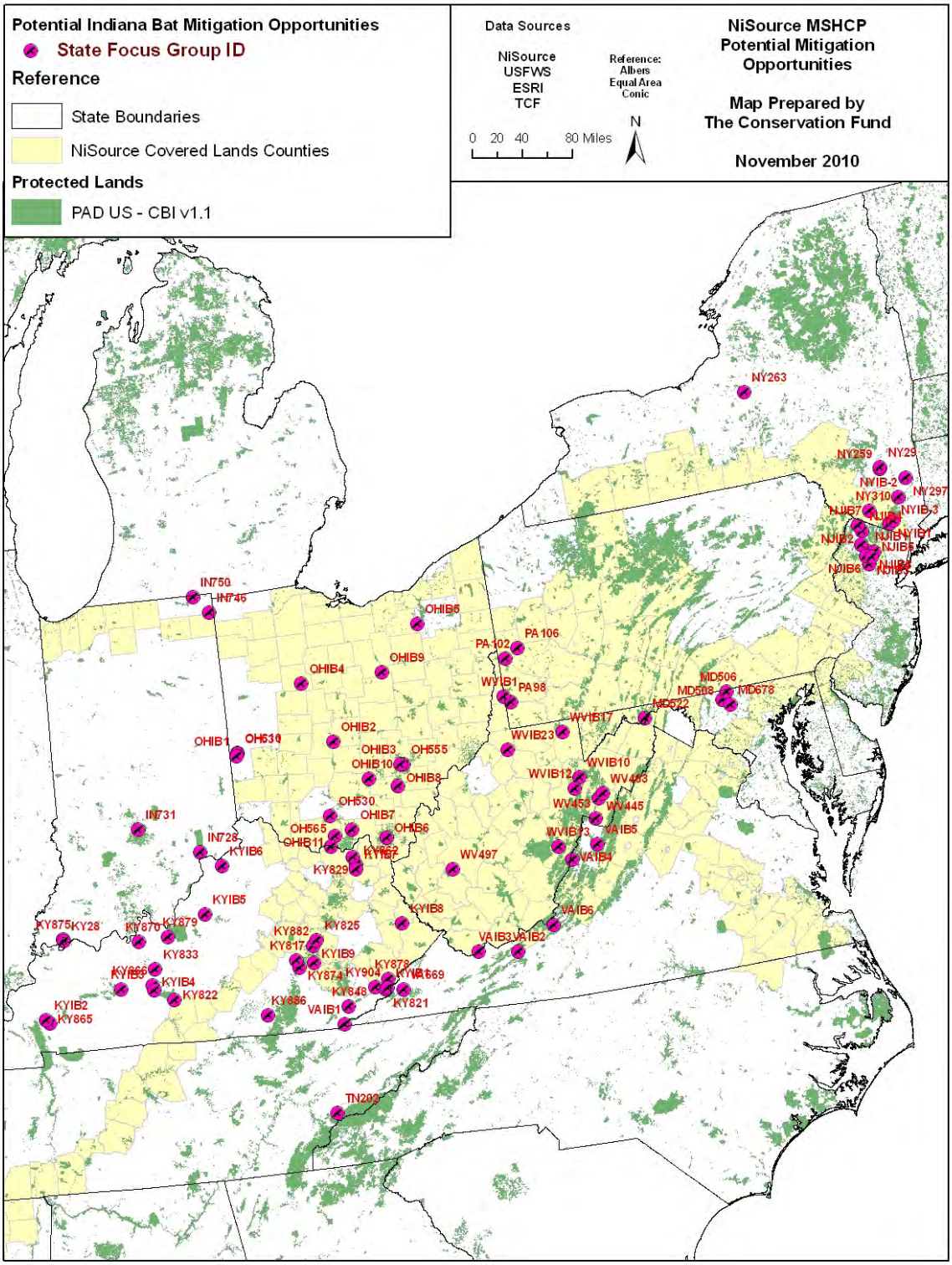
Map 1 – Indiana Bat Mitigation Opportunities and Occurrence



Map 2 – Indiana Bat Mitigation Opportunities and the Green Infrastructure Network



Map 3 – Indiana Bat Mitigation Opportunities and Protected Lands



Indiana Bat Decision Tree

1 Indiana Bat Mitigation Projects

11 Habitat Mitigation Needs

111 Mandatory Requirements

1111 Mitigation Units

1112 Site Assessment

11121 Summer Roosting Habitat Quality

111211 Canopy Closure

111212 Suitable Roost Trees Per Acre

111213 Suitable Roost Tree Size & Species

11122 Tree Stand Recruitment

11123 Parcel Size

1113 Physical Conditions

11131 Travel Corridor Quality

11132 Proximity to Water

1114 Species Occurrence

11141 Proximity to Known Sites

11142 Adjacent Protected Land

11143 Human Impacts to Occurrence

1115 Project Location

112 Desired Characteristics

1121 Protection in Perpetuity

11211 Reductions in Habitat & Connectivity

11212 Project Monitoring

1122 Listed Species Protection

11221 NiSource MSHCP Take Species

11222 Federal & State Listed Species

12 Strategic Conservation Goals

121 Green Infrastructure Network

122 Adopted Plans & Leverage

1221 State Wildlife Action Plans

1222 Conservation Planning

1223 Collaboration

KEY

Bold - Criteria where values are directly input into Decision Tree Software

Italic - Categories with logic structure (i.e. mandatory/desired, simultaneity, replaceability)

Indiana Bat Tree Logic & Criteria Weights

1 **Indiana Bat Mitigation Projects** [CPA -20+15]
- 11 MANDATORY Habitat Mitigation Needs
- 12 DESIRED Strategic Conservation Goals

The DESIRED input cannot compensate the absence of MANDATORY input, but the MANDATORY input can significantly compensate the absence or low value of the DESIRED input. There is a 20% penalty for a low DESIRED value and a 15% reward for a high DESIRED value. This is known as conjunctive partial absorption (CPA).

11 **Habitat Mitigation Needs** [CPA -25+20]
- 111 MANDATORY Requirements
- 112 DESIRED Characteristics

The DESIRED input cannot compensate the absence of MANDATORY input, but the MANDATORY input can significantly compensate the absence or low value of the DESIRED input. There is a 25% penalty for a low DESIRED value and a 20% reward for a high DESIRED value. This is known as conjunctive partial absorption (CPA).

111 **Mandatory Requirements** [C+- Medium-strong simultaneity]
- 1111 Mitigation Units – 30%
- 1112 Site Assessment – 20%
- 1113 Physical Conditions – 15%
- 1114 Species Occurrence – 20%
- 1115 Project Location – 15%

In medium-strong simultaneity, all inputs must be to some extent simultaneously satisfied. Any zero input yields a zero output. This is known as hard partial conjunction (HPC), which is used to model mandatory requirements. Percentages correspond to the relative weights of each criterion within this branch of the tree.

1112 **Site Assessment** [C-+ Medium-weak simultaneity]
- 11121 Summer Roosting Habitat Quality – 50%
- 11122 Tree Stand Recruitment – 25%
- 11123 Parcel Size – 25%

In medium-weak simultaneity, all inputs should be to some extent simultaneously satisfied. Any zero input yields a zero output. This is known as hard partial conjunction (HPC), which is used to model mandatory requirements. Percentages correspond to the relative weights of each criterion within this branch of the tree.

11121 **Summer Roosting Habitat Quality** [C-+ Medium-weak simultaneity]
- 111211 Canopy Closure – 40%
- 111212 Suitable Roost Trees Per Acre – 30%
- 111213 Suitable Roost Tree Size & Species – 30%

In medium-weak simultaneity, all inputs should be to some extent simultaneously satisfied. Any zero input yields a zero output. This is known as hard partial conjunction (HPC), which is used to model mandatory requirements. Percentages correspond to the relative weights of each criterion within this branch of the tree.

1113 **Physical Conditions** [C-+ Medium-weak simultaneity]
- 11131 Travel Corridor Quality – 50%
- 11132 Proximity to Water – 50%

In medium-weak simultaneity, all inputs should be to some extent simultaneously satisfied. Any zero input yields a zero output. This is known as hard partial conjunction (HPC), which is used to model mandatory requirements. Percentages correspond to the relative weights of each criterion within this branch of the tree.

1114 **Species Occurrence** [C-+ Medium-weak simultaneity]
- 11141 Proximity to Known Sites – 50%
- 11142 Adjacent Protected Land – 25%
- 11143 Human Impacts to Occurrence – 25%

In medium-weak simultaneity, all inputs should be to some extent simultaneously satisfied. Any zero input yields a zero output. This is known as hard partial conjunction (HPC), which is used to model mandatory requirements. Percentages correspond to the relative weights of each criterion within this branch of the tree.

112 **Desired Characteristics** [C-- Very-weak simultaneity]
- 1121 Protection in Perpetuity – 60%
- 1122 Listed Species Protection – 40%

In very weak simultaneity, all inputs should be to some extent simultaneously satisfied. A zero input does not necessarily yield a zero output. This is known as soft partial conjunction (SPC), which is used to model non-mandatory requirements. Percentages correspond to the relative weights of each criterion within this branch of the tree.

1121 **Protection in Perpetuity** [C-+ Medium-weak simultaneity]
- 11211 Reductions in Habitat & Connectivity – 60%
- 11212 Project Monitoring – 40%

In medium-weak simultaneity, all inputs should be to some extent simultaneously satisfied. Any zero input yields a zero output. This is known as hard partial conjunction (HPC), which is used to model mandatory requirements. Percentages correspond to the relative weights of each criterion within this branch of the tree.

1122 **Listed Species Protection** [DA Strong replaceability]
- 11221 NiSource MSHCP Take Species – 75%
- 11222 Federal & State Listed Species – 25%

In strong replaceability, each input can be used to completely compensate the lack of remaining inputs. This is known as hard partial disjunction (HPD), which is used to model sufficient conditions. Percentages correspond to the relative weights of each criterion within this branch of the tree.

12 **Strategic Conservation Goals** [C- Weak simultaneity 65/35]
- 121 Green Infrastructure Network – 65%
- 122 Adopted Plans & Leverage – 35%

In weak simultaneity, all inputs should be to some extent simultaneously satisfied. A zero input does not necessarily yield a zero output. This is known as soft partial conjunction (SPC), which is used to model non-mandatory requirements. Percentages correspond to the relative weights of each criterion within this branch of the tree.

122 **Adopted Plans & Leverage** [DA Strong replaceability 30/20/50]
- 1221 State Wildlife Action Plans – 30%
- 1222 Conservation Planning – 20%
- 1223 Collaboration – 50%

In strong replaceability, each input can be used to completely compensate the lack of remaining inputs. This is known as hard partial disjunction (HPD), which is used to model sufficient conditions. Percentages correspond to the relative weights of each criterion within this branch of the tree.

Indiana Bat Criteria Descriptions & Values

1 Indiana Bat Mitigation Projects
11 Habitat Mitigation Needs
111 Mandatory Requirements
1111 **Mitigation Units** – (30%)

1111		**Mitigation Units [0,100]**
Value	*%*	Evaluated as the following normalized indicator: U = 100 * M / Mmax [%] where M = Mitigation area protected by proposed project Mmax = Mitigation required by MSHCP (M and Mmax are measured in same units) The value of Mmax can be either expressed as: (a) the total mitigation required in the MSHCP, or (b) an annual or project specific mitigation requirement Mitigation units and amount will vary by project. This criterion represents a mandatory requirement.
0 100	0 100	

1 Indiana Bat Mitigation Projects
11 Habitat Mitigation Needs
111 Mandatory Requirements
1112 Site Assessment (20%)
11121 Summer Roosting Habitat Quality (50%)
111211 **Canopy Closure** – 40%
111212 **Suitable Roost Trees Per Acre** – 30%
111213 **Suitable Roost Tree Size & Species** – 30%
11122 **Tree Stand Recruitment** – 25%
11123 **Parcel Size** – 25%

111211		**Canopy Closure [0,100]**
Value	*%*	FWS, NiSource, and States have determined suitability based upon percentage canopy closure for potential mitigation projects. Between 60-80% is preferred
59 60 80	0 50 100	

		This criterion represents a mandatory requirement.

111212		**Suitable Roost Trees Per Acre [0,16]**
Value	*%*	FWS, NiSource, and States have determined suitability based upon suitable roost trees per acre (with direct sun exposure for more than half the day) for potential mitigation projects. Above 16 trees per acre is preferred This criterion represents a mandatory requirement.
15 16	0 100	

111213		**Suitable Roost Tree Size & Species [0,4]**
Value	*%*	FWS, NiSource, and States have determined suitability based upon suitable roost tree size and species for potential mitigation projects. 4 = live shagbark hickories (Carya ovata) >=18” dbh; lightning-struck trees >=18” dbh; dead, dying or damaged trees of any species >=18” dbh with at least 10% exfoliating bark; den trees, broken trees, or stumps >=18” dbh and >9 feet in height; and live trees of any species >26” dbh. 3 = live shagbark hickories (Carya ovata) >13” dbh; lightning-struck trees >13” dbh; dead, dying, or damaged trees of any species >13” dbh with at least 10% exfoliating bark; den trees, broken trees, or stumps >13” dbh and >9 feet in height. 2 = live shagbark hickories (Carya ovata) >9” dbh; lightning-struck trees >9” dbh; dead, dying, or damaged trees of any species >9” dbh with at least 10% exfoliating bark; den trees, broken trees, or stumps >9” dbh and >9 feet in height. 1 = live shagbark hickories (Carya ovata) >5” dbh; lightning-struck trees >5” dbh; dead, dying, or damaged trees of any species >5” dbh
0 4	0 100	

		with at least 10% exfoliating bark; den trees, broken trees, or stumps >5" dbh and >9 feet in height. 0 = Does not contain suitable trees This criterion represents a mandatory requirement.

11122		**Tree Stand Recruitment [0,3]**
Value	*%*	FWS, NiSource, and States have determined suitability based upon four scenarios that describe tree stand recruitment is an important factor for evaluating potential mitigation projects. This criterion represents a mandatory requirement. 3 = >=3 live trees/acre >20" dbh of other potential roost trees from the USFWS list, at least 6 live trees/acre >11" dbh of these species, and at least 16 live trees/acre of these species overall. (The "per acre" requirement can be expressed as the average per acre on a stand-wide basis.) 2 = Does not meet the higher criteria, but primarily deciduous or mixed forest 1 = Does not meet the higher criteria, but primarily pines 0 = Primarily scrub-shrub or herbaceous
0	0	
1	50	
2	75	
3	100	

11123		**Parcel Size [0,250]**
Value	*%*	FWS, NiSource, and States have determined that parcel size (measured in acres) is an important factor for evaluating potential mitigation projects. This is a separate measure from mitigation units. This criterion represents a mandatory requirement.
10	0	
250	100	

1 Indiana Bat Mitigation Projects
11 Habitat Mitigation Needs
111 Mandatory Requirements
1113 Physical Conditions (15%)
11131 **Travel Corridor Quality** – 50%
11132 **Proximity to Water** – 50%

11131		**Travel Corridor Quality [0,4]**
Value	*%*	FWS, NiSource, and the states have determined suitability based upon five scenarios that describe the quality of the travel corridors for a potential mitigation project. This criterion represents a mandatory requirement. 4 = Site is connected by or protects tree lined stream corridors, open pathways through contiguous forest, and/or continuous forest corridors >=100 ft wide 3 = Site is connected by or protects continuous forest corridors <100 feet wide but >1 tree width wide 2 = Site is connected by or protects continuous forest corridors or hedgerows one tree width wide 1 = Site is partly connected by trees, with gaps that could be closed by tree planting 0 = No travel corridors
0	0	
1	50	
2	70	
3	90	
4	100	

11132		**Proximity to Water [0,2]**
Value	*%*	FWS, NiSource, and the States have determined that proximity to water (measured in miles) is an important consideration for a mitigation project. This criterion represents a mandatory requirement.
0	100	
2	0	

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111 Mandatory Requirements
1114 Species Occurrence (20%)
11141 **Proximity to Known Sites** – 50%
11142 **Adjacent Protected Land** – 25%
11143 **Human Impacts to Occurrence** – 25%

11141		**Proximity to Known Sites [0,3]**
Value	*%*	FWS, NiSource, and the States have determined suitability based upon four scenarios that describe proximity to known Indiana Bat sites for a mitigation project location. This criterion represents a mandatory requirement. 3 = Project is a site known to be used by Indiana Bats for roosting, swarming, or hibernacula; and documented in the last 20 years 2 = Project is a site known to be used by Indiana Bats for foraging, documented in the last 20 years; or within 2.5 miles of known maternity colonies 1 = Site is not known to contain Indiana bats, but is within 10 miles of known hibernacula, or within 5 miles of a maternity capture mist-net record; documented in the last 20 years 0 = Site is not near any known sites used by Indiana bats
0	0	
3	100	

11142		**Adjacent Protected Land [0,1000]**
Value	*%*	FWS, NiSource, and the States have determined that proximity to adjacent protected land with suitable Indiana Bat habitat (measured in meters) is an important consideration for a potential mitigation project. This criterion represents a mandatory requirement.
0	100	
1000	0	

11143		Human Impacts to Occurrence [0,4]
Value	*%*	FWS, NiSource, and the States have determined suitability based upon the risk of additive mortality from human impacts, including but not limited to development, wind turbines, mining, and gas/oil exploration. 4 = None 3 = Low 2 = Medium 1 = High 0 = Very High This criterion is a mandatory requirement.
0	0	
4	100	

1 Indiana Bat Mitigation Projects
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111 Mandatory Requirements
1115 **Project Location** – 15%

1115		Project Location [0,4]
Value	*%*	Location of the project based on priority locations for species viability and geographic equity considerations for MSHCP take impact. The suitability of locations will be based on factors such as FWS Recovery Plans, recent evidence of species occurrence and viability, and NiSource covered lands impacts and operating states. 4 = a. Fall swarming/Spring staging habitat (Buffer Lands) within 10 miles around known Priority I hibernacula, OR b. Summer Habitat with Known Maternity Colonies (within 2.5 miles of maternity roost tree, 5.0 miles of maternity mist net record) AND Project is within the same state as take 3 = Same habitat as #4 above but project is outside state where take is occurring
0	0	
4	100	

		2 = Fall swarming/Spring staging habitat (Buffer Lands) within 10 miles around known Priority II hibernacula AND Project is within the same state as take 1 = Same habitat as #2 above but project is outside state where take is occurring This criterion represents a mandatory requirement.

1 Indiana Bat Mitigation Projects
11 Habitat Mitigation Needs
112 Desired Characteristics
1121 Protection in Perpetuity (60%)
11211 **Reductions in Habitat & Connectivity** – 60%
11212 **Project Monitoring** – 40%

11211		**Reductions in Habitat & Connectivity [0,4]**
Value	*%*	FWS, NiSource, and the States have determined suitability based upon the risk of reductions in habitat and connectivity, including but not limited to development, wind turbines, mining, and gas/oil exploration. 4 = None 3 = Low 2 = Medium 1 = High 0 = Very High This criterion is not a mandatory requirement.
0	0	
4	100	

11212		Project Monitoring [0,4]
Value	*%*	FWS, NiSource, and the States have determined
0	0	suitability based upon the quality and efficacy of the
4	100	monitoring program for a mitigation project.
		An excellent monitoring program would be multi-year,
		require dual phase qualitative and quantitative sampling,
		and have an experienced monitoring team.
		4 = Excellent
		3 = Very Good
		2 = Good
		1 = Fair
		0 = Poor
		This criterion is not a mandatory requirement.

1 Indiana Bat Mitigation Projects
11 Habitat Mitigation Needs
112 Desired Characteristics
1122 Listed Species Protection (40%)
11221 **NiSource MSHCP Take Species** – 75%
11222 **Federal & State Listed Species** – 25%

11221		NiSource MSHCP Take Species [0,3]
Value	*%*	FWS, NiSource, and the States have determined
0	0	suitability based upon where the potential mitigation
1	80	project supports protection of other NiSource MSHCP
3	100	take species.
		Evaluated as the number of supported species.
		This criterion is not a mandatory requirement.

11222		Federal & State Listed Species [0,3]
Value	*%*	FWS, NiSource, and the States have determined
0	0	suitability based upon where the potential mitigation
1	80	project supports protection of federally listed threatened or
3	100	endangered species, G1-G3 species, GCN species,

		or state listed rare habitats or communities not included as take species within the MSHCP: Evaluated as the number of species (0-3). This criterion is not a mandatory requirement.

1 Indiana Bat Mitigation Projects
12 Strategic Conservation Goals
121 **Green Infrastructure Network** (65%)

121		**Green Infrastructure Network [0,5]**
Value	*%*	Characterized green infrastructure network.
0	0	
1	50	The value is generated by combining the following
2	70	GIS layers: GI hubs (2 points), GI core forest (1),
3	80	GI aquatic areas (1), GI wetlands (1) and GI corridors (1).
4	90	The maximum number of points is 6, and 5 points is
5	100	sufficient for complete satisfaction of this criterion.
		The value is a proxy for the contribution of the mitigation project to the protection of an interconnected network of natural resource lands. This criterion is not a mandatory requirement.

1 Indiana Bat Mitigation Projects
12 Strategic Conservation Goals
122 Adopted Plans & Leverage (35%)
1221 **State Wildlife Action Plans** – 30%
1222 **Conservation Planning** – 20%
1223 **Collaboration** – 50%

1221		**State Wildlife Action Plans [0,4]**
Value	*%*	How well does the potential mitigation project support the adopted State Wildlife Action Plan.
0	0	
1	50	
3	90	Evaluated as the number of supported actions/plans.
4	100	

		This criterion is not a mandatory requirement.

1222		**Conservation Planning [0,4]**
Value	*%*	Does the potential mitigation project support other state and regional planning efforts?
0	0	
1	50	
3	90	Plans may include, but are not limited to:
4	100	
		Coastal and Estuarine Land Conservation Plan State Wetlands Plan State Greenways and Trails Plan State Forestry Plan Climate Action Plans Statewide Comprehensive Recreation Plan State GAP Analysis, Forest Legacy Needs Assessment, Natural Areas Statewide Plan Nature Conservancy Eco-regional Plans/Assessments Eastern Brook Trout Joint Venture Report Ohio River Valley Ecosystem Mollusk Conservation Plan Ohio River Islands National Wildlife Refuge CCR Partners in Flight North American Conservation Plan Chesapeake Bay Health and Restoration Assessment Evaluated as the number of supported actions/plans. This criterion is not a mandatory requirement.

1223		**Collaboration [0,100]**
Value	*%*	How well does the potential mitigation project leverage in-kind resources for restoration, monitoring, stewardship, management, and education/interpretation?
0	0	
100	100	
		Projects that bring additional resources will receive additional consideration when compared with projects that rely solely on funding from the project application. Value range is 0-100% based on the level of collaboration included in the mitigation project proposal. This criterion is not a mandatory requirement.

Criteria Lookup Tables and Supplemental Information

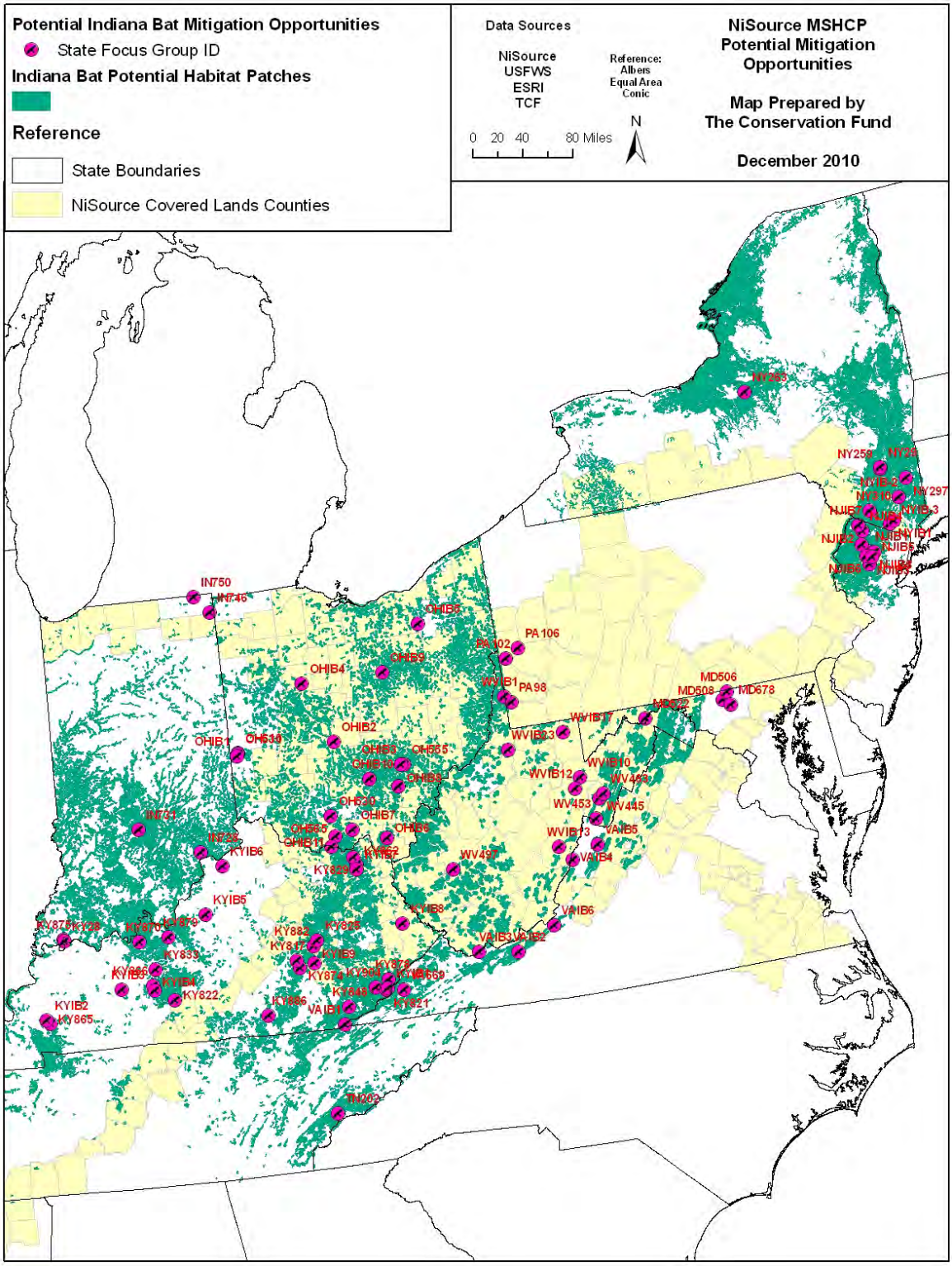
Branch #11

- **Pilot Modeling of *Myotis sodalis* Summer Habitat**
  - **Kentucky and Tennessee**
  - **Indiana**
  - **Ohio**
  - **New York and New Jersey**
- **Mature Hardwood Forest Models**
  - **Kentucky**
  - **Ohio**
  - **Pennsylvania**
  - **Tennessee**

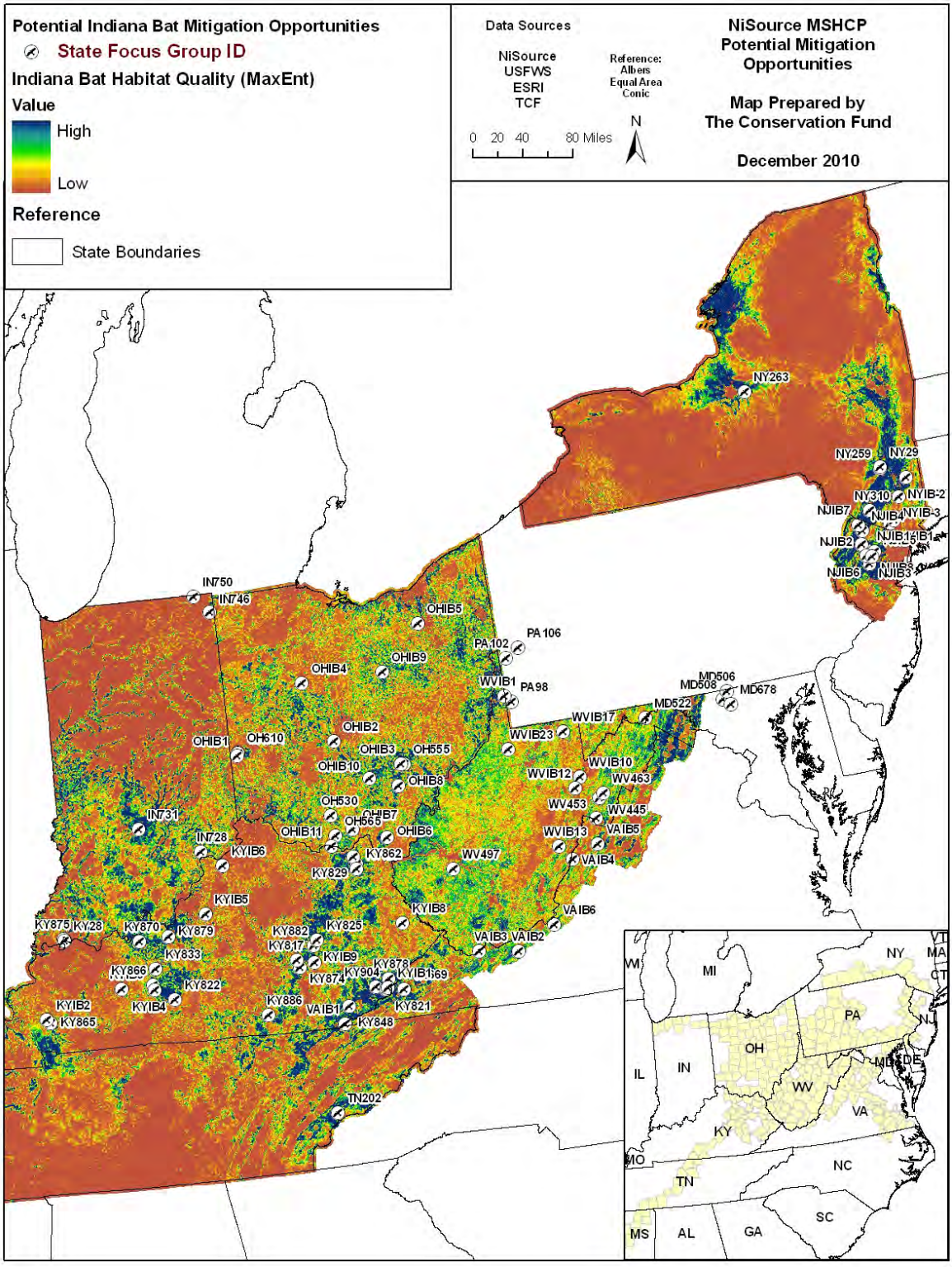
Branch #122

- **State Wildlife Action Plans (#1221)**
  - **Indiana Bat SWAP supported actions**
    - **Indiana**
    - **Kentucky**
    - **Maryland**
    - **New Jersey**
    - **New York**
    - **Pennsylvania**
    - **Tennessee**
    - **Virginia**
    - **West Virginia**

Map 4 – Indiana Bat Mitigation Opportunities and Potential Habitat Patches



Map 5 – Indiana Bat Mitigation Opportunities and Habitat Quality Modeling



Pilot Modeling of *Myotis sodalis* Summer Habitat

Kentucky and Tennessee

Feb 4, 2010

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Methods

Study area

The study area included all of Tennessee and Kentucky, plus far western Virginia (Buchanan, Dickenson, Lee, Russell, Scott, Washington, Wise, Bristol, and Norton counties) because this area seemed to share bat populations with KY. We buffered TN and KY 3 km to allow for focalsum computations along the borders. The total study area (including the 3 km buffer) was 230,154 km^2.

Locational data

We obtained summer records of Myotis sodalis in KY and TN from USFWS, ENSR, TWRA, and KYNPC. We had only a handful of records in TN; thus, we modeled TN and KY together, including the possibly shared populations in far western VA. We omitted records prior to 1990, occurrences with poor estimated viability, transient roost sites, and transient mist-net records. We also added two occurrences in TN and two in KY from ESI surveys in summer 2009.

In VA, we converted WERMS polygons to points, and selected those in the study counties. We omitted five clustered locations from a 1992 study, some of which contained Keen's Myotis and some Indiana bat, because they appeared to be swarming and male roosting locations near hibernacula, and did not contain any female Indiana bats. The other two locations were <1 km from KY NPC data, so were not added either.

Summer point locations totaled 104: 94 in KY and 10 in TN. We then used Hawth's Tools to add the coordinates to the attribute table.

Environmental variables

Expanding on pilot studies in Indiana, we calculated 18 variables within 10 km of KY and TN (Table 1), using ArcGIS Model Builder. We based the 1 km scale on the average foraging range of 11 individuals tracked by Sparks et al. (2005), and the 3 km scale on their averaged maximum linear distance from roost. To speed computations, which otherwise would have taken many hours, we resampled land cover variables to a resolution of 90m for 3 km focal statistics. We did not think this would introduce appreciable error.

Table 1. Variables examined for habitat modeling for Myotis sodalis in Kentucky and Tennessee.

Variable name	Variable description	Source data
pct_forwet_1k	Percent forested wetlands within 1 km	NLCD
pct_forstr_1k	Percent area within 1 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_1k	Percent development within 1 km	NLCD
pct_edges_1k	Length of forest edges with fields or open water within 1 km	NLCD
str_dfor_m_1k	Length of unchannelized streams or rivers in deciduous forest within 1 km	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_forwet_3k	Percent forested wetlands within 3 km	NLCD
pct_forstr_3k	Percent area within 3 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_3k	Percent development within 3 km	NLCD
pct_edges_3k	Length of forest edges with fields or open water within 3 km	NLCD
str_dfor_m_3k	Length of unchannelized streams or rivers in deciduous forest within 3 km	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
dist_maj_rds	Distance from major roads	ESRI street data
dist_hibernac	Distance to known winter hibernacula with at least 100 *M. sodalis* individuals recorded in surveys between 2000-8. We used 100 as a cutoff based on the Kentucky Bat Working Group.	USFWS + state heritage programs
junsol_fmn_1k	Mean June insolation within 1 km	Calculated by TCF from 30m DEMs and latitude
tnky_jn_solar	June insolation at grid cell	Calculated by TCF from 30m DEMs and latitude
tnky_tmin_06	June min. temperature	Climate Source, ~400m resolution, 1971-2000 average
tnky_tmax_06	June max. temperature	Climate Source, ~400m resolution, 1971-2000 average
tnky_tmean_06	June mean temperature	Climate Source, ~400m resolution, 1971-2000 average
tnky_precip06	June mean precipitation	Climate Source, ~400m resolution, 1971-2000 average

Maxent modeling

We then processed locational data and environmental layers in Maxent. We used 10-fold cross-validation and examined the mean and standard deviation of the replicate runs. The use of 10 replications was somewhat arbitrary, but was based on standard practice, as well as time limitations.

FunConn modeling

We used the Maxent average model output (Myotis_sodalis_avg.asc; converted to an integer grid between 0 and 100) as the Habitat Quality Raster input to the program FunConn, to identify potential habitat patches. We modified the Habitat Quality Raster by giving busy roads and developed land (NLCD classes 22-24; i.e., excluding developed open space) a habitat value of 0 (i.e., the lowest possible suitability). Based on the pilot study in the upper Wabash watershed, we set the minimum patch size as the average foraging range (335 ha) of 11 Indiana bats tracked by Sparks et al. (2005); and the foraging radius to the average maximum linear distance that these bats traveled from their roost (3020 m). We set the Resource Quality Threshold to the average model output that captured 90% of test points. We used the default value (0.1) for core habitat percentage.

Results

Maxent habitat suitability

Fig. 1 shows mean Maxent output. The average test area under the receiver operating characteristic curve (AUC) for the replicate runs was 0.886 (standard deviation 0.057). Distance to hibernacula (dist_hibernac) had the greatest contribution to the Maxent models (Table 2). This was followed by the percent area of development within 1 km (pct_devel_1k), and percent area within 1 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers (pct_forstr_1k). Jackknife tests showed that the environmental variable with highest gain when used in isolation was dist_hibernac, which therefore appeared to have the most useful information by itself. This was closely followed by pct_forstr_1k and pct_devel_1k. The environmental variable that decreased the gain the most when it was omitted was dist_hibernac, which therefore appeared to have the most information that wasn't present in the other variables. Table 3 lists the values associated with higher probabilities of suitable Myotis sodalis summer habitat, for variables that contributed >5% to the model. Variables were inter-related, and combined in a variety of ways to create the model.

Table 2. Heuristic estimate of relative contributions of the environmental variables in Table 1 to the Maxent model. To determine the estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. As with the jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

Variable	Percent contribution
dist_hibernac	26.0
pct_devel_1k	13.1
pct_forstr_1k	12.9
pct_forwet_1k	8.4
str_dfor_m_3k	5.9
dist_maj_rds	5.3
pct_forwet_3k	5.3
junsol_fmn_1k	3.9
pct_forstr_3k	3.6
pct_edges_1k	3.4
tnky_precip06	3.0
pct_edges_3k	2.6
tnky_tmax_06	2.5
str_dfor_m_1k	1.6
pct_devel_3k	1.0
tnky_tmin_06	0.9
tnky_jn_solar	0.4
tnky_tmean_06	0.1

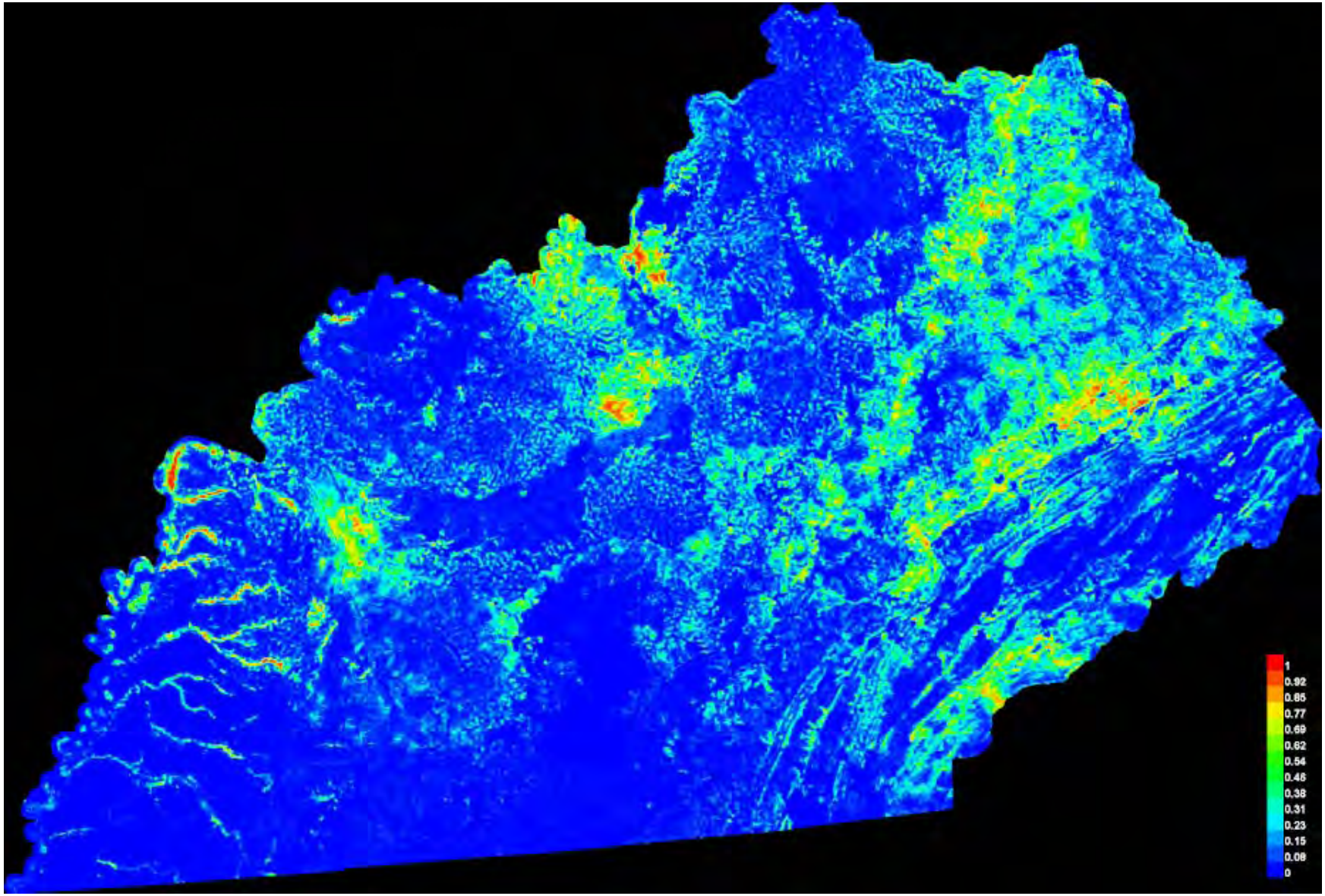
1
0.92
0.85
0.77
0.69
0.62
0.54
0.46
0.38
0.31
0.23
0.15
0.08
0

Fig. 1. Maxent modeled summer habitat suitability for *Myotis sodalis.*

Table 3. Values associated with higher probabilities of *Myotis sodalis* summer habitat, for variables that contributed >5% to the model.

Variable	Values associated with *Myotis sodalis* habitat
dist_hibernac	<25 km, but also with a peak around 110 km
pct_devel_1k	Rapid decline between 0-5%, and slower decline after that.
pct_forstr_1k	Continual increase, especially >25%
pct_forwet_1k	Peak at 50-55%
str_dfor_m_3k	Keeping other variables: peak around 1800-3000 m. By itself: increasing after 1800 m, but with a trough around 3000-5000 m.
dist_maj_rds	< 6 km (which may have been an artifact)
pct_forwet_3k	Keeping other variables: >30%. By itself: peak around 30%

FunConn patch model

We ran two FunConn models. First, we set the Resource Quality Threshold to 30.30, which included on average approximately 89% of Maxent training locations, 86% of test locations, and 15% of total area ($p<0.0001$). This threshold corresponded to Maxent maximum test sensitivity plus specificity. FunConn identified 474 patches with a minimum size 583 ha, maximum size 794,301 ha, mean size 8538 ha, and total area 4,046,888 ha (17.6% of the study area; see Fig. 3). 89 of 104 M. sodalis locations (86%) fell within these patches. This model was overly restrictive (<90% of locations included).

Next, we set the Resource Quality Threshold to 23.55, which included on average approximately 91% of Maxent training locations, 82% of test locations, and 18% of total area ($p=0.0007$). This threshold corresponded to Maxent equal test sensitivity and specificity. FunConn identified 624 patches with a minimum size 461 ha, maximum size 2,187,634 ha, mean size 8189 ha, and total area 5,109,970 ha (22.2% of the study area; see Fig. 3). 96 of 104 M. sodalis locations (92%) fell within these patches. We preferred this model, since it captured >90% of locations.

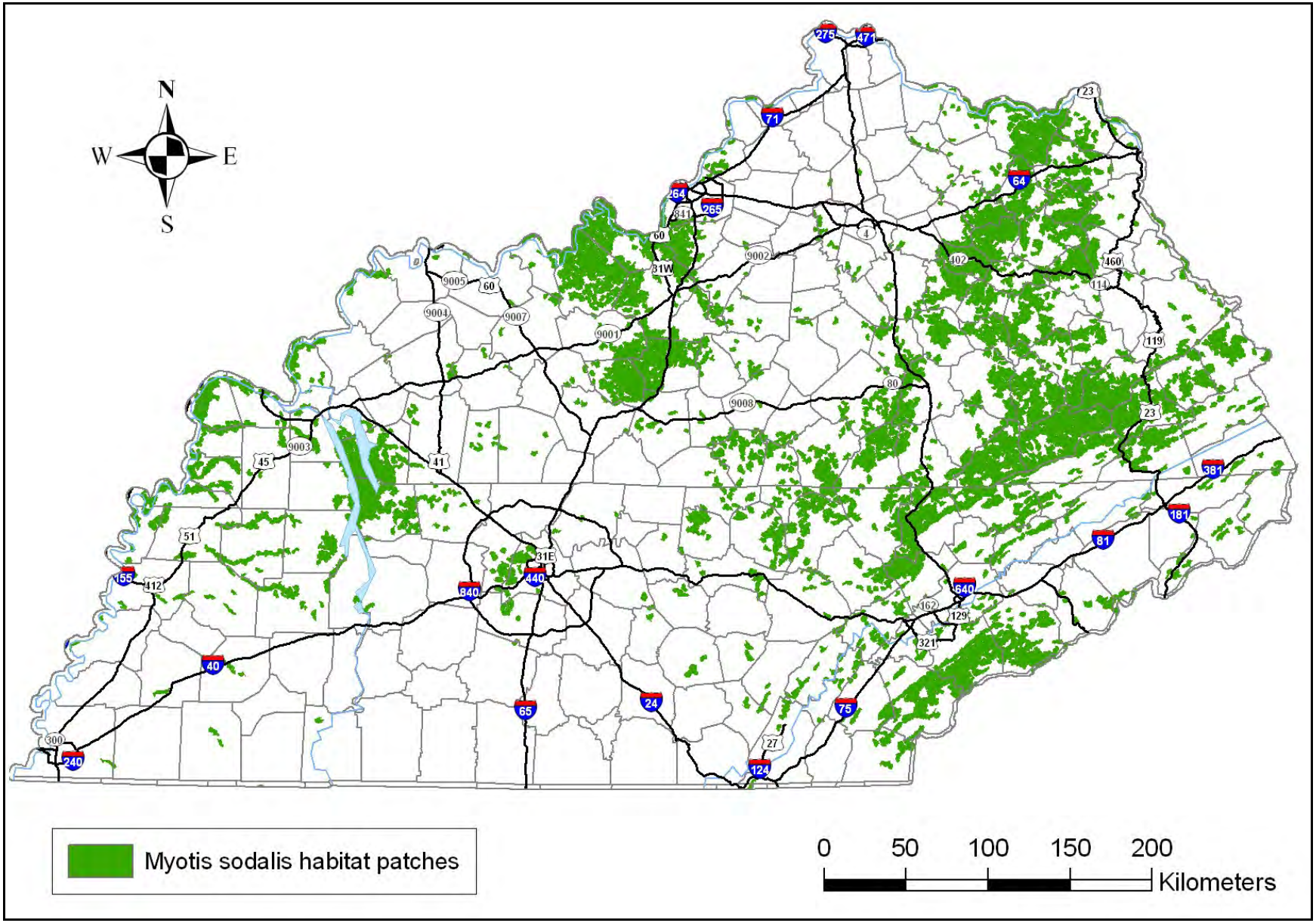
N
W
E
S
Myotis sodalis habitat patches
0
50
100
150
200
Kilometers

Fig. 2. Modeled habitat patches for *Myotis sodalis*, with a Resource Quality Threshold of 30.30

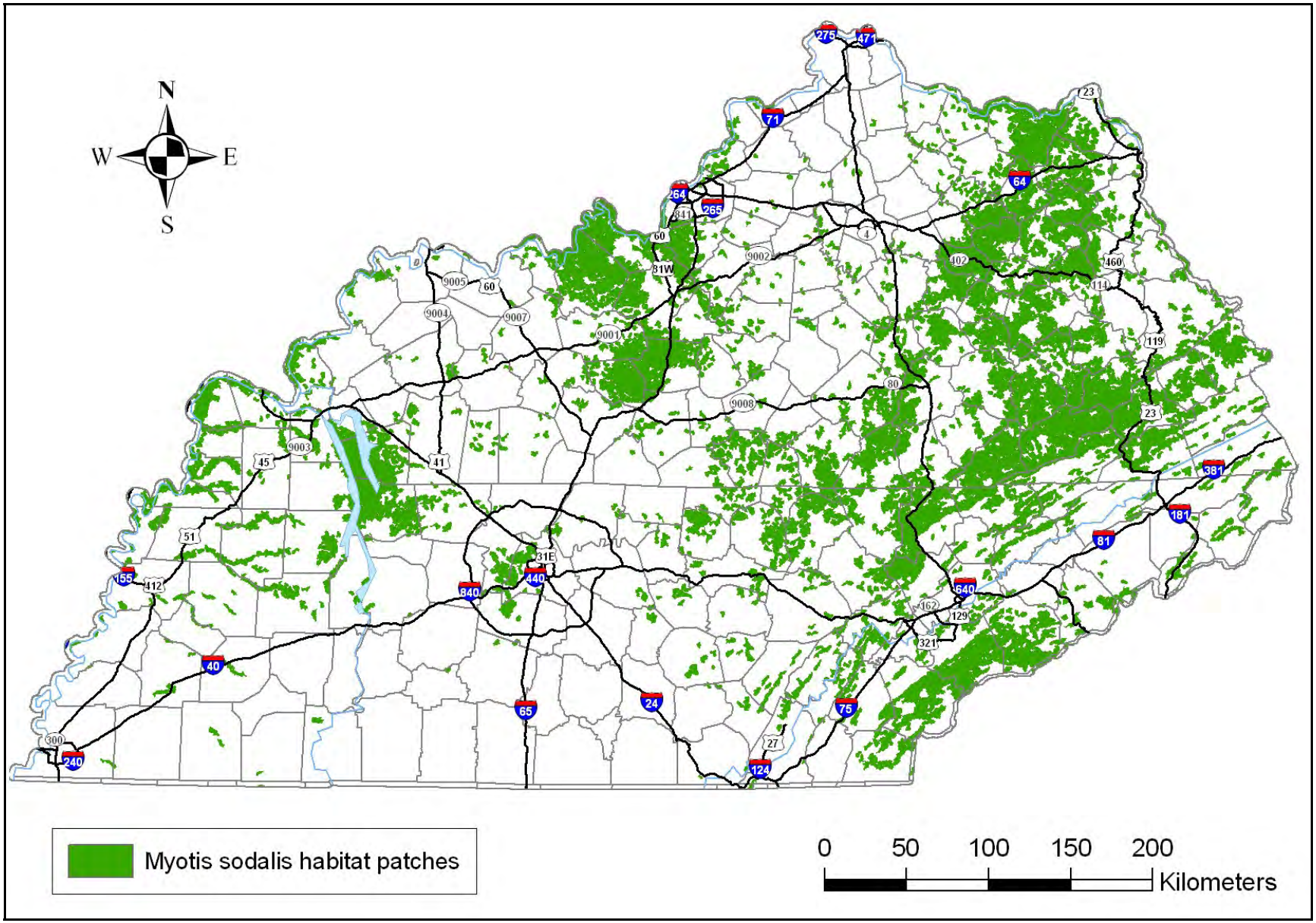
N
W
E
S
Myotis sodalis habitat patches
0
50
100
150
200
Kilometers

Fig. 3. Modeled habitat patches for *Myotis sodalis*, with a Resource Quality Threshold of 23.55.

Pilot Modeling of *Myotis sodalis* Summer Habitat

Indiana

August 25, 2009

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Introduction

The Conservation Fund is assisting the US Fish and Wildlife Service (USFWS), NiSource, and 13 affected states (DE, IN, KY, LA, MD, MS, NJ, NY, OH, PA, TN, VA, and WV) to create a multi-species, multi-state habitat conservation plan covering future construction, operation, and maintenance of NiSource natural gas pipelines and ancillary facilities. Indiana bat (*Myotis sodalis*) is one of the covered species.

Myotis sodalis hibernates in caves with temperatures around 37-43 °F and humid in mid-winter; then migrates up to 575 km to summer roosts (USFWS 2007). Indiana bats are loyal to summer home territories where they select primary roosts that are often in open lowland habitats, near water, and receive direct sun exposure for at least half of each day (Bat Conservation International 2001). Maternity sites generally are under the sloughing bark of large-diameter live, dead, and partially dead trees (typically elms, cottonwoods, green ash, oaks, and shagbark hickory) or in tree cavities in upland and lowland forest (Bat Conservation International 2001, USFWS 2007). They use the best remaining forest blocks available (USFWS 2007). *Myotis sodalis* typically forages in closed to semi-open forest and forest edges, following tree-lined paths through the landscape rather than crossing large open areas (USFWS 2007).

Duchamp and Swihart (2008) surveyed bats in the upper Wabash River basin, Indiana, and compared species composition, morphology, and landscape characteristics. They found that bat species diversity was higher in areas with more forest, and that Indiana bats and other *Myotis* species were found in unfragmented forest. Duchamp and Swihart wrote that bats like *Myotis spp.* adapted to flying in forest rely on this habitat for survival, that cavity roosters are found in areas with more forest, that retaining and restoring large forest blocks can benefit bat diversity, and that retaining forest corridors can also benefit bat diversity.

Using data from Duchamp and Swihart's 2008 study, we performed pilot modeling of *Myotis sodalis* habitat in the upper Wabash basin ("Pilot Modeling of *Myotis sodalis* Summer Habitat in the Upper Wabash River Watershed"), with the hope that these methods could be extrapolated throughout the NiSource project states. We employed two complementary modeling programs, Maxent and FunConn, which are described in detail in "A summary of maximum entropy, FunConn, and least cost path modeling". Here, we describe these methods applied to the entire state of Indiana.

Methods

Locational data

We obtained summer records of *Myotis sodalis* from USFWS. We omitted records prior to 1990 and those outside the Indiana state border, and reprojected the shapefile to match the environmental variables (UTM, Zone 16, NAD 1927, meters). Records lacking coordinates were not used; 204 records remained. We then used Hawth's Tools to add the coordinates to the attribute table. We then re-ran the model after being supplied additional data; adding four records from Indiana State University (ISU)'s Indianapolis airport study (3708, SB 196, 472, and 3483) that have received extensive use across multiple years (Dale Sparks, email, 25 Aug. 2009) and were not immediately adjacent (<100 m) to USFWS points.

Environmental variables

Expanding on a pilot study in the Upper Wabash watershed, we calculated 17 variables within the study area (Table 1), using ArcGIS Model Builder. Based on results from this group of variables and the pilot study, we then examined the variables in Table 2. We also sought to compare NLCD to GAP land cover. Table 3 shows how GAP was reclassified for some of these variables. We based the 1 km scale on the average foraging range of 11 individuals tracked by Sparks et al. (2005), and the 3 km scale on their averaged maximum linear distance from roost. To speed computations, which otherwise would have taken many hours, we resampled land cover variables to a resolution of 90m for 3 km focal statistics. We did not think this would introduce appreciable error.

Table 1. Initial variables examined for habitat modeling for *Myotis sodalis* in Indiana.

Variable name	Variable description	Source data
pct_forwet_1k	Percent forested wetlands within 1 km	NLCD
pct_forstr_1k	Percent area within 1 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_1k	Percent development within 1 km	NLCD
pct_edges_1k	Length of forest edges with fields or open water within 1 km	NLCD
str_dfor_m_1k	Length of unchannelized streams or rivers in deciduous forest within 1 km	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_forwet_3k	Percent forested wetlands within 3 km	NLCD
pct_forstr_3k	Percent area within 3 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_3k	Percent development within 3 km	NLCD
pct_edges_3k	Length of forest edges with fields or open water within 3 km	NLCD
str_dfor_m_3k	Length of unchannelized streams or rivers in deciduous forest within 3 km	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
dist_busy_rds	Distance from busy roads (Average Annual Daily Traffic >10,000)	IN DOT roads with traffic counts
dist_caves	Distance to karst caves	
dist_hibernac	Distance to known winter hibernacula	USFWS
in_mintemp06	June min. temperature	Climate Source, ~400m resolution, 1971-2000 average
in_maxtemp06	June max. temperature	Climate Source, ~400m resolution, 1971-2000 average
in_avgtemp	Annual mean temperature	Climate Source, ~400m resolution, 1971-2000 average

Variable name	Variable description	Source data
in_precip06	June mean precipitation	Climate Source, ~400m resolution, 1971-2000 average

Table 2. Second group of variables examined for habitat modeling for *Myotis sodalis* in Indiana.

Variable name	Variable description	Source data
pct_decfor_1k	Percent closed canopy hardwood forest, floodplain forest, and swamps within 1 km	GAP
pct_forstr_1k	Percent area within 1 km of blocks of closed canopy hardwood forest, floodplain forest, or swamp containing unchannelized streams or rivers	GAP and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
str_dfor_m_1k	Length of unchannelized streams and rivers in closed canopy hardwood forest, floodplain forest, or swamp within 1 km	NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_1k	Percent development within 1 km	GAP
pct_edges_1k	Length of forest edges with fields or open water within 1 km	GAP
pct_decfor_3k	Percent closed canopy hardwood forest, floodplain forest, and swamps within 3 km	GAP
pct_forstr_3k	Percent area within 3 km of blocks of closed canopy hardwood forest, floodplain forest, or swamp containing unchannelized streams or rivers	GAP and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
str_dfor_m_3k	Length of unchannelized streams and rivers in closed canopy hardwood forest, floodplain forest, or swamp within 3 km	NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_3k	Percent development within 3 km	GAP
pct_edges_3k	Length of forest edges with fields or open water within 3 km	GAP
dist_busy_rds	Distance from busy roads (Average Annual Daily Traffic >10,000)	IN DOT roads with traffic counts
dist_caves	Distance to karst caves	
dist_hibernac	Distance to known winter hibernacula	USFWS

Table 3. GAP vegetation reclassifications.

Value	Class	Deciduous forest	Floodplain forest or swamps	Open water	Open fields	Develop -ment
1	Unclassified	No data	No data	No data	No data	No data
2	Developed or barren	0	0	0	0	1
3	High density urban	0	0	0	0	1
4	Low density urban	0	0	0	0	1
6	Agriculture - row crops	0	0	0	1	0
7	Agriculture - pasture and grasslands	0	0	0	1	0
8	Old field deciduous saplings and shrubs	0	0	0	0	0
9	Early successional deciduous woodland	0	0	0	0	0
10	Closed canopy hardwood mid-successional forest	1	0	0	0	0
11	Pine forest	0	0	0	0	0
12	Mixed pine-hardwood mid-successional forest	0	0	0	0	0
13	Floodplain forest; also swamp forest or larch bogs	1	1	0	0	0
14	Bald cypress swamps or open canopy floodplain forest	1	1	0	0	0
15	Willow or buttonbush shrubby wetlands	0	0	0	0	0
16	Herbaceous wetlands	0	0	0	1	0
17	Unvegetated wetlands and shorelines	0	0	0	0	0
18	Open water	0	0	1	0	0

According to the Maxent programmers (pers. comm. with Michael Dougherty, WV DNR, 9 March 2009), as long as we used <30 variables, based on their experience, the program shouldn't experience overfitting of data. Dougherty found that even models with 100 variables had output similar to models with 30 variables. The Maxent programmers recommended limiting the variables using expert judgment.

Maxent modeling

Locational data and environmental layers were then processed in Maxent (see separate description). We used 10-fold cross-validation and examined the mean and standard deviation of the replicate runs. The use of 10 replications was somewhat arbitrary, but was based on standard practice, as well as time limitations.

FunConn modeling

We used the Maxent average model output (Myotis_sodalis_avg.asc; converted to an integer grid between 0 and 100) as the Habitat Quality Raster input to the program FunConn (see separate description), to identify potential habitat patches. We modified the Habitat Quality Raster by giving busy roads and developed land a habitat value of 0 (i.e., the lowest possible suitability). Based on the pilot study in the upper Wabash watershed, we set the minimum patch size as the average foraging range (335 ha) of 11 Indiana bats tracked by Sparks et al. (2005); and the foraging radius to the average maximum linear distance that these bats traveled from their roost (3020 m). We set the Resource Quality Threshold to the average model output that captured 90% of test points.

Results

Maxent habitat suitability – Table 1 variables, without ISU data

Fig. 1 shows mean Maxent output from the variables in Table 1 and summer records of *Myotis sodalis* supplied by USFWS (i.e., before the ISU data was available). The average test area under the receiver operating characteristic curve (AUC) for the replicate runs was 0.878 (standard deviation 0.014). Percent area within 1 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers (pct_forstr_1k) had the greatest contribution to the Maxent models (Table 4). This was followed by the length of unchannelized streams or rivers in deciduous forest within 1 km (str_dfor_m_1k). Jackknife tests showed that the environmental variable with highest gain when used in isolation was pct_forstr_1k, which therefore appeared to have the most useful information by itself. The environmental variable that decreased the gain the most when it was omitted was str_dfor_m_1k, which therefore appeared to have the most information that wasn't present in the other variables. Percent forested wetlands (pct_forwet_1k and pct_forwet_3k) provided minimal contributions to the models.

As expected, predicted habitat suitability was greater as the amount of nearby deciduous forest and forested wetlands containing unchannelized streams or rivers (pct_forstr_1k, str_dfor_m_1k, pct_forstr_3k, and str_dfor_m_3k) increased, and distance from caves (dist_caves), distance from winter hibernacula (dist_winter), and the percentage of nearby development (especially pct_devel_1k) decreased. Distance from busy roads (dist_busy_rds) did not seem to have a strong relationship. Predicted suitability actually decreased as percent forested wetlands (pct_forwet_1k and pct_forwet_3k) increased, but variance among models was quite high. Percent edges seemed to add the most at intermediate values (10% within 1 km and 40% within 3 km), with the 3 km distance contributing more. Predicted suitability was generally greater for areas with higher temperatures, but these areas also had much more forest and caves. Precipitation had a highly variable relationship with suitability, but this may not have been causative.

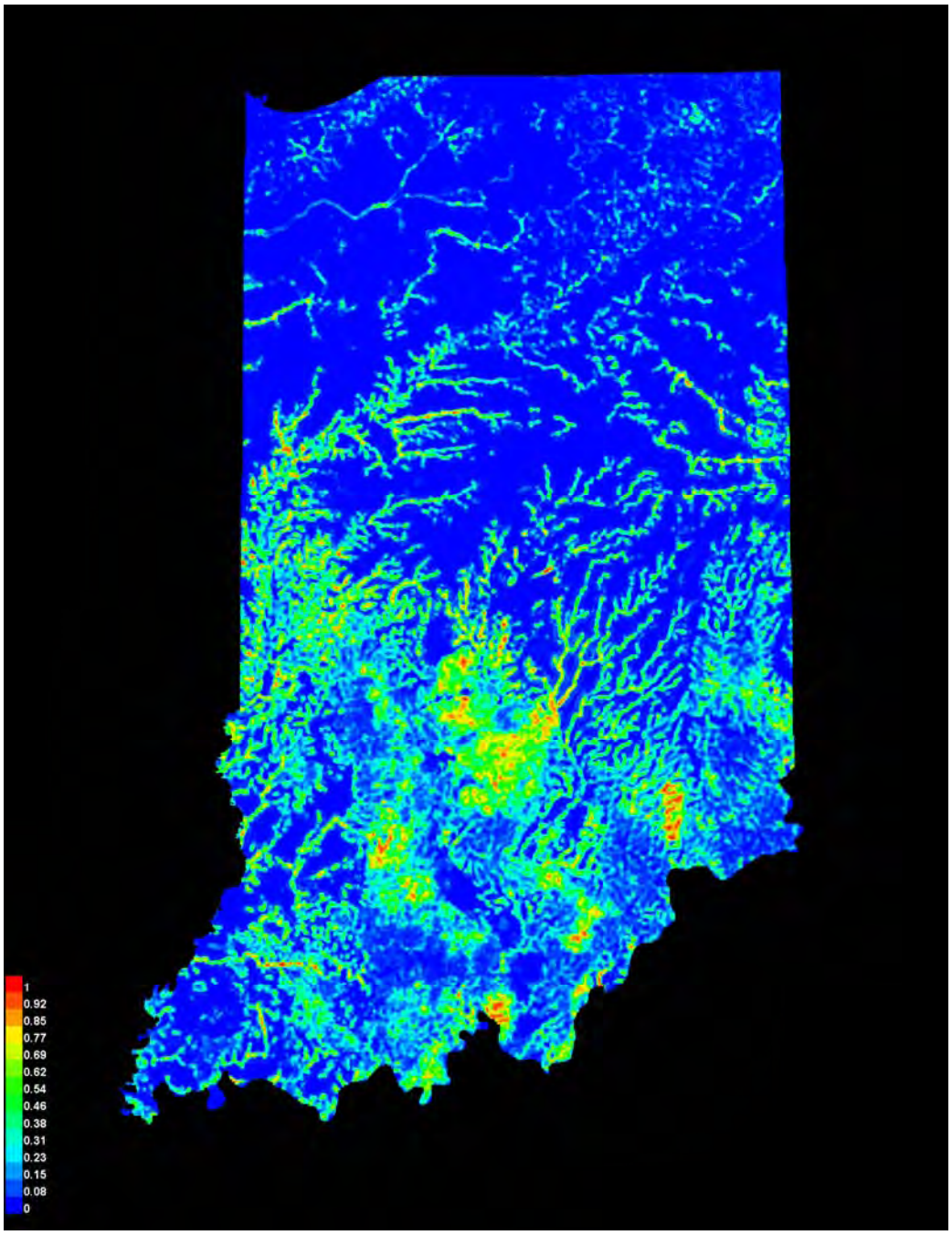

Fig. 1. Maxent modeled habitat suitability for *Myotis sodalis*, using variables in Table 1.

Table 4. Heuristic estimate of relative contributions of the environmental variables in Table 1 to the Maxent model. To determine the estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. As with the jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

Variable	Percent contribution
pct_forstr_1k	39.5
str_dfor_m_1k	16.3
pct_edges_3k	8.6
pct_forstr_3k	6.0
in_mintemp06	4.3
dist_caves	3.6
str_dfor_m_3k	3.3
dist_winter	3.0
in_precip06	2.7
pct_devel_1k	2.5
in_maxtemp06	2.4
in_avgtemp06	2.0
dist_busy_rds	1.8
pct_forwet_1k	1.1
pct_edges_1k	1.1
pct_forwet_3k	1.1
pct_devel_3k	0.9

Maxent habitat suitability – Table 2 variables, without ISU data

Fig. 2 shows mean Maxent output from the variables in Table 2 and summer records of *Myotis sodalis* supplied by USFWS. Similar to running with the variables in Table 1, the average test area under the receiver operating characteristic curve (AUC) for the replicate runs was 0.877 (standard deviation 0.017). Percent area within 1 km of blocks of closed canopy hardwood forest, floodplain forest, or swamp containing unchannelized streams or rivers (pct_forstr_1k) had the greatest contribution to the Maxent models (Table 5). This was followed by the length of unchannelized streams or rivers in closed canopy hardwood forest, floodplain forest, or swamp within 1 km (str_dfor_m_1k). Jackknife tests showed that the environmental variable with highest gain when used in isolation was pct_forstr_1k, which therefore appeared to have the most useful information by itself. The environmental variable that decreased the gain the most when it was omitted was str_dfor_m_1k, which therefore appeared to have the most information that wasn't present in the other variables. Percent development (pct_devel_1k and pct_devel_3k) and distance to busy roads (dist_busy_rds) provided minimal contributions to the models.

Similar to the models using the Table 1 variables, predicted habitat suitability was greater as the amount of nearby closed canopy hardwood forest, floodplain forest, or swamp containing unchannelized streams or rivers (pct_forstr_1k, str_dfor_m_1k, pct_forstr_3k, and str_dfor_m_3k) increased, and distance from winter hibernacula (dist_hibernac) and distance from caves (dist_caves) decreased. Predicted suitability increased as percent closed canopy hardwood forest, floodplain forest, and swamps (pct_decfor_1k and pct_decfor_3k) increased, but this was only apparent when the variables were used

alone, not in combination with other variables. Similarly, predicted suitability decreased as percent development (pct_devel_1k and pct_devel_3k) increased, but this was only apparent when the variables were used alone. Percent edges within 1 km provided minimal information, but when considered alone, percent edges within 3 km seemed to predict better habitat between around 25-40%.

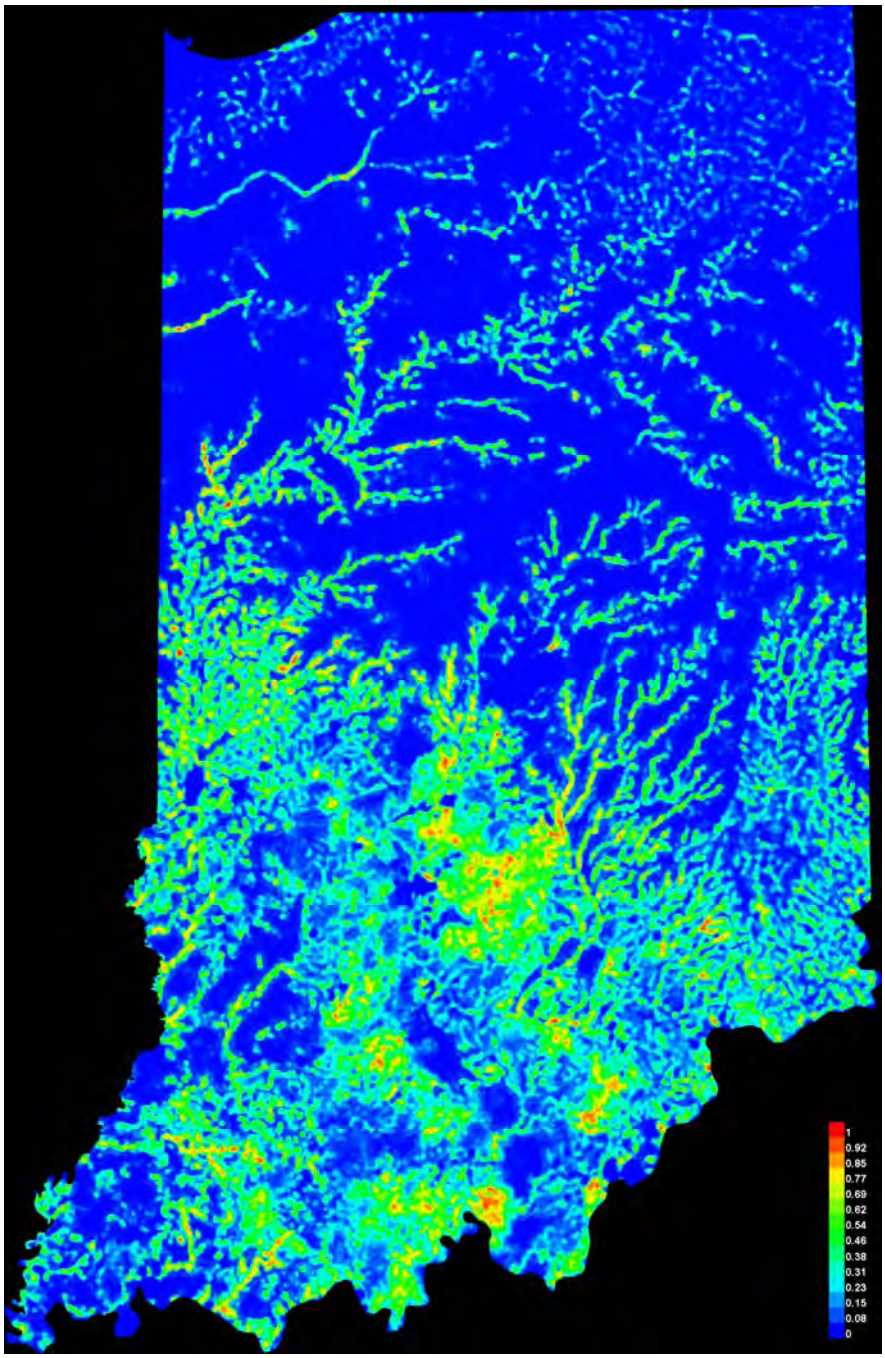

Fig. 2. Maxent modeled habitat suitability for *Myotis sodalis*, using variables in Table 2.

Table 5. Heuristic estimate of relative contributions of the environmental variables in Table 2 to the Maxent model. To determine the estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. As with the jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

Variable	Percent contribution
pct_forstr_1k	33.0
str_dfor_m_1k	20.9
dist_hibernac	9.6
pct_decfor_1k	7.2
pct_edges_3k	6.7
str_dfor_m_3k	6.0
dist_caves	3.6
pct_forstr_3k	3.1
dist_busy_rds	2.9
pct_devel_3k	2.1
pct_decfor_3k	1.9
pct_devel_1k	1.8
pct_edges_1k	1.1

Maxent habitat suitability – Table 2 variables, with ISU data included

Adding the Indianapolis airport roosts increased model accuracy (AUC averaging 88.5%) but with more variability between models (std 0.038). Model output (Fig. 3) and variable contributions (e.g., Table 6) resembled that without the ISU data.

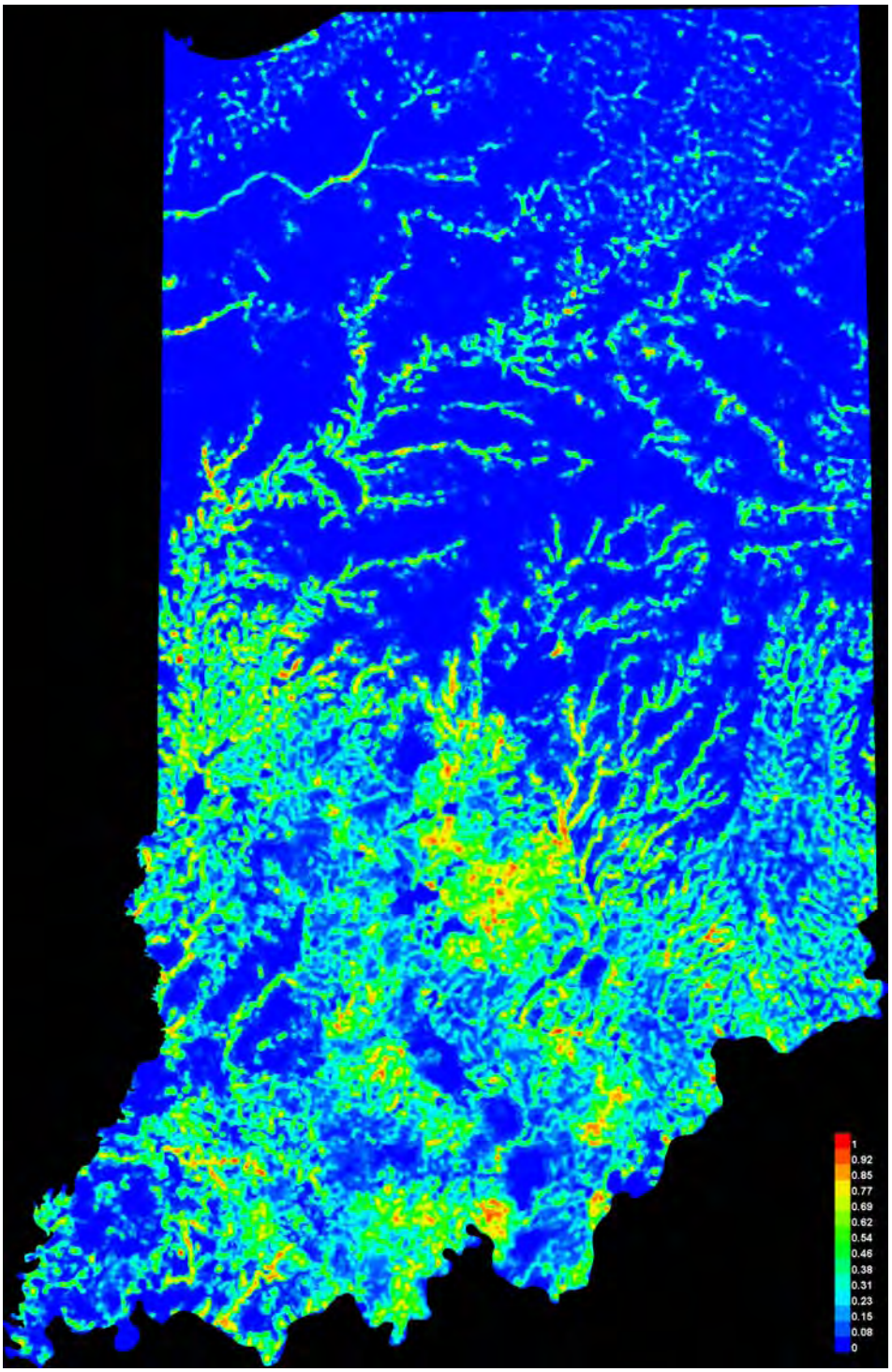

Fig. 3. Maxent modeled habitat suitability for *Myotis sodalis*, using variables in Table 2, and with ISU data added.

Table 6. Heuristic estimate of relative contributions of the environmental variables in Table 2, to the Maxent model with ISU locations included.

Variable	Percent contribution
pct_forstr_1k	28.7
str_dfor_m_1k	22.6
dist_hibernac	11.5
pct_decfor_1k	9.7
str_dfor_m_3k	7.3
pct_edges_3k	7
dist_busy_rds	3
dist_caves	2.7
pct_forstr_3k	2.1
pct_devel_3k	1.9
pct_devel_1k	1.4
pct_decfor_3k	1.2
pct_edges_1k	0.8

FunConn patch model, without ISU data

We did not notice a difference in model output using variables from Table 1 or Table 2. Therefore, following the principle of parsimony, we selected the average output of models using Table 2, since this used fewer variables. We set the Resource Quality Threshold to 17.65, which included on average approximately 95% of training locations, 90% of test locations, and 30% of total area.

FunConn identified 277 patches with a minimum size 482 ha, maximum size 2,597,804 ha, mean size 12,464 ha, and total area 3,452,594 ha (36.8% of the state; see Fig. 4). 431 of 444 *M. sodalis* locations (97%) fell within these patches.

FunConn patch model, with ISU data included

We set the Resource Quality Threshold to 18.08, which included on average approximately 95% of training locations, 90% of test locations, and 30% of total area.

FunConn identified 272 patches with a minimum size 372 ha, maximum size 2,702,422 ha, mean size 12,839 ha, and total area 3,492,118 ha (37.2% of the state; see Fig. 5). 432 of 448 *M. sodalis* locations (96%) fell within these patches.

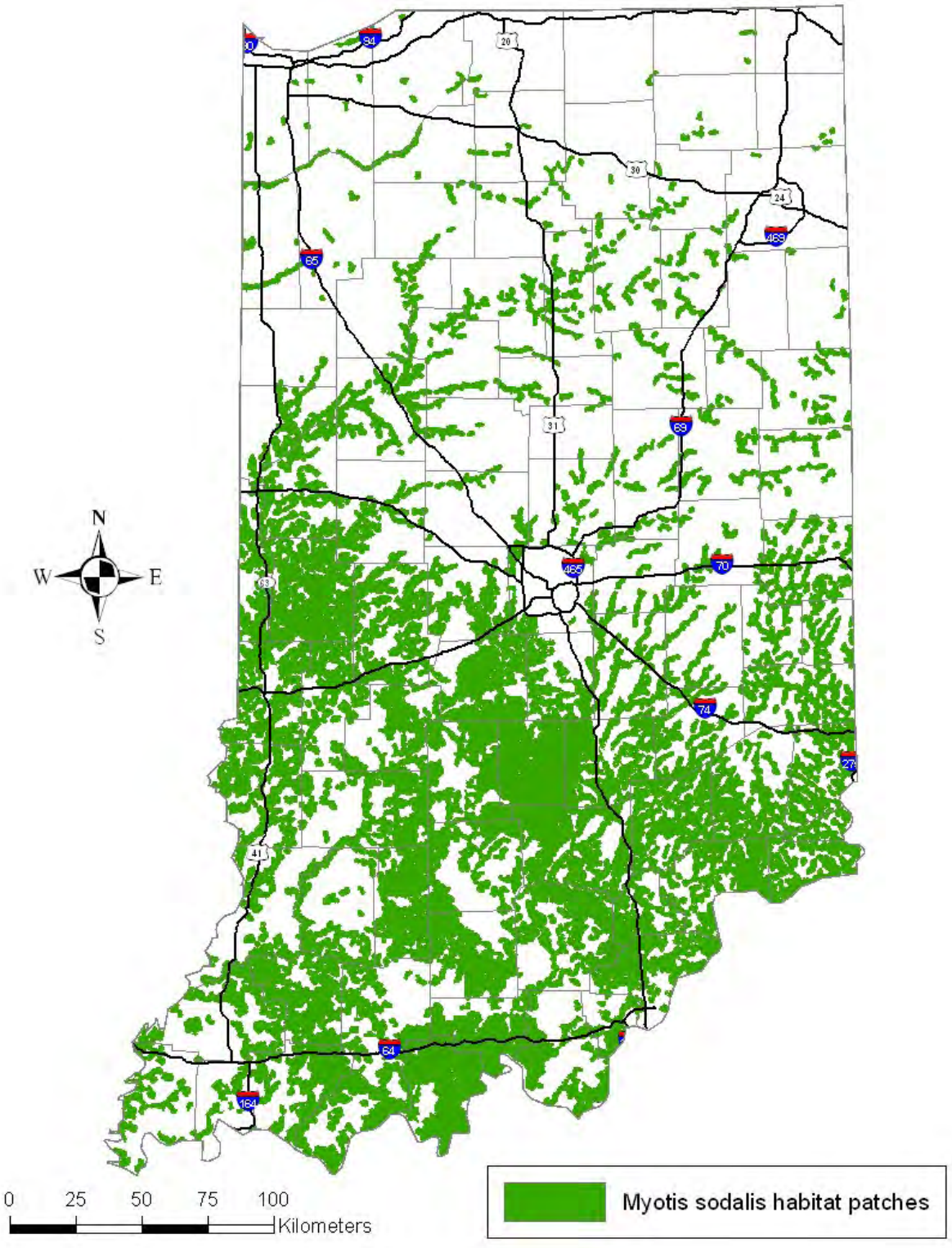

Fig. 4. Modeled habitat patches for *Myotis sodalis.*

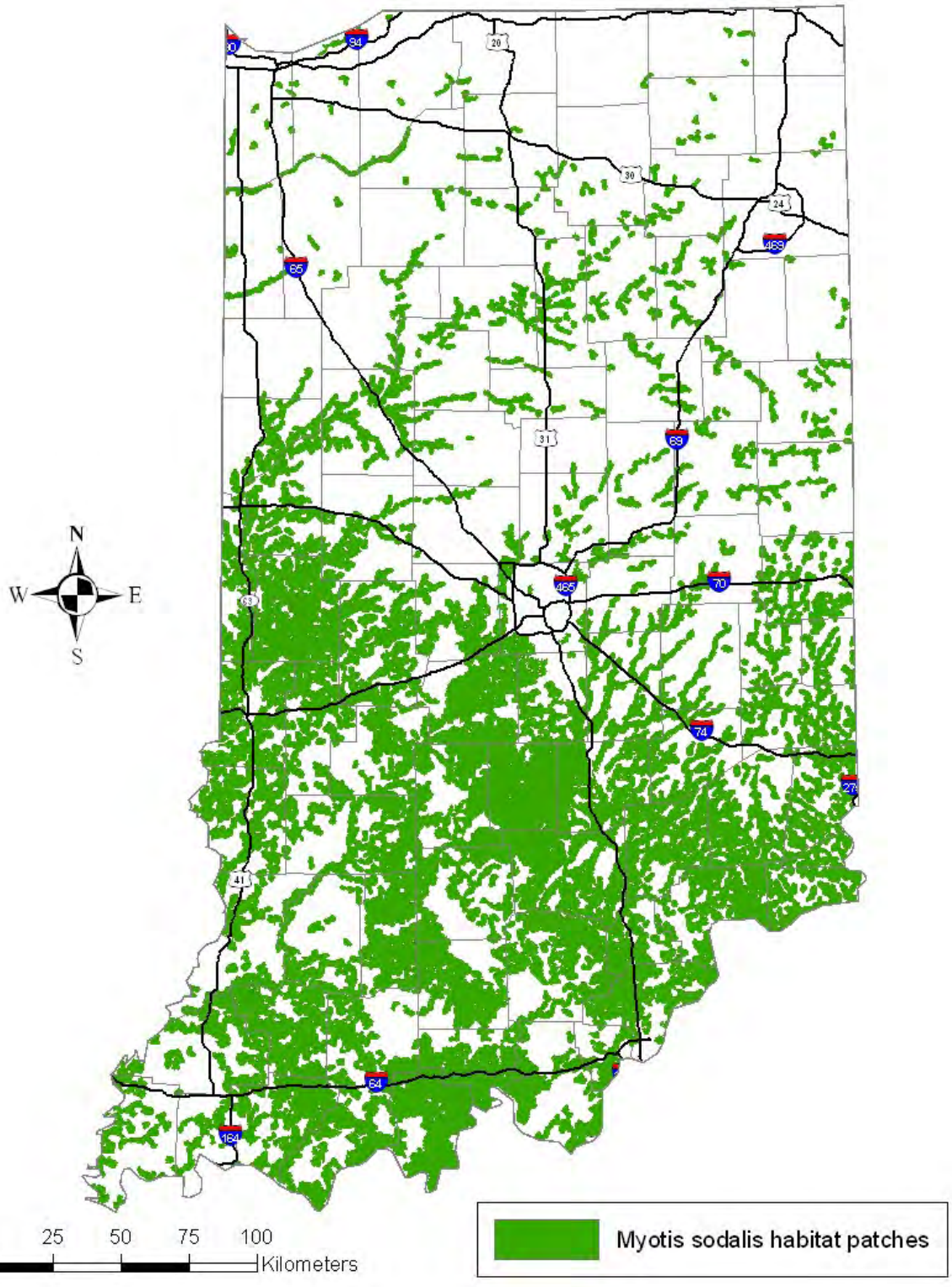

Fig. 5. Modeled habitat patches for *Myotis sodalis*, with ISU data included.

Discussion

The various Maxent models created similar output. It did not seem to matter whether we used NLCD or GAP land cover, or whether we added climate variables or not. Mature riparian forest seemed to be the strongest predictor of *Myotis sodalis* presence, although other variables such as availability of forest edges also seemed to be important. Climate variables did not appear to influence habitat suitability except as geographic correlates (i.e., southern Indiana is both warmer and more forested). Similarly, winter hibernacula were also concentrated in southern Indiana, but aside from the greater amount of forest in this area, summer occurrences were not specifically clustered around winter hibernacula or other caves.

These findings are consistent with the literature cited in the introduction. Riparian forest is likely to contain older trees than upland forest since it is less suitable for farming, and may have been retained for nutrient reduction, erosion control, or flood control purposes. Furthermore, floods may kill trees, creating snags ideal for bat roosts. Finally, water in streams, rivers, ponds, and wetlands may supply mosquitoes and other insects. Forest edges with fields and water are utilized by bats for foraging.

The FunConn models identified over a third of the state as suitable *M. sodalis* summer habitat. This should include primary and secondary roosting trees, foraging locations, drinking water, and other habitat needs. Because this species is endangered, we purposely sought to minimize errors of omission rather than errors of commission. Therefore, we strongly recommend field verification within the modeled habitat patches before making specific conservation or mitigation decisions. Furthermore, suitable roost trees cannot be identified remotely, only inferred; and identification of such microhabitat features requires ground level surveys.

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Pilot Modeling of Myotis sodalis Summer Habitat

Ohio

Feb 4, 2010

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Methods

Study area

The study area included all of Ohio, except the islands in Lake Erie, plus the northern panhandle of WV (Brooke, Hancock, Marshall, and Ohio counties). We buffered this area 3 km to account for focalsum computations on the border. The total study area (including the 3 km buffer) was 113,293 km^2.

Locational data

We obtained summer records of *Myotis sodalis* in Ohio and the northern panhandle of WV from Ohio Dept. of Natural Resources (ODNR) and U.S. Fish and Wildlife Service (FWS). We omitted records prior to 1990, and records where comments indicated no exact location. We had 45 locations from a wind power survey in Logan County. So as not to spatially bias the statewide model, only the 8 roost tree locations were used from this study. Similarly, we had 17 locations from a 2008 study in Franklin County. So as not to spatially bias the statewide model, only the roost tree location was used from this study. There were 3 spatially coincident points on Big Darby Creek. We deleted two of them, keeping only the record labeled "primary maternity roost tree". There were also two other points 100 m from this location, that we deleted. There were two spatially coincident points in Greene County. We deleted one.

We added five summer locations from OH_IBat_Summer_ODNR since 1990 that were >1 km from OH_IBAT_2009_Summer locations. We converted these polygons to centroids. We also added 17 occurrences in OH and 4 in the northern panhandle of WV from ESI surveys in summer 2009. Summer point locations totaled 85. We then used Hawth's Tools to add the coordinates to the attribute table.

Environmental variables

Expanding on pilot studies in Indiana, we calculated 18 variables within the study area (Table 1), using ArcGIS Model Builder. We based the 1 km scale on the average foraging range of 11 individuals tracked by Sparks et al. (2005), and the 3 km scale on their averaged maximum linear distance from roost. To speed computations, which otherwise would have taken many hours, we resampled land cover variables to a resolution of 90m for 3 km focal statistics. We did not think this would introduce appreciable error.

Table 1. Variables examined for habitat modeling for *Myotis sodalis* in the Ohio study area.

Variable name	Variable description	Source data
pct_forwet_1k	Percent forested wetlands within 1 km	NLCD
pct_forstr_1k	Percent area within 1 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_1k	Percent development within 1 km	NLCD
pct_edges_1k	Length of forest edges with fields or open water within 1 km	NLCD
str_dfor_m_1k	Length of unchannelized streams or rivers in deciduous forest within 1 km	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_forwet_3k	Percent forested wetlands within 3 km	NLCD
pct_forstr_3k	Percent area within 3 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_3k	Percent development within 3 km	NLCD
pct_edges_3k	Length of forest edges with fields or open water within 3 km	NLCD
str_dfor_m_3k	Length of unchannelized streams or rivers in deciduous forest within 3 km	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
dist_maj_rds	Distance from major roads	ESRI street data
dist_hibernac	Distance to known winter hibernacula with at least 100 *M. sodalis* individuals recorded in surveys between 2000-8. We used 100 as a cutoff based on the Kentucky Bat Working Group.	USFWS + state heritage programs
junsol_fmn_1k	Mean June insolation within 1 km	Calculated by TCF from 30m DEMs and latitude
oh_jn_solar	June insolation at grid cell	Calculated by TCF from 30m DEMs and latitude
oh_tmin_06	June min. temperature	Climate Source, ~400m resolution, 1971-2000 average
oh_tmax_06	June max. temperature	Climate Source, ~400m resolution, 1971-2000 average
oh_tmean_06	June mean temperature	Climate Source, ~400m resolution, 1971-2000 average
oh_precip06	June mean precipitation	Climate Source, ~400m resolution, 1971-2000 average

Maxent modeling

We then processed locational data and environmental layers in Maxent. We used 10-fold cross-validation and examined the mean and standard deviation of the replicate runs. The use of 10 replications was somewhat arbitrary, but was based on standard practice, as well as time limitations.

FunConn modeling

We used the Maxent average model output (Myotis_sodalis_avg.asc; converted to an integer grid between 0 and 100) as the Habitat Quality Raster input to the program FunConn, to identify potential habitat patches. We modified the Habitat Quality Raster by giving busy roads and developed land (NLCD classes 22-24; i.e., excluding developed open space) a habitat value of 0 (i.e., the lowest possible suitability). Based on the pilot study in the upper Wabash watershed, we set the minimum patch size as the average foraging range (335 ha) of 11 Indiana bats tracked by Sparks et al. (2005); and the foraging radius to the average maximum linear distance that these bats traveled from their roost (3020 m). We hoped to set the Resource Quality Threshold to the average model output that captured 90% of test points, if the binomial probability was <0.05. We used the default value (0.1) for core habitat percentage.

Results

Maxent habitat suitability

Fig. 1 shows mean Maxent output. The average test area under the receiver operating characteristic curve (AUC) for the replicate runs was 0.788 (standard deviation 0.089). The length of streams in deciduous forest within 1 km (str_dfor_m_1k) had the greatest contribution to the Maxent models (Table 2). This was followed by distance to hibernacula (dist_hibernac), and the percent area within 1 km and 3 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers (pct_forstr_1k and pct_forstr_3k). Jackknife tests showed that the environmental variable with highest gain when used in isolation was str_dfor_m_1k, which therefore appeared to have the most useful information by itself. The environmental variable that decreased the gain the most when it was omitted was pct_forstr_3k, which therefore appeared to have the most information that wasn't present in the other variables.

Predicted habitat suitability was greater as the length of forested streams and percent of nearby deciduous forest and forested wetlands containing unchannelized streams or rivers (str_dfor_m_1k, str_dfor_m_3k, and pct_forstr_1k) increased. Distance from winter hibernacula (dist_hibernac) and maximum June temperature (oh_tmax_06) were also related to predicted distribution, but as non-intuitive step functions.

Table 2. Heuristic estimate of relative contributions of the environmental variables in Table 1 to the Maxent model. To determine the estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. As with the jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

Variable	Percent contribution
str_dfor_m_1k	13.9
dist_hibernac	13.8
pct_forstr_1k	12.6
pct_forstr_3k	12.1
str_dfor_m_3k	9.4
pct_edges_3k	5.9
pct_edges_1k	5.5
pct_devel_3k	5.2
oh_tmax_06	4.9
oh_tmin_06	3.5
dist_maj_rds	3.0
junsol_fmn_1k	2.6
oh_jn_solar	2.4
pct_forwet_3k	1.5
pct_devel_1k	1.5
oh_precip06	1.2
pct_forwet_1k	0.7
oh_tmean_06	0.3

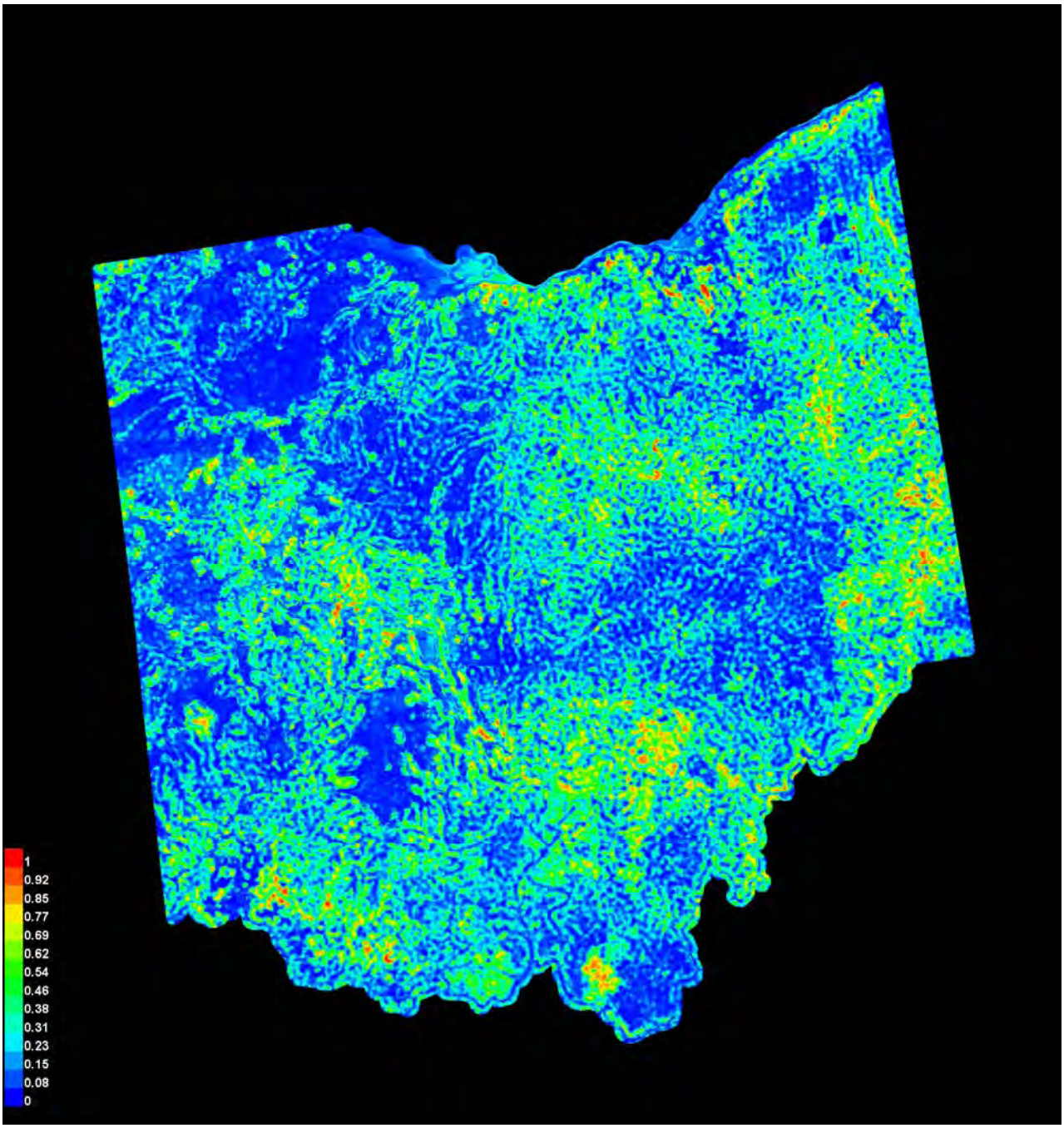

Fig. 1. Maxent modeled summer habitat suitability for *Myotis sodalis*.

FunConn patch model

The logistic threshold (11.21) that balanced Maxent training omission, predicted area, and threshold value included on average over 99% of Maxent training locations, 91% of test locations, but 64% of total area, and p = 0.1355. We therefore used a more restrictive threshold, 42.62, corresponding to maximum test sensitivity plus specificity. This threshold included on average approximately 82% of Maxent training locations, 74% of test locations, and 20% of total area (p=0.0082).

FunConn identified 455 patches with a minimum size 402 ha, maximum size 381,590 ha, mean size 5,865 ha, and total area 2,668,457 ha (23.6% of the study area). 66 of 96 M. sodalis locations (69%) fell within these patches. We considered an inclusion rate of 69% to be unacceptable.

Therefore, we ran FunConn again with a threshold of 20. This identified 457 patches with a minimum size 362 ha, maximum size 3,845,162 ha, mean size 13,114 ha, and total area 5,993,074 ha (52.9% of the study area; see Fig. 2). 88 of 96 M. sodalis locations (92%) fell within these patches.

We also ran FunConn with a threshold of 30. This identified 496 patches with a minimum size 377 ha, maximum size 1,293,788 ha, mean size 8848 ha, and total area 4,388,670 ha (38.7% of the study area; see Fig. 2). 83 of 96 M. sodalis locations (86%) fell within these patches. This last threshold seemed better than the alternatives.

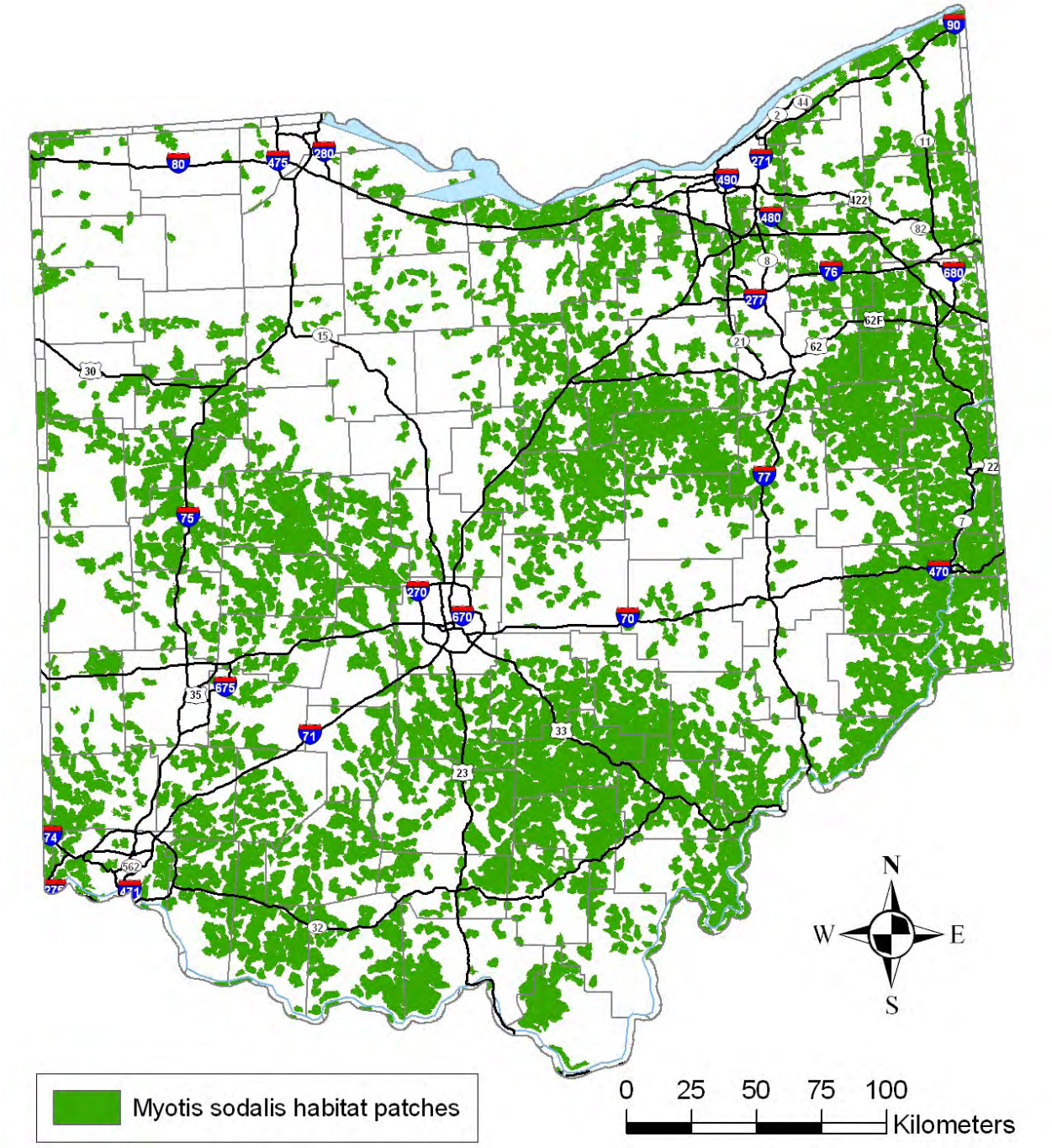

Fig. 2. Modeled summer habitat patches for *Myotis sodalis* in Ohio.

Pilot Modeling of Myotis sodalis Summer Habitat

New York and New Jersey

December 3, 2010

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Methods

Study area

The study area included all of New York, plus most of northern New Jersey (Bergen, Essex, Hunterdon, Mercer, Middlesex, Morris, Passaic, Somerset, Sussex, Union, and Warren counties). We buffered this area 3 km to account for focalsum computations on the border. The total study area (including the 3 km buffer) was 137,725 km^2.

Locational data

We obtained summer records of *Myotis sodalis* in New York and New Jersey from New York Natural Heritage Program (NY NHP), New Jersey Department of Environmental Protection (NJ DEP), and U.S. Fish and Wildlife Service (FWS). We omitted records prior to 1990, and converted polygons to centroids. Records tended to be spatially clumped. We removed records <1 km from others to minimize spatial bias, following these preferences:

- maternity sites
- roost sites over feeding locations
- confirmed identity over telemetry
- females over males
- adults over juveniles
- multiple years over single years
- multiple nights over single nights
- more recent locations
- points in the center of clusters

We also added 5 occurrences in western NY from ESI surveys in summer 2009. Summer point locations totaled 160. We then used Hawth's Tools to add the coordinates to the attribute table.

Environmental variables

Expanding on pilot studies in Indiana, we calculated 18 variables within the study area (Table 1), using ArcGIS Model Builder. We based the 1 km scale on the average foraging range of 11 individuals tracked by Sparks et al. (2005), and the 3 km scale on their averaged maximum linear distance from roost. To

speed computations, which otherwise would have taken many hours, we resampled land cover variables to a resolution of 90m for 3 km focal statistics. We did not think this would introduce appreciable error.

Table 1. Variables examined for habitat modeling for Myotis sodalis in the NY-NJ study area.

Variable name	Variable description	Source data
pct_forwet_1k	Percent forested wetlands within 1 km	NLCD
pct_forstr_1k	Percent area within 1 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_1k	Percent development within 1 km	NLCD
pct_edges_1k	Length of forest edges with fields or open water within 1 km	NLCD
str_dfor_m_1k	Length of unchannelized streams or rivers in deciduous forest within 1 km	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_forwet_3k	Percent forested wetlands within 3 km	NLCD
pct_forstr_3k	Percent area within 3 km of blocks of deciduous forest and forested wetlands containing unchannelized streams or rivers	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
pct_devel_3k	Percent development within 3 km	NLCD
pct_edges_3k	Length of forest edges with fields or open water within 3 km	NLCD
str_dfor_m_3k	Length of unchannelized streams or rivers in deciduous forest within 3 km	NLCD and NHD; Ftype = STREAM/RIVER or ARTIFICAL PATH
dist_busy_rds	Distance from major roads	ESRI street data
dist_hibernac	Distance to known winter hibernacula with at least 100 M. sodalis individuals recorded in surveys between 2000-8. We used 100 as a cutoff based on the Kentucky Bat Working Group.	USFWS + state heritage programs
junsol_fmn_1k	Mean June insolation within 1 km	Calculated by TCF from 30m DEMs and latitude
nynj_jn_solar	June insolation at grid cell	Calculated by TCF from 30m DEMs and latitude
nynj_tmin_06	June min. temperature	Climate Source, ~400m resolution, 1971-2000 average
nynj_tmax_06	June max. temperature	Climate Source, ~400m resolution, 1971-2000 average
nynj_tmean_06	June mean temperature	Climate Source, ~400m resolution, 1971-2000 average
nynj_precip06	June mean precipitation	Climate Source, ~400m resolution, 1971-2000 average

Maxent modeling

We then processed locational data and environmental layers in Maxent. We used 10-fold cross-validation, which split the sample into ten different sets of 142-143 training samples and 15-16 test samples, and examined the mean and standard deviation of the replicate runs. The use of 10 replications was somewhat arbitrary, but was based on standard practice, as well as time limitations. Our first model retained all possible variable relationships, but this produced highly artificial output, delineating exact circles corresponding to a distance from hibernacula threshold. Therefore, we subsequently omitted threshold relationships, but kept linear, quadratic, product, and hinge. Only results from this second model are presented here.

FunConn modeling

We used the Maxent average model output (Myotis_sodalis_avg.asc; converted to an integer grid between 0 and 100) as the Habitat Quality Raster input to the program FunConn, to identify potential habitat patches. We modified the Habitat Quality Raster by giving busy roads and developed land (NLCD classes 22-24; i.e., excluding developed open space) a habitat value of 0 (i.e., the lowest possible

suitability). Based on the pilot study in the upper Wabash watershed, we set the minimum patch size as the average foraging range (335 ha) of 11 Indiana bats tracked by Sparks et al. (2005); and the foraging radius to the average maximum linear distance that these bats traveled from their roost (3020 m). We hoped to set the Resource Quality Threshold to the average model output that captured 90% of test points, if the binomial probability was <0.05. We used the default value (0.1) for core habitat percentage.

Results

Maxent habitat suitability

Fig. 1 shows mean Maxent output. The average test area under the receiver operating characteristic curve (AUC) for the replicate runs was 0.930 (standard deviation 0.030). The distance to hibernacula (dist_hibernac) had the greatest contribution to the Maxent models (Table 2). Jackknife tests showed that the environmental variable with highest gain when used in isolation was dist_hibernac, which therefore appeared to have the most useful information by itself. This was followed by mean and maximum June temperature. The environmental variable that decreased the gain the most when it was omitted was dist_hibernac, which therefore appeared to have the most information that wasn't present in the other variables. Table 3 lists the values associated with higher probabilities of suitable *Myotis sodalis* summer habitat, for variables that contributed >5% to the model. Variables were inter-related, and combined in a variety of ways to create the model.

Table 2. Heuristic estimate of relative contributions of the environmental variables in Table 1 to the Maxent model. To determine the estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. As with the jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

Variable	Percent contribution
dist_hibernac	36.4
pct_edges_3k	11.2
pct_forwet_3k	8.6
junsol_fmn_1k	8.3
pct_devel_3k	6.9
pct_forwet_1k	6.0
nynj_tmax_06	4.0
pct_devel_1k	3.3
nynj_tmean_06	3.2
nynj_precip06	2.2
str_dfor_m_1k	1.6
pct_edges_1k	1.6
dist_busy_rds	1.6
nynj_tmin_06	1.2
pct_forstr_1k	1.1
str_dfor_m_3k	1.0
pct_forstr_3k	0.8
nynj_jn_solar	0.8

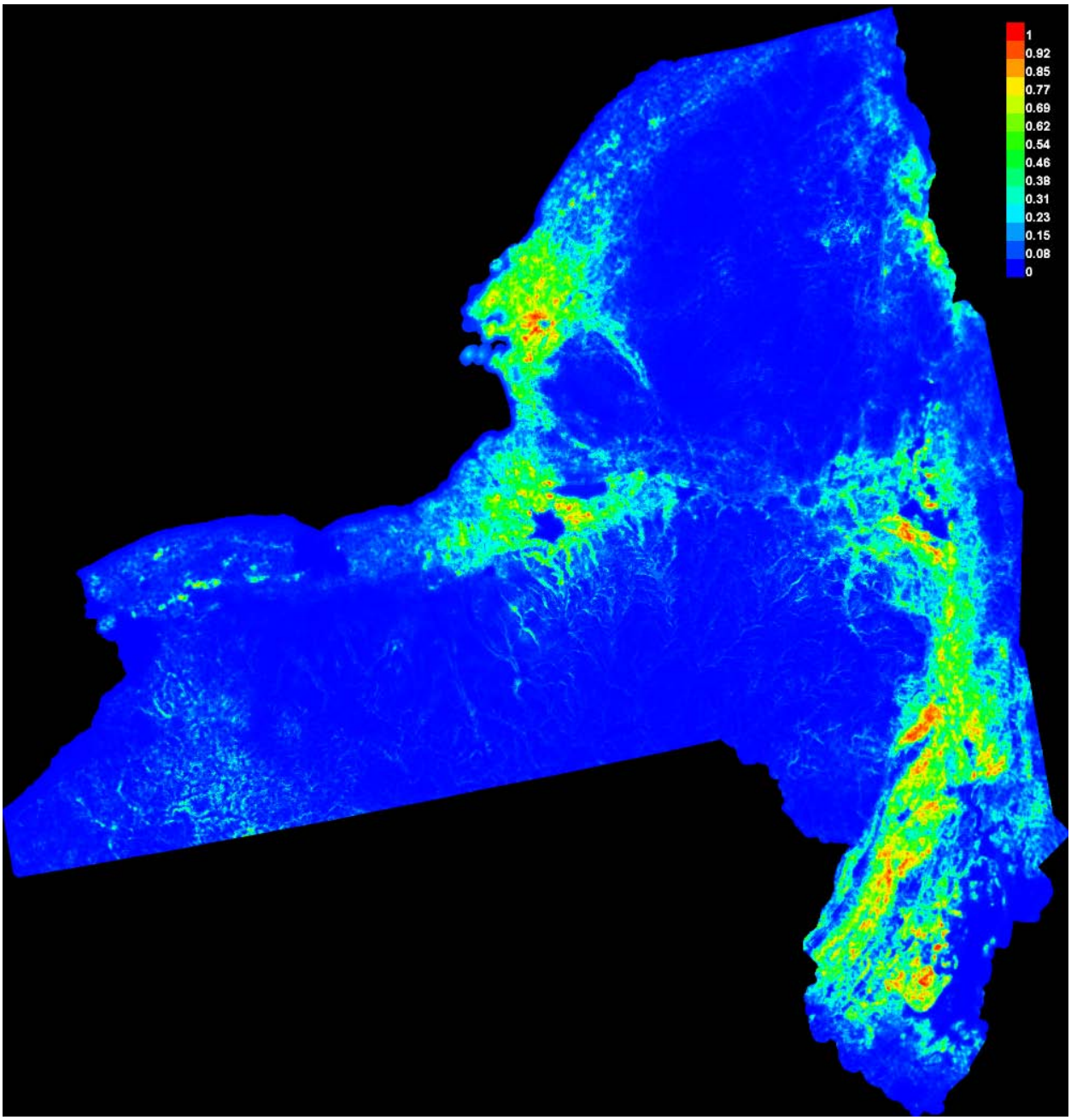

Fig. 1. Maxent modeled summer habitat suitability for *Myotis sodalis*.

Table 3. Values associated with higher probabilities of *Myotis sodalis* summer habitat, for variables that contributed >5% to the model.

Variable	Values associated with *Myotis sodalis* habitat
dist_hibernac	<60 km, especially <40 km
pct_edges_3k	>23%
pct_forwet_3k	>9%
junsol_fmn_1k	peak around 177,000
pct_devel_3k	peak around 10%
pct_forwet_1k	gradual increase after 5%

FunConn patch model

The logistic threshold (4.77) that balanced Maxent training omission, predicted area, and threshold value included on average over 99% of Maxent training locations, 96% of test locations, and 36% of total area ($p < 0.0001$). A more restrictive threshold, 25.49, corresponded to maximum test sensitivity plus specificity. This threshold included on average 91% of Maxent training locations, 92% of test locations, and 13% of total area ($p < 0.0001$).

Using the lower threshold, FunConn identified 230 patches with a minimum size 369 ha, maximum size 3,797,048 ha, mean size 20,906 ha, and total area 4,808,476 ha (35% of the study area; see Fig. 2). 143 of 160 M. sodalis locations (96%) fell within these patches, including 4 out of 5 (80%) identified by ESI in western NY.

Using the higher threshold, FunConn identified 106 patches with a minimum size 387 ha, maximum size 887,337 ha, mean size 18,499 ha, and total area 1,960,923 ha (14% of the study area). 154 of 160 M. sodalis locations (89%) fell within these patches, including none of those identified by ESI in western NY.

Although it covered more than twice the area, we recommend using the lower threshold, because the higher threshold did not capture any points in western NY, and may have been overtrained. The lower threshold, in contrast captured 80% of the western points.

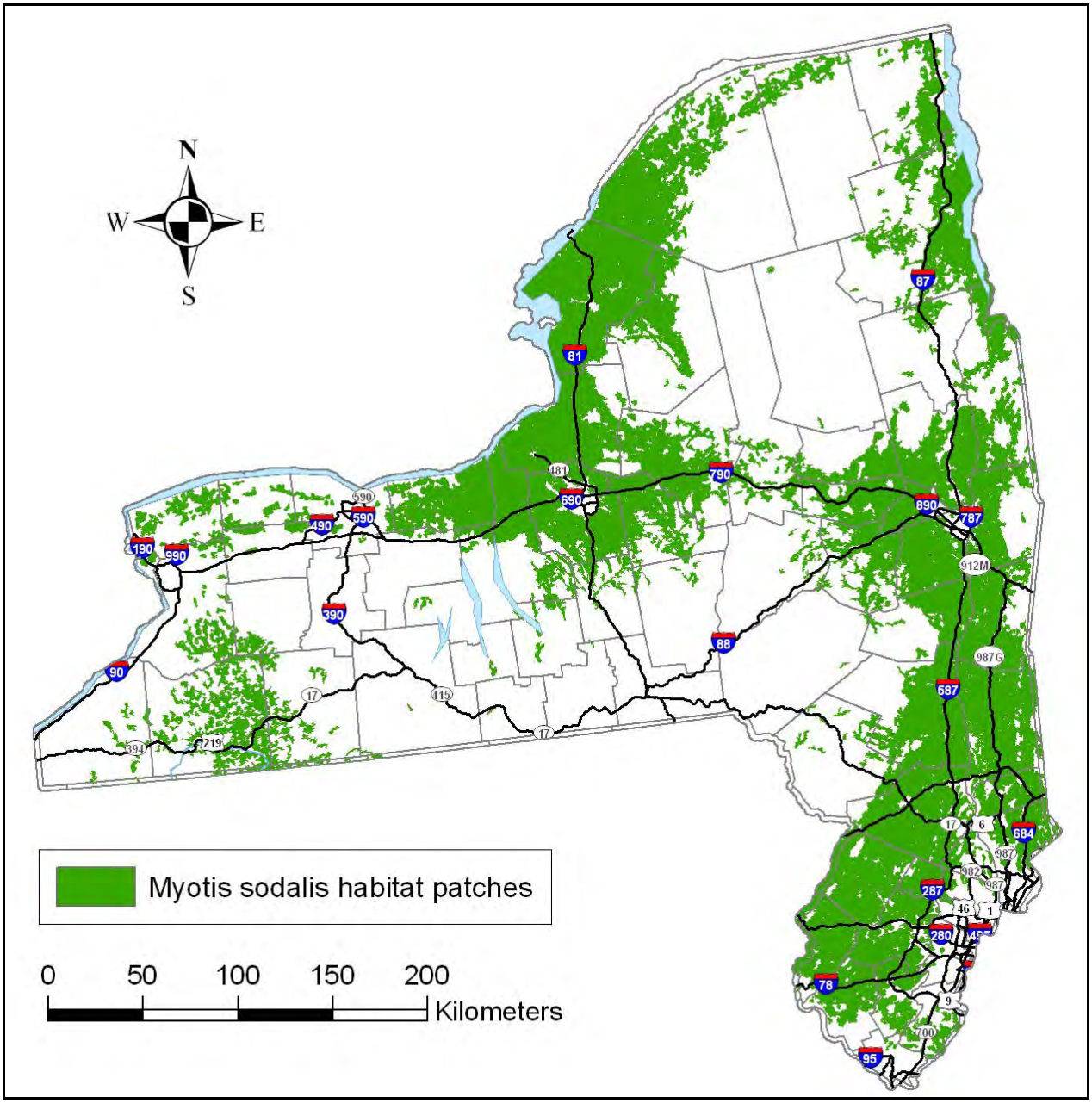

Fig. 2. Modeled summer habitat patches for *Myotis sodalis* in New York and New Jersey.

State Wildlife Action Plans

Branch #122

State Wildlife Action Plans (#1221)

- **Indiana Bat SWAP supported actions**
  - **Indiana**
  - **Kentucky**
  - **Maryland**
  - **New Jersey**
  - **New York**
  - **Pennsylvania**
  - **Tennessee**
  - **Virginia**
  - **West Virginia**

Indiana

Indiana Bat (*Myotis Sodalis)*

Taxa: Mammal
Indiana Bat Status:
(ICWS: 29)
Federal Status: Endangered

State Status: Endangered

Indiana Bat Location and Habitat Defined:
(ICWS: 29)
Range – Statewide

Relative Abundance: Occasional
Disjunct populations whose occurrence is sporadic yet significantly less than historic or expected levels.

(ICWS: 94)
Indiana Bat – Species of Greatest Conservation Need (SGCN) in Forests:
A plant community extending over a large area and dominated by trees, the crowns of which form an unbroken covering layer or canopy. Almost 23% of Indiana is covered by forests. This habitat includes: deciduous, early forest stage, evergreen, floodplain forests, forested wetlands, mature or high canopy stage, old forest stage, pole stage, pre-forest stage, riparian wooded corridors/streams, suburban, upland and urban forests

Indiana Bat – SGCN in Subterranean Systems:

Surface openings of subterranean features reaching as far as natural light can penetrate (i.e.,twilight zone) and connected underground rooms and passages beyond natural light penetration. This habitat encompasses the following sub-types: caves and cave entrances.

Conservation Process – Issues and Actions for the Indiana Bat:

(ICWS 95-96)

High Priority Conservation Actions for Forests:

- Land use planning
- Habitat protection on public lands
- Habitat restoration on public lands
- Succession control (fire, mowing)
- Corridor development/protection
- Habitat protection incentives (financial)
- Habitat restoration through regulation
- Habitat protection through regulation
- Habitat restoration incentives (financial)
- Adaptive Management

(ICWS: 96-97)

High Priority Conservation Actions for SGCN (Indiana Myotis) in Forests

Habitat protection:

- Determine what constitutes high quality foraging and roosting habitat for forest dwelling bats.
- Implement silvicultural strategies that provide for a continuous supply of large, dead and/or dying deciduous trees to provide roost sites for crevice-dwelling bats such as the Indiana bat.

Protection of migration routes:

- Investigate forest distribution in Indiana and provide adequate forestlands for migrating birds and bats.

Population management:

- Determine distribution and relative abundance of rare forest-dependent wildlife such as the Indiana bat, Northern myotis, and Allegheny woodrat.
- Develop survey and monitoring programs for forest-dwelling bats.

Food plots:

- Provide for adequate regeneration of native tree species to provide adequate food for forest dwelling SGCN.

Regulation of collecting:

- Develop technical assistance materials that promote leaving SGCN in the natural environment.

Threats reduction:

- Determine threats to forest-dwelling bats.
- Determine impacts of different forest management regimes on habitat quality (foraging and roosting) for forest-dwelling bats.

Limiting contact with pollutants/contaminants:

- Monitor the impacts of forest-pest management measures on forest SGCN.

Public education to reduce human disturbance:

- Post signs at important cave sites used by forest bats to reduce/eliminate unauthorized human visitation.

Adaptive Management:

- Modify survey and monitoring, research and other conservation actions and activities in response to new information to improve conservation efficiency for SGCN.

(ICWS: 111)
High Priority Conservation Actions for Subterranean Systems:

- Technical assistance
- Cooperative land management agreements (conservation easements)
- Restrict public access and disturbance
- Land use planning
- Habitat protection on public lands
- Habitat protection through regulation
- Habitat restoration on public lands
- Protection of adjacent buffer zone
- Pollution reduction
- Corridor development/protection
- Adaptive Management

High Priority Conservation Actions for SGCN (Indiana Myotis) in Subterranean Systems
Habitat protection:

- Inventory subterranean systems cave-dependent SGCN such as the Indiana bat and southeastern bat.
- Restrict human access to caves during seasonal use by Indiana bats and other cave-dwelling species. Erect physical barriers (gates, fences) as needed.

Regulation of collecting:

- Provide public notification materials throughout the Karst region of Indian regarding the adverse consequences of collecting or disturbing subterranean system SGCN.

Threats reduction:

- Investigate the threats (e.g. pesticides, water level changes, soil erosion, human disturbance) to subterranean system SGCN.

Public education to reduce human disturbance:

- Erect interpretive warning signs at entrances to important cave sites to discourage human entry.

Limiting contact with pollutants/contaminants:

- Investigate sinkhole buffer systems to minimize the adverse impacts of runoff into subterranean systems from surrounding lands on SGCN.
- Investigate the impact of smoke and other air quality problems on subterranean system SGCN.

Adaptive Management:

- Modify survey and monitoring, research and other conservation actions and activities in response to new information to improve conservation efficiency for SGCN.

Kentucky

Indiana Bat (*Myotis Sodalis*)

Taxa: Mammal

Indiana Bat Status:

Federal Status	Heritage Status	GRank (Simplified)	SRank	GRank	SRank (Simplified)
LE	E	G2	S1S2	G2	S1

G-Trend: Decreasing

G-Trend Comment: Census data from 1995-1997 indicate an abundance decline of about 60 percent. Since population surveys began in the 1960s; the most severe declines have occurred in Kentucky and Missouri, where the decline totals 430,000 individuals over the past few decades.

S-Trend: Decreasing

Indiana Bat Location and Habitat Defined:

Special features Indiana bats tend to use include standing snag/hollow tree and trees with a high percentage of exfoliating bark (e.g., Shagbark hickory). Wetlands may be classified as suitable if they are within an undetermined buffer of suitable vegetation. Hibernates in caves; maternity sites are in trees.

Habitat throughout Kentucky distribution:
Breeding: UNKNOWN
Wintering: GOOD

Key Habitat Locations (and their condition):
1. Grahn Quad and Wesleyville Quad (Good)
2. Mammoth Cave National Park (Good)
3. Lee County (Good)
4. Ballard County (Good)
5. Derby Quad (Good)
6. Hart County (Good)

Guilds:
- Caves, rock shelters, and clifflines
- Cumberland highland forest
- Emergent and shrub-dominated wetlands
- Forested wetland
- Running water,
- Savanna/ shrub scrub
- Upland forest.

Statewide Map IndianaBat.pdf

Conservation Process – Issues and Actions for the Indiana Bat:

Miscellaneous Mortality Factors:

- Human disturbance (spelunking, destruction/disturbance of nest sites)
- Winter caves illegal killing

Terrestrial Habitat Degradation:

- Row-crop agriculture (conversion to, annual reuse of fields, etc)
- Urban/residential development
- Habitat loss outside of Kentucky
- Surface mining
- Timber harvest
- Removal of dead trees
- Loss, lack and degradation of special and unique microhabitats
- Commercialization altering microclimate and bat-unfriendly structures as formerly at Long's Cave in Mammoth Cave National Park, Kentucky

Top Conservation Actions for Caves, Rock Shelters, and Clifflines:

- Identify unique microhabitats important to priority species and acquire or protect through acquisition, easements, or cost-share programs.
- Encourage landowners to incorporate strategies into management plans that benefit priority species during technical guidance sessions.
- Create a unique habitat stewardship program.
- Work with partners to prioritize land protection, acquisition, and restoration projects that work toward connecting blocks of habitat and restoring ecological processes.
- Partner with appropriate agencies to encourage regional land use planning and cooperation on private lands (i.e. watershed management vs. individual property management).
- Work with other agencies and landowners to protect critical habitats from human disturbance through acquisition, easements, gates, buoys, etc.
- Create education programs to inform the public about the potential impacts of human disturbance to priority species (create signs, presentations, brochures, etc.).
- Partner with the Office of Surface Mining to develop regulations that increase the use of wildlife friendly reclamation practices and provide incentives to the industry for doing so.
- Partner with the appropriate agency to develop new habitat restoration and enhancement projects using abandoned mine lands funding.
- Work with industry and regulatory agencies to develop better protocol for the timing of pre-mining logging and survey needs

Objectives for Caves, Rock Shelters, and Clifflines - Terrestrial Guild:

- Protection, restoration, and management of unique habitats.
- Implement landscape level conservation projects in priority areas.
- Minimize impacts of human disturbance.
- Minimize impacts of mining to priority species.

Top Conservation Actions for Cumberland Highland Forest Guild:

- Work with partners to prioritize land protection, acquisition, and restoration projects that work toward connecting blocks of habitat and restoring ecological processes.
- Partner with appropriate agencies to encourage regional land use planning and cooperation on private lands (i.e. watershed management vs. individual property management).
- Identify unique microhabitats important to priority species and acquire or protect through acquisition, easements, or cost-share programs.
- Partner with the Office of Surface Mining to develop regulations that increase the use of wildlife friendly reclamation practices and provide incentives to the industry for doing so.
- Work with industry and regulatory agencies to develop better protocol for the timing of pre-mining logging and survey needs
- Provide information and guidance to the mining industry and contractors on reclamation practices that benefit wildlife.
- Create innovative methods to better use Fees-in-lieu-of money (or other programs) for permanent protection/restoration of streams and riparian corridors (purchase surface and mineral rights)
- Revise current Best Management Practices and develop new ones (if needed).
- Encourage practices that increase structural and vegetative diversity that benefit priority species.
- Develop workshops for loggers and forestry consultants about timber management practices that most benefit wildlife.

Objectives for Cumberland Highland Forest Guild:

- Implement landscape level conservation projects in priority areas
- Protection, restoration, and management of unique habitats
- Minimize impacts of mining to priority species
- Increase acreage of and protect existing highland forests
- Encourage landowners to include wildlife friendly practices in timber management plans
- Manage public forests for priority species
- Increase acreage of hard mast trees

Top Conservation Actions for Emergent And Shrub-Dominated Wetlands Guild:

- Work with partners to prioritize land protection, acquisition, and restoration projects that work toward connecting blocks of habitat and restoring ecological processes.
- Partner with appropriate agencies to encourage regional land use planning and cooperation on private lands (i.e. watershed management vs. individual property management).
- Acquire and protect wetland habitat and manage for priority species (manage for prey species, breeding and cover habitat, etc.).
- Restore or create wetland habitat on Kentucky Department of Fish and Wildlife Resources owned or managed lands and manage for priority species.
- Partner with appropriate agencies to promote construction or restoration of wetland habitat.
- Encourage creation of wetland habitat for priority species on private land through incentive programs (i.e. Wetland Reserve Program, Conservation Reserve Program, etc.).
- Increase disturbance regimes (i.e. prescribed fire, targeted timber harvest, strip disking, etc.) where appropriate on Kentucky Department of Fish and Wildlife Resources owned or managed lands.

- Encourage private landowners to reduce woody encroachment of shallow water wetlands (by flooding, disking, mowing, draining, herbicide application, etc.) through private land consultations and incentive programs.
- Identify and prioritize high ecological value areas most at risk to urban sprawl and protect from development through acquisition or conservation easements.
- Implement control of invasive and exotic species on both public and private land through partnerships.

Objectives for Emergent and Shrub-Dominated Wetlands Guild:

- Implement landscape level conservation projects in priority areas
- Maintain, restore, and/or increase acreage of shallow water wetlands
- Reduce pace and impacts of urban sprawl
- Control the use and spread of invasive and exotic plants
- Minimize impacts of mining to priority species
- Protection, restoration, and management of unique habitats

Top Conservation Actions for Forested Wetland Guild:

- Work with partners to prioritize land protection, acquisition, and restoration projects that work toward connecting blocks of habitat and restoring ecological processes.
- Partner with appropriate agencies to encourage regional land use planning and cooperation on private lands (i.e. watershed management vs. individual property management).
- Acquire land previously managed for timber resources and restore to native forest.
- Increase Kentucky Department of Fish and Wildlife Resources staff devoted to raising public awareness and implementation of cost-share programs.
- Encourage creation of wetland habitat for priority species on private land through incentive programs (i.e. Wetland Reserve Program, Conservation Reserve Program, etc.).
- Restore or create wetland habitat on Kentucky Department of Fish and Wildlife Resources owned or managed lands and manage for priority species.
- Encourage the timber industry to use Best Management Practices (buffer strips of native forest, wider tree spacing) when converting to rotational crop trees.
- Identify unique microhabitats important to priority species and acquire or protect through acquisition, easements, or cost-share programs.
- Partner with the appropriate agency to develop new habitat restoration and enhancement projects using abandoned mine lands funding.
- Create more snags and cavity trees on Kentucky Department of Fish and Wildlife Resources owned or managed lands

Objectives for Forested Wetland Guild:

- Implement landscape level conservation projects in priority areas
- Increase acreage of and protect existing bottomland hardwood forests
- Protection, restoration, and management of unique habitats
- Minimize impacts of mining to priority species
- Increase the amount of snag habitat
- Reduce pace and impacts of urban sprawl

Top Conservation Actions for Running Water Guild:

- Work with partners to prioritize land protection, acquisition, and restoration projects that work toward connecting blocks of habitat and restoring ecological processes.
- Partner with appropriate agencies to encourage regional land use planning and cooperation on private lands (i.e. watershed management vs. individual property management).
- Acquire or protect through acquisition or easements shoreline and riparian habitat.
- Acquire and protect wetland habitat and manage for priority species (manage for prey species, breeding and cover habitat, etc.).
- Identify and implement shoreline and riparian zone habitat restoration projects.
- Provide information and guidance to the mining industry and contractors on reclamation practices that benefit wildlife.
- Create innovative methods to better use Fees-in-lieu-of money (or other programs) for permanent protection/restoration of streams and riparian corridors (purchase surface and mineral rights)
- Work with state and federal partner to identify sources of pollutants.
- Encourage and assist in using, developing, and implementing Best Management Practices, including revision and evaluation as applied to aquatic systems.
- Partner with the appropriate permitting agency to expand Kentucky Department of Fish and Wildlife Resources' role in assessing impacts of development on fish and wildlife prior to the permit being issued.

Objectives for Running Water Guild:

- Implement landscape level conservation projects in priority areas
- Protect, restore, and enhance riparian zones and shoreline habitat
- Minimize impacts of mining to priority species
- Reduce input of pollutants and other contaminants into aquatic systems
- Mitigate impacts of shoreline development
- Protection, restoration, and management of unique habitats

Top Conservation Actions for Savanna/ Shrub-scrub Guild:

- Work with partners to prioritize land protection, acquisition, and restoration projects that work toward connecting blocks of habitat and restoring ecological processes.
- Partner with appropriate agencies to encourage regional land use planning and cooperation on private lands (i.e. watershed management vs. individual property management).
- Encourage practices that increase structural and vegetative diversity that benefit priority species.
- Reduce impacts of livestock grazing through partnerships that increase the use of Best Management Practices (e.g., rotational grazing, fencing of woodlands, vegetative diversity, planting later maturing grasses, etc.) on private land.
- Provide technical guidance to public agencies and private landowners on how to restore fire regimes.
- Partner with the appropriate agency to identify sources of invasive and exotic species (i.e. fescue, phragmites, serecia, etc.), discourage continued use, and encourage the use of native herbaceous species.
- Implement control of invasive and exotic species on both public and private lands through partnerships.
- Identify unique microhabitats important to priority species and acquire or protect through acquisition, easements, or cost-share programs.

- Encourage landowners to incorporate strategies into management plans that benefit priority species during technical guidance sessions.
- Identify and prioritize high ecological value areas most at risk to urban sprawl and protect from development through acquisition or conservation easements.

Objectives for Savanna/Shrub-Scrub Guild:

- Implement landscape level conservation projects in priority areas
- Increase acreage of or maintain early succession habitat
- Restore fire regimes to public and private land
- Control the use and spread of invasive and exotic plants
- Protection, restoration, and management of unique habitats
- Reduce pace and impacts of urban sprawl

Top Conservation Actions for Upland Forest:

- Work with partners to prioritize land protection, acquisition, and restoration projects that work toward connecting blocks of habitat and restoring ecological processes.
- Partner with appropriate agencies to encourage regional land use planning and cooperation on private lands (i.e. watershed management vs. individual property management).
- Encourage practices that increase structural and vegetative diversity that benefit priority species.
- Partner with the KY State Foresters Association and the KY Division of Forestry to provide recommendations on management practices that benefit wildlife.
- Provide technical guidance to public agencies and private landowners on how to restore fire regimes.
- Partner with the Office of Surface Mining to develop regulations that increase the use of wildlife friendly reclamation practices and provide incentives to the industry for doing so.
- Encourage landowners to incorporate strategies into management plans that benefit priority species during technical guidance sessions.
- Revise current Best Management Practices and develop new ones (if needed).
- Create educational programs for the public, agencies, and consultants about the value of snags and/or cavity trees and how to manage for them (create a how-to video, distribute information on where to place them, etc.).
- Identify and prioritize high ecological value areas most at risk to urban sprawl and protect from development through acquisition or conservation easements.

Objectives for Upland Forest:

- Implement landscape level conservation projects in priority areas
- Encourage landowners to include wildlife friendly practices in timber management plans
- Restore fire regimes to public and private land
- Minimize impacts of mining to priority species
- Protection, restoration, and management of unique habitats
- Increase acreage of and protect existing upland forests
- Increase the amount of snag habitat
- Reduce pace and impacts of urban sprawl
- Reduce impacts of cervids on vegetative communities
- Increase acreage of hard mast trees

Maryland

Indiana Bat (*Myotis Sodalis)*
Taxa: Mammal
Indiana Bat Status:
(Chapter 3: 8)
Federal Status: Endangered

State Status: Endangered

S1: Highly State rare. Critically imperiled in Maryland because of extreme rarity (typically 5 or fewer estimated occurrences or very few remaining individuals or acres in the State) or because of some factor(s) making it especially vulnerable to extirpation. Species with this rank are actively tracked by the Natural Heritage Program.

Indiana Bat Location and Habitat Defined:
(Chapter 4)
Terrestrial Forested Habitats:

- Old Growth Forests
- Mesic Deciduous Forests
- Dry Oak - Pine Forests
- Northern Conifer - Hardwood Forests
- Floodplain Forests
- Bog and Fen Wetland Complexes
- Cliffs and Rock Outcrops
- Caves, Mines, and Springs

Conservation Process – Issues and Actions for the Indiana Bat:
(Chapter 3: 7)
Threats: The removal of large tree snags and forest cover affects species such as Indiana bat
Old Growth Forests Conservation Actions:

- Conserve large blocks of contiguous forest where appropriate *[Measure: # of acres contiguous forests conserved]*
- Protect all old growth forest habitat and adequate forested buffers *[Measure: # of acres old growth forest and buffers protected]*
- Increase old growth forest habitats where feasible *[Measure: # of acres additional potential old growth forest protected]*
- Establish and maintain landscape-scale protected habitat and movement corridors; *[Measure: # of acres protected habitat established; # of acres new corridors established and protected]*
- Incorporate forest conservation actions into land use and land planning efforts by local, state, and federal agencies *[Measure: # of local, state, and federal agency plans incorporating wildlife focused forest habitat management actions]*
- Minimize fragmentation of large, contiguous forest blocks *[Measure: % of large, contiguous forest blocks remaining unfragmented]*
- Identify areas that will become future old growth forests *[Measure: # of sites identified as potential future old growth forests]*

- Develop incentives for private land owners to conserve old growth on their properties *[Measure: # of incentives developed; # of new participants maintaining this habitat type]*
- Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*
- Limit access and educate the public about the value of old growth and its conservation to address human disturbance issues *[Measure: # of sites with limited access and educational signage; # of educational materials developed and distributed]*
- Develop habitat management guidelines for use by foresters and land managers and work with them to implement such *[Measure: guidelines developed; # of sites with cooperative management project; # of acres of this habitat managed for GCN species]*
- Restore spruce, hemlock and chestnut components where feasible *[Measure: # of acres forest with spruce/hemlock/chestnut components restored]*

Mesic Deciduous Forests Conservation Actions:

- Conserve large blocks of contiguous forest where appropriate *[Measure: # of acres contiguous forests conserved]*
- Control the conversion to other forest types *[Measure: # of acres mesic deciduous forest protected from conversion]*
- Establish and maintain landscape-scale protected habitat and movement corridors *[Measure: # of existing targeted large forested patches connected by new corridors; # of acres new corridors established]*
- Incorporate forest conservation actions into land use and land planning efforts by local, state, and federal agencies *[Measure: # of local, state, and federal agency plans incorporating forest wildlife focused habitat management actions]*
- Develop habitat management guidelines for use by foresters and land managers and work with them to implement such *[Measure: guidelines developed; # of sites with cooperative management project; # of acres of this habitat managed for GCN species]*
- Minimize fragmentation of large, contiguous forest blocks *[Measure: % of large forest blocks remaining unfragmented]*
- Increase presence of snags and vertical structure complexity to enhance existing habitat *[Measure: # of acres managed to increase presence of snags and vertical structure complexity]*
- Incorporate appropriate forest management practices into forest stewardship plans *[Measure: # of forest stewardship plans with forest wildlife focused habitat management guidelines incorporated]*
- Educate the public about the value of these forests and their conservation to address human disturbance issues *[Measure: # of educational materials developed and disseminated]*
- Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*
- Restore chestnut component where feasible *[Measure: # of acres with restored chestnut component]*

- Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites or acres with reduced quantity or frequency of pesticide use]*
- *D*evelop and implement protocols to control deer populations to reduce browsing levels *[Measure: protocols developed; # of sites or acres with management implemented]*
- Implement appropriate IPM practices to minimize the effects of serious forest pest species *[Measure: # of sites or acres with IPM practices implemented]*
- Restore degraded habitats through appropriate techniques *[Measure: # of sites or acres with degraded habitat restored]*
- Work with Maryland DOT to improve transportation planning for new roads to minimize fragmentation of habitat *[Measure: # or miles of new roads planned with comments/input to minimize forest fragmentation]*

Dry Oak - Pine Forests Conservation Actions:

- Re-establish natural fire regimes to restore and maintain habitats *[Measure: # of acres maintained with controlled burn program; # of sites with natural fire regimes allowed]*
- Conserve large blocks of contiguous forest where appropriate *[Measure: # of acres contiguous forests conserved]*
- Control the conversion of this habitat to pine plantations *[Measure: # of acres dry oak pine forests protected from conversion]*
- Conserve appropriate corridors for movement and dispersal of GCN species *[Measure: # of acres forest corridors conserved]*
- Minimize fragmentation of large, contiguous forest blocks *[Measure: % of large forest blocks remaining unfragmented]*
- Develop habitat management guidelines for use by foresters and land managers and work with them to implement such *[Measure: guidelines developed; # of sites with cooperative management project; # of acres of this habitat managed for GCN species]*
- Incorporate forest conservation actions into land use and land planning efforts by local, state, and federal agencies *[Measure: # of local, state, and federal agency plans incorporating forest wildlife focused habitat management actions]*
- Work through the Public Service Commission to reduce impacts of wind farms on this habitat and associated GCN species *[Measure: # of wind farm plans approved by Public Service Commission with input to mitigate impacts]*
- Educate the public about the value of these forests and their conservation, especially addressing human disturbance issues *[Measure: # of educational materials developed and disseminated]*
- Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*
- Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites or acres with reduced quantity or frequency of pesticide use]*
- Develop and implement protocols to control deer populations to reduce browsing levels *[Measure: protocols developed; # of sites or acres with management implemented]*
- Implement appropriate IPM practices to minimize the effects of serious forest pest species *[Measure: # of sites or acres with IPM practices implemented]*
- Restore degraded habitats through appropriate techniques *[Measure: # of sites or acres with degraded habitat restored]*

- Work with Maryland DOT to improve transportation planning for new roads to minimize fragmentation of habitat *[Measure: # or miles of new roads planned with comments/input to minimize forest fragmentation]*

Northern Conifer - Hardwood Forests Conservation Actions:

- Maintain conifer component of forest or restore such where appropriate *[Measure: # of acres with conifer component maintained; # of acres with conifer component restored]*
- Conserve large blocks of contiguous forest where appropriate *[Measure: # of acres contiguous forests conserved]*
- Minimize fragmentation of large, contiguous forest blocks *[Measure: % of large forest blocks remaining unfragmented]*
- Establish and maintain landscape-scale protected habitat and movement corridors *[Measure: # of existing targeted large forested patches connected by new corridors; # of acres new corridors established]*
- Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*
- Work through the Public Service Commission to reduce impacts of wind farms on this habitat and associated GCN species *[Measure: # of wind farm plans approved by Public Service Commission with input to mitigate impacts]*
- Incorporate forest conservation actions into land use and land planning efforts by local, state, and federal agencies *[Measure: # of local, state, and federal agency plans incorporating forest wildlife focused habitat management actions]*
- Develop habitat management guidelines for use by foresters and land managers and work with them to implement such *[Measure: guidelines developed; # of sites with cooperative management project; # of acres of this habitat managed for GCN species]*
- Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites or acres with reduced quantity or frequency of pesticide use]*
- Develop and implement protocols to control deer populations to reduce browsing levels *[Measure: protocols developed; # of sites or acres with management implemented]*
- Implement appropriate IPM practices to minimize the effects of serious forest pest species *[Measure: # of sites or acres with IPM practices implemented]*
- Restore degraded habitats through appropriate techniques *[Measure: # of sites or acres with degraded habitat restored]*
- Work with Maryland DOT to improve transportation planning for new roads to minimize fragmentation of habitat *[Measure: # or miles of new roads planned with comments/input to minimize forest fragmentation]*
- Implement appropriate IPM practices to minimize the effects of serious forest pest species *[Measure: # of sites or acres with IPM practices implemented]*
- Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites with reduced quantity or frequency of pesticide use]*
- Develop and implement protocols to control deer populations to reduce browsing levels *[Measure: protocols developed; # of sites with management implemented]*
- Restore degraded habitats through appropriate techniques *[Measure: # of acres degraded habitat restored]*
- Work with Maryland DOT to improve transportation planning for new roads to minimize fragmentation of habitat *[Measure: # or miles of new roads planned with comments/input to minimize forest fragmentation]*

Floodplain Forests Conservation Actions:

- Restore floodplain forests including reestablishment of old growth, natural hydrology, and improved water quality *[Measure: # of acres restored]*
- Conserve large blocks of contiguous forest where appropriate *[Measure: # of acres contiguous forests conserved]*
- Improve storm water management practices and sediment erosion control measures to avoid/minimize development impacts to forested wetland areas and surrounding watershed *[Measure: # of development projects near forested wetlands with improved storm water and sediment management incorporated into plans]*
- Establish and maintain landscape-scale protected habitat and movement corridors *[Measure: # of existing targeted large forested patches connected by new corridors; # of acres new corridors established]*
- Promote and support watershed-based initiatives to restore and protect watersheds *[Measure: # of watershed-based initiatives implemented]*
- Minimize fragmentation of large, contiguous forest blocks *[Measure: % of large forest blocks remaining unfragmented]*
- Establish and maintain adequate forest buffers along streams and rivers *[Measure: # of miles of stream/river forested buffers established and maintained]*
- Incorporate forest conservation actions into land use and land planning efforts by local, state, and federal agencies *[Measure: # of local, state, and federal agency plans incorporating forest wildlife focused habitat management actions]*
- Work with farming community to conserve, restore, and protect floodplain forests *[Measure: # of acres floodplain forest protected or restored from agricultural use; # of sites with cooperative management projects]*
- Enforce and modify, as needed, nontidal wetland protection regulations especially as they relate to Wetlands of Special State Concern *[Measure: # of regulation modifications proposed; # of violations prosecuted; # of citations issued]*
- Develop habitat management guidelines for use by foresters and land managers and work with them to implement such *[Measure: guidelines developed; # of sites with cooperative management project; # of acres of this habitat managed for GCN species]*
- Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*
- Protect target riverside prairie habitat *[Measure: # of acres protected]*
- Develop and implement protocols to control deer populations to reduce browsing levels *[Measure: protocols developed; # of sites or acres with management implemented]*
- Maintain natural beaver populations *[Measure: # of viable beaver populations; # of miles of stream influenced by beaver activity]*
- Remove certain dams to allow for flooded areas to revert back to forest *[Measure: # of dams removed; # of acres reverted to floodplain forest]*
- Work with watershed groups to encourage forest conservation as a strategy for water conservation *[Measure: # of groups contacted; # of cooperative projects and meetings with watershed groups]*
- Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites or acres with reduced quantity or frequency of pesticide use]*
- Restore degraded habitats through appropriate techniques *[Measure: # of sites or acres with degraded habitat restored]*

- Implement appropriate IPM practices to minimize the effects of serious forest pest species *[Measure: # of sites or acres with IPM practices implemented]*
- Work with Maryland DOT to improve transportation planning for new roads to minimize fragmentation of habitat *[Measure: # or miles of new roads planned with comments/input to minimize forest fragmentation]*

Bog and Fen Wetland Complexes Conservation Actions:

- Establish and maintain protected networks of bog-fen wetland sites and provide sufficient landscape connectivity within an extensive forest matrix *[Measure: # of acres wetland/forest matrix and corridors protected]*
- Avoid or minimize timber harvesting impacts in wetland areas and surrounding forest matrix *[Measure: # of wetland wildlife focused habitat management guidelines incorporated into silviculture plans]*
- Protect wetlands through acquisitions and easements *[Measure: # of acres of wetlands newly protected through acquisitions and easements]*
- Incorporate wetland conservation actions into land planning efforts and public land management plans *[Measure: # of acres of wetlands conserved during land use and land planning efforts; # of public land management plans incorporating wetland wildlife focused habitat conservation actions]*
- Protect wetlands from drainage, ditching, filling, water withdrawal, and other damaging practices that alter hydrology *[Measure: # of acres of wetlands protected from practices that alter hydrology]*
- Work with farming community to restore and protect wetlands *[Measure: # of sites with cooperative management projects; # of acres wetlands restored and protected]*
- Develop and implement protocols to control invasive species and prevent their establishment *[Measure: # of protocols developed; # of sites with management implemented]*
- Enforce and improve, as needed, nontidal wetland protection regulations especially as it relates to Nontidal Wetlands of Special Concern *[Measure: # of regulation modifications proposed; # of violations prosecuted; # of citations issued]*
- Restore northern conifer component of bog-fen wetland complexes on Allegheny Plateau and Atlantic white-cedar component on Coastal Plain, including working with TNC to accomplish such *[Measure: # of acres restored]*
- Prohibit ORV's in and around wetland sites *[Measure: # of sites with limited access and educational signage]*
- Limit development impacts within wetland areas and surrounding watershed *[Measure: # of development projects implementing BMPs to limit surrounding wetland impacts; % of development permits denied for wetland protection]*
- Minimize runoff from roads, including silt, salt and contaminants *[Measure: # of sites with improved runoff BMPs implemented]*
- Minimize and reduce habitat fragmentation *[Measure: # of development projects designed and developed to minimize habitat fragmentation]*
- Manage or control livestock grazing within the wetlands *[Measure: # of sites with livestock grazing impacts reduced or eliminated]*
- Strictly enforce existing federal and state wetland protection laws *[Measure: # of violations prosecuted; # of citations issued]*
- Restore wetlands affected by acid mine drainage *[Measure: # of acres restored]*

- Educate the public to reduce impacts and disturbances to wetlands *[Measure: # of educational materials developed and distributed]*
- Implement nitrogen and phosphorus reduction strategies for septic and stormwater runoff *[Measure: # of sites with nutrient reduction strategies implemented]*
- Develop and implement protocols to control deer populations to reduce browsing levels *[Measure: protocols developed; # of sites or acres with management implemented]*
- Work with watershed groups, watershed-based initiatives, landowners, and federal programs to expand and coordinate wetland conservation efforts *[Measure: # acres of wetlands conserved through expanded and coordinated multi-partner cooperative programs]*
- Restore wetlands where appropriate *[Measure: # of acres wetlands restored]*
- Better train certified wetland delineators to identify wetland types *[Measure: # of certified wetland delineators with updated training]*
- Implement controlled burn programs as appropriate *[Measure: # of acres maintained with controlled burn program; # of sites with natural fire regimes allowed]*
- Avoid gypsy moth control in wetland areas and surrounding forest matrix *[Measure: # of sites with reduced quantity or frequency of pesticide use]*
- Work with landowners and farming community to develop and encourage BMPs for agricultural practices *[Measure: # of BMPs developed and promoted; # of sites with BMPs implemented]*
- Work with Maryland DOT to minimize wetland impacts and explore offsite mitigation for wetland complexes *[Measure: # or miles of new roads planned with comments/input to minimize wetland impacts; # of offsite mitigation projects established]*

Cliffs and Rock Outcrops Conservation Actions:

- Develop habitat management guidelines for use by foresters and land managers and work with them to implement such *[Measure: guidelines developed; # of sites with cooperative management project; # of acres of this habitat managed for GCN species]*
- Provide adequate forest buffers *[Measure: # of acres of adequate forested buffers established]*
- Develop and implement shore erosion control practices that are compatible with cliff maintenance and the needs of GCN species *[Measure: # of BMPs developed; # of projects that incorporate BMPs into land management efforts]*
- Educate the general public, land owners, and land managers about the value of these habitats *[Measure: # of educational materials developed and distributed]*
- Incorporate conservation actions into land use and land planning efforts by local, state, and federal agencies *[Measure: # of local, state, and federal agency plans incorporating wildlife focused habitat management actions]*
- Limit access to minimize human disturbance *[Measure: # of sites with limited access]*
- Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*
- Reduce impacts of wind turbines through appropriate siting/micrositing *[Measure: # of new wind turbine plans that incorporate comments/input for siting to minimize impacts]*
- Incorporate best management practices into land management plans *[# of development projects and other land management plans implementing BMPs]*
- Minimize fragmentation *[Measure: # of development projects and land use plans that incorporate measures to minimize habitat fragmentation]*
- Maintain functioning subsurface habitats *[Measure: # of acres with functioning subsurface habitats]*

- Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites with reduced quantity or frequency of pesticide use]*
- Reintroduce blight resistant American chestnut to appropriate rock outcrops *[Measure: # of sites with blight resistant American chestnut restored]*
- Work with climbing clubs to minimize degradation and disturbance *[Measure: # of groups with cooperative management projects; # of sites with human disturbance minimized]*

Caves, Mines, and Springs Conservation Actions:

- Limit land use changes that may impact hydrology *[Measure: # of acres protected from altered hydrology]*
- Incorporate conservation actions into land planning efforts and public land management plans by local, state, and federal agencies *[Measure: # of local, state, and federal agency plans incorporating wildlife focused habitat management actions]*
- Delineate and protect watersheds for seeps, springs and caves with globally rare subterranean aquatic invertebrates *[Measure: # of watershed areas identified and mapped; # of targeted landowners participating in conservation programs]*
- Protect groundwater supply feeding springs inhabited by GCN species *[Measure: average and minimum annual groundwater flow maintained at priority sites; water quality maintained at priority sites]*
- Work with Bureau of Mines to protect mines supporting GCN species *[Measure: # of joint cooperative projects implemented; # of mines protected]*
- Limit access to minimize human disturbance *[Measure: # of sites with limited access]*
- Educate spelunkers about the value of these habitats and the impacts of disturbance to caves and mines supporting GCN species *[Measure: # of educational materials developed and distributed]*
- Protect known sites from future strip mining or development of surrounding forests *[Measure: # of sites protected]*
- Install and maintain appropriate gates at entrances to caves and mines that support GCN species *[Measure: # of gates installed and maintained]*
- Develop and implement protocols to control invasive species in a manner compatible with GCN species *[Measure: # of protocols developed; # of sites with management implemented]*
- Incorporate best management practices into land management plans *[# of development projects and other land management plans implementing BMPs]*
- Add sites to Maryland Natural Areas Registry (MNAR) *[Measure: MNAR program developed; # of sites with landowners participating in MNAR]*
- Use registry or acquisition to restore and protect groundwater aquifers *[Measure: # of acres conserved]*
- Initiate measures to prevent pollution of first and second order streams by surrounding habitat with adequate buffers *[Measure: # of miles of adequate buffer established]*
- Limit the use of pesticides such that GCN species and this habitat are not adversely affected *[Measure: # of sites with reduced quantity or frequency of pesticide use]*
- Minimize or eliminate soil disturbance in estimated catchment basin *[Measure: # of catchment basins identified and mapped; # of acres with management plans that incorporate minimal or no soil disturbance]*
- Avoid any degradation or alteration of spring areas *[Measure: # of springs protected]*
- Conserve appropriate corridors for movement and dispersal of GCN species *[Measure: # of acres corridors conserved]*

- Restore forest cover to deforested catchment basins *[Measure: # of acres restored]*
- Maintain appropriate vegetation around springs *[Measure: # of sites with appropriate surrounding vegetation maintained]*

New Jersey

Indiana Bat (*Myotis Sodalis)*

Taxa: Mammal

Indiana Bat Status:

(NJ SWAP: Appendix)

Federal Status: Endangered

State Status: Endangered

Indiana Bat Location and Habitat Defined:

- Forest
- Forested Wetland

(NJWAP: 12)

Skylands Landscape

This landscape region combines two of New Jersey's physiographic regions, the Ridge and Valley and the Highlands. It encompasses all or parts of Sussex, Warren, Hunterdon, Somerset, Passaic, Essex, Bergen, and Morris counties. The region contains extensive tracts of contiguous upland and wetland forests that support diverse animal populations including the state's only known wintering populations of Indiana bat. Due to the proximity of known hibernacula, the forests of this zone likely provide summer foraging and roosting habitat for Indiana bats.

- Upper Delaware River Valley and Kittatinny Ridge – forests and forested wetlands (Potential presence)
- KittatinnyValley – forests and forested wetlands (Potential presence)
- Northern Highlands – forests and forested wetlands (Potential presence)
- Central Highlands – forests and forested wetlands (Potential presence)
- Urban Highlands – forests and forested wetlands (Potential presence)
- Southern Highlands – forests and forested wetlands (Potential presence)

(NJWAP: 53)

Atlantic Coastal Landscape

The region's forests and riparian areas also host summer and migratory populations of forest-dwelling bats and may contain habitat suitable for summer colonies of Indiana bats.

- Atlantic Coastal Cape May Zone – forests and forested wetlands (Potential presence)
- Atlantic City Area Zone – forests and forested wetlands (Potential presence)
- Great Bay Zone – forests and forested wetlands (Potential presence)
- Barnegat Bay - Little Egg Harbor Zone – forests and forested wetlands (Potential presence)
- Northern Atlantic Coastal Zone – forests and forested wetlands (Potential presence)
- Delaware Bay Landscape – Maurice River Watershed/Tuckahoe River Watershed (Potential Presence)
- Cape May Peninsula

(NJWAP: 243)

Piedmont Plains Landscape

- Northern Piedmont – forests and forested wetlands (Potential presence)
- Raritan Bay – forests and forested wetlands (Potential presence)
- Central Piedmont – forests and forested wetlands (Potential presence)
- Southern Piedmont – forests and forested wetlands (Potential presence)

(NJWAP: 346)
Pinelands Landscape

- Southern Pinelands – forests and forested wetlands (Potential presence)
- Western Pinelands – forests and forested wetlands (Potential presence)
- Mullica River Watershed – forests and forested wetlands (Potential presence)
- Northern Pinelands – forests and forested wetlands (Potential presence)

(NJWAP: 159)
Delaware Bay Landscape

- Maurice River Watershed
- Tuckahoe River Watershed
- Cohansey Zone

Conservation Process – Issues and Actions for the Indiana Bat:
Atlantic Coastal Landscape / Atlantic City Area Zone / Great Bay Zone/ Barnegat Bay - Little Egg Harbor Zone / Northern Atlantic Coastal Zone / Cape May Peninsula / Piedmont Plains Landscape / Northern Piedmont / Raritan Bay / Central Piedmont / Southern Piedmont **/** Pinelands Landscape / Southern Pinelands / Western Pinelands / Mullica River Watershed / Northern Pinelands/ Skylands Landscape / Upper Delaware River Valley and Kittatinny Ridge / Kittatinny Valley / Northern Highlands / Central Highlands / Urban Highlands

Priority Conservation Actions – Identify and protect summer bat habitat and migratory corridors.

- Continue volunteer-based summer bat concentration surveys to locate important maternity sites and determine roost characteristics. Trap and band bats at summer concentration sites to identify bat species; apply plastic colored bands to Indiana bats to aid in recognition during hibernation surveys.
- Assess significance of coastal region as an important travel corridor and concentration site for migratory tree-roosting bats.
- Evaluate and assess impacts of wind turbines to populations of bats.
- Develop a GIS model of Indiana bat habitat to incorporate into the Landscape Project.
- Identify appropriate protection strategies to maintain and enhance habitat.
- Develop Indiana bat recovery plan in accordance with federal guidelines and strategies set forth in the USFWS Indiana Bat Recovery Plan.
- DFW to work with neighboring state fish and wildlife agencies to radio-track dispersing Indiana bats across state boundaries.
- Identify and protect hibernation sites for Indiana bat and other winter resident bat species within New Jersey.
- Determine habitat use by forest bats (including Indiana bat), and incorporate into the Landscape Project. Identify appropriate protection strategies to maintain and enhance habitat (e.g., landowner incentives for protecting habitat, and public education regarding importance of bat conservation).

- Continue to investigate habitat requirements for Indiana bats. Research and experimentally implement planned silviculture to develop guidance for enhancing forests for these species and species suites.
- Identify and protect habitat for Indiana bats and other forest-dwelling bat species
    - Conduct statewide sampling to determine distribution, range, and habitat use of summer bats.
    - Trap Indiana bats during spring emergence from hibernacula and apply colored plastic bands to aid in recovery efforts during summer concentration surveys.
    - Continue volunteer-based summer bat concentration surveys to locate important maternity sites and determine roost characteristics. Trap and band bats at summer concentration sites to identify bat species; apply colored plastic bands to Indiana bats to aid in recognition during hibernation surveys.
    - Conduct telemetry studies during spring emergence from hibernacula to determine dispersal distances, roost characteristics, and travel corridors of Indiana bats.
    - Conduct telemetry studies during summer months to determine roost characteristics and habitat requirements for maternity colonies.
    - Evaluate and assess impacts of wind turbines on populations of bats.
    - Develop a GIS model of Indiana bat habitat to incorporate into the Landscape Project. Identify appropriate protection strategies to maintain and enhance habitat (landowner incentives for protecting summer habitat, public education regarding importance of bat conservation, development of best management practices).
    - Develop Indiana bat recovery plan in accordance with federal guidelines and strategies set forth in the USFWS Indiana Bat Recovery Plan

Maurice River Watershed, Tuckahoe River Watershed, and Cohansey Zone of the Delaware Bay Landscape Region Conservation Goals:

Identify and protect summer roosting habitat for Indiana bats and other forest-dwelling bat species.

- Determine summer range and habitat use for Indiana bats and other forest dwelling bat species.
- Use data to develop a GIS model to incorporate into the Landscape Project.
- Identify appropriate protection strategies to maintain and enhance habitat (e.g., providing landowner incentives for enhancing and protecting habitat, promoting public education regarding importance of bat conservation).
- Survey suitable habitats for Indiana bats and other forest-dwelling bat species to determine population distribution, status, and trends.
- Develop Indiana bat recovery plan in accordance with federal guidelines and strategies set forth in the USFWS Indiana Bat Recovery Plan.

New York

Indiana Bat (*Myotis Sodalis)*
Taxa: Mammal
Indiana Bat Status:
(Appendix D1: 17)
Federal Status: Endangered

State Status: Endangered

Indiana bats is listed as endangered by both the Federal government and the State of New York. It comprises roughly 7% of the wintering bats counted to date in the state; the second most common species by number. However they are found in just 10 of the roughly 140 caves and mines surveyed to date, with 80% wintering in just three mines. New York's wintering population of roughly 33,000 of the federally endangered Indiana bat and numbers within the state appear to be at least stable and probably increasing. New York harbors 9% of the range wide population and the fourth largest state total. The state's contribution to the Indiana bat population continues to grow in importance as range wide numbers continue to drop.

Indiana Bat Location and Habitat Defined:
(Appendix D1: 17)
Migratory Status: Resident

(Appendix A6: Mammals)
Indiana bat (Myotis sodalis)

Life Stage or Use	*System*	*SubSystem*	*Habitat*
Breeding	Terrestrial	forested	southern deciduous
Hibernating/Overwintering	Subterranean	cultural	mines
Hibernating/Overwintering	Subterranean	natural	terrestrial caves
Roosting/Congregating	Subterranean	cultural	mines
Roosting/Congregating	Subterranean	natural	terrestrial caves

(Appendix A6: Mammals)
Species Distribution - Watershed Basin
Historical:

- Lake Champlain
- Lower Hudson - Long Island Bays
- Upper Hudson
- SE Lake Ontario
- NE Lake Ontario - St. Lawrence

Current:

- Lower Hudson - Long Island Bays (Stability: Increasing)
- Upper Hudson (Stability: Increasing)
- SE Lake Ontario (Stability: Increasing)
- NE Lake Ontario - St. Lawrence (Stability: Stable)
- Lake Champlain (Stability: Increasing)

Species Distribution – By Ecoregion
Historical:

- St. Lawrence-Lake Champlain Valley
- Lower New England Piedmont
- Great Lakes

Current:

- St. Lawrence-Lake Champlain Valley (Stability: Increasing)
- Lower New England Piedmont (Stability: Increasing)
- Great Lakes (Stability: Increasing)

Lower Hudson - Long Island Bays Cliff and Cave Habitats:
In the Palisades and Taconic Highlands areas of the lower Hudson River there are cliff and cave areas that provide critical habitat to the Indiana bat.

Upper Hudson Forested Habitats:
Abandoned mines and natural caves provide bat habitat and support listed species such as the Indiana bat. Limestone caves on the Helderberg Escarpment provide habitat for bat species including Indiana bat. The area also contains mines used as bat hibernacula, including for the Indiana bat

Southeast Lake Ontario Basin:
There is also a wintering population of Indiana Bats in Jamesville. Indiana bats breed and roost in mature trees during the summer months, but specific locations are unknown.

N.E. Lake Ontario -St. Lawrence Basin Forested Habitats:
Abandoned mines and natural caves provide bat habitat and support listed species such as the Indiana bat.

Conservation Process – Issues and Actions for the Indiana Bat:
(Appendix A6 Mammals: 20)
Threats to the Indiana Bat:
The reason for the overall decline of this species, and the reason for the decline occurring primarily in the southern regions, continues to be a mystery (US Fish and Wildlife Service 1999). For the time being, the Indiana bat appears to be secure in New York as populations are stable to increasing (Hicks and Novak 2002). The Indiana bat in New York is most important as a standard of a success in the face of a range- wide decline, and as a means of understanding the causes of the decline. The only obvious long term potential threat to the species in the state will likely be widespread development in the lower elevation regions of the lower Hudson Valley, where roughly 70% of the state's population winters. Although apparently capable of doing well in suburban settings, Indiana bats appear to need interspersed patches of undeveloped mature woods as maternity roosts and feeding areas. We do not know how densely developed a region can be before the species is put in jeopardy. Widespread development of wind turbines and other tall structures may also present a risk to migrants, although the degree of risk, if any, is unknown at this time. There is some concern that the warming of hibernacula temperatures may be a cause of decline in the southern portions of the species range.

(Appendix A6:21)
Goal for the Indiana Bat:

- Assure the perpetuation of the Indiana bat within the state of New York.

Objectives for the Indiana Bat:

- Within 6 months, develop and implement efficient criteria for reviewing applications for residential developments that will identify the likely loss of Indiana bat maturity colonies and result in a decline in the population
- Develop a temperature profile for all New York Indiana bat hibernacula within 5 years . This will include at least three years of data with comparative information from existing and historical roosts and a sample of conditions throughout the site.
- Conduct complete surveys of all hibernacula with greater than 30,000 bats once every 10 years and 5 selected non-sodalis sites every 5 years.
- Conduct semi-annual winter surveys of hibernating Indiana bats at all Indiana bat hibernacula, with counts of all species as sites with less than 30,000 total individuals.
- Regulate access to the six largest Indiana bat hibernacula (Barton Hill, Glen Park, Jamesville Quarry, Williams Complex - Preserve, Hotel and Lake Mines) within 5 years.
- Survey new potential hibernacula as they are discovered.
- Within 10 years, determine the likely effects of wind turbines on Indiana bats, including but not limited to, identifying migratory corridors, height of travel above the ground, summer distribution of the species, and kill rates at turbines.
- Within 3 years, determine the timing of the spring emergence, fall swarm and fall entry into hibernation of Indiana bats at least one new York hibernacula.
- Within 5 years develop and implement (if feasible) hydrogen isotope analysis techniques for use with hair samples to identify the broad scale distribution of maternity colonies.
- Within 5 years radio track no less than 1% of the reproductive females from each of the 5 largest hibernacula to their summer range to determine summer distribution and habitat preferences.
- Within 5 years, determine the relationship between the density of development and the abundance and success of Indiana bat populations.
- Within 8 years , design and implement field investigations to determine the consequences of the destruction of maternity colonies on the survival and success of the individual bats from that colony.
- Within 8 years, determine the likely mark retention rates and the effects on survival resulting from the application of wing bands and Passive Integrated Transponders (PIT) tags to Indiana bats.
- Within 8 years, develop an alternative means of monitoring Indiana bat populations other than direct counts at hibernacula.

Recommended Actions for the Indiana Bat

Habitat management:

- Work with landowners to erect gates to regulate access to the selected hibernacula.

Habitat monitoring:

- Complete three years of roost temperature monitoring at all sodalis sites using continually monitoring temperature probes.
- Survey for Indiana bats using vocalization detectors and mist netting at sites that are geographically similar but that have differences in the density of development over large areas.

Habitat research:

- Identify the specific summer habitat requirements for the Indiana bats by radio tracking 1% or more of the hibernating reproductive females from winter to summer range.

Other action:

- Conduct marking studies during the summer maternity , fall swarm and spring emergence that will detect differences in mark retention and survival rates for PIT tags, and at least two types of wing bands.

Population monitoring:

- Live trap and mark sodalis during the fall swarm , fall entry and spring emergence at one hibernacula to determine the arrival and departure periods of the species by age and sex.
- Continue to survey new potential hibernacula as they are discovered.
- Survey winter populations as indicated in the objectives, develop alternative population monitoring techniques

Lower Hudson - Long Island Bays Goals and Objectives:

- Coordinate existing resource management structures in this basin like the National Estuary Programs, state estuary programs, Pine Barrens Commission, fisheries commissions, and others to improve monitoring, management, and protection of SGCN and their habitat basin-wide.
- Use the State Wildlife Grants program staff within DEC to strengthen partner agencies' and management structures' involvement in research, management, and restoration of SGCN and their habitats.
- Preserve and restore key representative habitats that support the basin's biodiversity.
- Ensure that no at-risk species becomes extirpated from the basin by better understanding the current distribution abundance and most immediate threats of these species and responding appropriately. Share this information with local governments in a way that helps inform their decision making related to local land use.
- Improve the health of remaining habitats for SGCN by reducing the limiting factors on them. On public lands this should include better monitoring and management of habitat health and balancing human recreational and other uses of viable habitat. On private lands this should include data sharing and incentive programs that assist landowners in habitat improvements.
- Town and Villages play a key role in protecting SGCN which can be improved by strengthening land use and zoning codes. Federal, State and County policies should also be strengthened.
- Develop a "stepped down", more targeted plan for the basin that expands upon the recommendations made here. This plan may focus on goals within the basin for specific species and habitats, where and when management actions will occur, who will execute those actions, and how they will be implemented on the ground.

Upper Hudson Goals and Objectives:

- Study and evaluate the appropriate balance of habitat types within the Upper Hudson Basin. Once a set of target acreages for each habitat type is agreed upon, set priority actions for SGCN and their habitats based upon these targets.
- Establish a conservation framework within the Upper Hudson Basin through which public and private stakeholder interested in wildlife conservation can work cooperatively towards the management, enhancement, and protection of the Basin's at-risk biodiversity.
- Ensure that no at-risk (threatened/endangered, rare, or declining) species becomes extirpated from the Basin. Furthermore, ensure that common species remain common.
- Manage animals, habitats, and land use practices to produce sustainable benefits for species of conservation concern.
- Maintain knowledge of species and their habitats in sufficient detail to recognize long-term population shifts.

- Fill “data gaps” for those habitats/natural communities used by SGCN where the habitat vulnerability and factors influencing habitat quality are not fully understood.
- Develop a “stepped down”, more targeted plan for the Basin that expands upon the recommendations made here. This plan may focus on specific species and habitats, where and when management actions will occur, who will execute those actions, and how they will be implemented “on the ground”.

SE Lake Ontario Goals and Objectives:

- Establish a conservation framework within the SELO Basin through which public and private stakeholders (including local government, Native Americans, and private landowners) interested in wildlife conservation can work cooperatively towards the management, enhancement, and protection of biodiversity in the Basin.
- Ensure that no at-risk (threatened/endangered) species becomes extirpated from the Basin, and seek opportunities to restore extirpated species where feasible.
- Manage animals, habitats, and land use practices to produce long-term benefits for species of conservation concern.
- Maintain knowledge of species and their habitats in sufficient detail to recognize long-term population shifts.
- Fill “data gaps” for those species where population status, distribution, and habitat needs are unknown.
- Identify, manage, protect, maintain, and restore habitat/natural communities over as broad a spatial scale as possible. Work to keep large forest, wetland, and grassland complexes unfragmented, and to restore fragmented habitats where feasible to increase patch size and connectivity.
- Work with land managers to incorporate wildlife-based objectives into traditional land management activities such as forestry and agriculture that still allow these activities to be economically sustainable.
- Strengthen existing relationships between water quality and wildlife management planning programs in the basin and create new ones.
- Develop a “stepped down”, more targeted plan for the Basin that expands upon the recommendations made here. This plan may focus on specific species and habitats, where and when management actions will occur, who will execute those actions, and how they will be implemented “on the ground”.

Data Collection Recomendations for SGCN w/n SE Lake Ontario Basin:

- Survey Jamesville Quarry in Onondaga County for Indiana bats on an annual basis during fall swarm, fall entry, and spring emergence to monitor population status. Conduct marking studies of Indiana bats using the quarry as hibernacula to identify habitats used during summer maternity period and migration.

Management and Restoration Recommendations w/n SE Lake Ontario Basin:

- Restrict and manage human access to Jamesville Quarry (by gating) to prevent damage or disturbance of Indiana bat hibernacula.

NE Lake Ontario - St. Lawrence Goals and Objectives:

- Establish a conservation framework within the NELO-SLR Basin through which public and private stakeholders interested in wildlife conservation can work cooperatively toward the management, enhancement, and protection of the basin's at-risk biodiversity.
- Ensure that no at-risk (threatened/endangered) species becomes extirpated from the Basin.
- Manage animals, habitats, and land use practices to produce sustainable benefits for species of conservation concern.
- Maintain knowledge of species and their habitats in sufficient detail to recognize long-term population shifts.
- Fill "data gaps" for those species where population status, distribution, and habitat needs are unknown.
- Identify, manage, protect, maintain, and restore habitat/natural communities over as broad a spatial scale as possible. Work to keep large forest, wetland, and grassland complexes unfragmented, and to restore fragmented habitats where feasible to increase patch size and connectivity.
- Work with land managers to incorporate wildlife-based objectives into traditional land-management activities such as forestry and agriculture that still allow these activities to be economically sustainable.
- Develop a "stepped down," more targeted plan for the basin that expands upon the recommendations made here. This plan may focus on specific species and habitats, where and when management actions will occur, who will execute those actions, and how they will be implemented "on the ground."

NE Lake Ontario - St. Lawrence Priority Strategies and Actions for Basinwide Implementation
Data Collection Recommendations for Indiana Bat

- Continue to survey new potential hibernacula as they are discovered.
- Survey winter populations.
- Survey for Indiana bats using vocalization detectors and mist netting at sites that are geographically similar but that have differences in the density of development over large areas.
- Identify the specific summer habitat requirements for the Indiana bat by radio-tracking 1% or more of the hibernating reproductive females from winter to summer range.
- Conduct marking studies during the summer maternity, fall swarm, and spring emergence that will detect differences in mark retention and survival rates for PIT tags, and at least two types of wing bands.
- Live trap and mark Indiana bats during the fall swarm, fall entry, and spring emergence at one hibernaculum to determine the arrival and departure periods of Indiana bats by age and sex.
- Complete three years of roost temperature monitoring at all Indiana bat sites using continually monitoring temperature probes.

NE Lake Ontario - St. Lawrence Structure Collisions

- Targeted efforts should be made in the unique landscapes of the NELO-SLR Basin to determine the magnitude of this threat for SGCN based on land use and development trends (number and distribution of structures), human population distributions, and other characteristics unique to this basin.
- Provide technical guidance to state and private entities planning the siting and installation of tall structures (e.g., wind mills, cell towers, and power lines) that are likely to adversely affect populations of migrating birds and bats.

NE Lake Ontario - St. Lawrence Human-Wildlife Interactions
Indiana Bat

- Work with public and private landowners to erect gates to regulate access at selected existing and newly discovered Indiana bat hibernacula (e.g., Glen Park, Jefferson County).
- Enhance public education to dissuade killing of bats roosting on human structures. The Indiana bat is known to occasionally use structures such as houses and sheds for roosting. Public education efforts to prevent the killing of endangered bats would reduce any illegal taking of this species under federal and state statutes.

Lake Champlain Goals and Objectives:

- Establish a conservation framework within the Lake Champlain Basin through which public and private stakeholders interested in wildlife conservation can work cooperatively towards the management, enhancement, and protection of the basin's biodiversity, focusing on at-risk species.
- Ensure that no at-risk (threatened/endangered) species becomes extirpated from the basin. Furthermore, ensure that common species remain common.
- Manage animals, fish, mussels, invertebrates, their habitats, and land use practices to produce sustainable benefits for species of conservation concern.
- Maintain knowledge of species and their habitats in sufficient detail to recognize long-term population shifts.
- Fill "data gaps" for those species where population status, distribution, and habitat needs are unknown.
- Identify, manage, protect, maintain, and restore habitat/natural communities over as broad a spatial scale as possible. Work to keep large forest and wetland complexes unfragmented, and to restore fragmented wetlands and forests where feasible to increase patch size and connectivity. Quality grassland habitats should be maintained where they occur and increased in size only if it does not fragment adjacent habitats. Similarly, within this basin, the restoration and management of early successional forest habitats must be evaluated relative to the effects on other communities of significance.
- Reduce the effects of dams, culverts and other human-made obstructions to the movement of fish and wildlife dependent upon aquatic habitats.
- Work with land managers to incorporate wildlife-based objectives into traditional land management activities such as forestry and agriculture that still allow these activities to be economically sustainable.
- For species that migrate beyond state borders, conservation actions must be evaluated for consistency with regional, national, and international management plans for those species. Furthermore, actions for all SGCN should be consistent with management goals and objectives of the Lake Champlain Fish and Wildlife Management Cooperative (includes DEC, VT Fish and Wildlife, US Fish and Wildlife Service, and Quebec Wildlife and Parks).
- Develop a "stepped down", more targeted plan for the Basin that expands upon the recommendations made here. This plan may focus on specific species and habitats, where and when management actions will occur, who will execute those actions, and how they will be implemented "on the ground".

Lake Champlain Forested Habitats
Abandoned mines and natural caves provide bat habitat and support listed species such as the Indiana bat.

Lake Champlain Priority Strategies/Actions for Basin-wide Implementation Indiana bat

- Survey winter populations and continue to survey new potential hibernacula in the basin as they are discovered.
- Survey for Indiana bats using vocalization detectors and mist netting at sites that are geographically similar but that have differences in the density of development over large areas.
- Live trap and mark Indiana bats during the fall swarm, fall entry, and spring emergence at one hibernacula to determine the arrival and departure periods of the species by age and sex.
- Complete three years of roost temperature monitoring at all Indiana bat sites in the basin using continually monitoring temperature probes.

Lake Champlain Human-Wildlife Interactions

- Indiana bat - work with public and private landowners to erect gates to regulate access

Ohio

Indiana Bat (Myotis Sodalis)

Taxa: Mammal

Indiana Bat Status:
State list: Endangered

Indiana Bat Location, Record Status and Habitat Defined:
(CWCS Section 1.2.2: 3 of 34)
Habitat Association: Forests and Caves

(CWCS 9 of 980)
Species of greatest conservation need - within the Appalachian Foothills Focus Area Plan

(CWCS 146 of 980)
Focus Area Species on State-listed Terrestrial Wildlife Tactical Plan

(CWCS 77 of 980)
Focus Area Species on Unique Habitats Tactical Plan

(CWCS 9 of 980)
Species of greatest conservation need - within the Tecumseh (Shawnee Focus Area Plan) Forestland Focus Area Tactical Plan

Conservation Process – Issues and Actions for the Indiana Bat:

For Appalachian Foothills Forestland Focus Area Tactical Plan (Zaleski Focus Area Plans)

Appalachian Foothills Forestland Focus Area Tactical Plan
(CWCS Page 12 of 980)
Goal**:** To provide the habitat requirements necessary to maintain and enhance the existing forest wildlife community within the Appalachian Foothills Focus Area.

Priority Conservation Actions for the Appalachian Foothills Forestland Focus Area:
Managing forested landscapes for wildlife diversity involves managing patterns of succession. A forest landscape with stands of many age classes will have more kinds of wildlife than a single-aged forest landscape. For forest wildlife, age classes can be broken down into four stages: seedling-sapling, pole timber, saw timber and mature forest. Some wildlife species are restricted to the earliest stage, some are dependent upon the latter stages of succession, and some are generalists. To maximize forest wildlife diversity, all age classes must be present in suitable amounts across the forest landscape at any given time. If an age class is altered or missing, the wildlife species dependent upon that age class for survival and reproduction will be adversely affected.

Management opportunities for forest wildlife are influenced by the proportion and distribution of principal forest types and age classes, marketability of trees for commercial operations, and the composition and density of understory and ground layer food and cover plants. The unglaciated southcentral, southeastern, and east-central regions of Ohio support more than 70% of the state's forestland. Forest habitat management should be emphasized in this part of the state. In glaciated Ohio, opportunities to manage large blocks of forestland are limited. However, many forest wildlife species can thrive where there is a mosaic of interconnected woodlots in that part of the state. With the exception of tracts being managed to meet the needs of grassland-dependent wildlife, all woodlots on public land in glaciated Ohio should be retained and, where appropriate, expanded. Efforts aimed at encouraging private landowners to retain woodlots should also continue.

The proportion and distribution of forest types and age classes need to be determined immediately. After determining what forest types and age classes are available, management plans can be developed to bring large forested landscape areas into the preferred 30% seedling/sapling, 25% pole timber, 25% saw timber, and 20% mature forest age/size class distribution.

Forest inventory data will also be used to direct where the oak-hickory component of Ohio's forested landscape can be increased. Clearcutting should be emphasized to increase the proportion of these species in future stands. Research results from the effects of burning and thinning on oak regeneration should be incorporated on public and private forestlands throughout Ohio if these management practices are shown to increase the vigor of advance oak reproduction. In addition, oaks and other high value wildlife trees will be planted on selected sites on wildlife areas which have been surface mined.

More emphasis needs to be placed on educating the public about forest management practices. The Information and Education Group should be asked to emphasize making the public aware that clearcutting is a form of forest regeneration, not destruction. Private landowners should be encouraged to implement even-aged and uneven-aged forest management practices wherever appropriate. An early successional forest wildlife habitat management unit should be established on the larger wildlife areas in unglaciated Ohio. These management units should be >500 acres and placed on a long term (75-100 years depending on current age classes) timber harvest rotation that emphasizes small (<20 acres), well-distributed clearcuts. Controlled burns should be considered for these sites if research shows fire to be an effective management tool to increase the proportion of oaks and hickories.

To meet the habitat requirements of all of the forest-wildlife species found at the Appalachian Foothills, a variety of age and size classes of timber must be distributed throughout the Focus Area. An age/size class distribution of 30% seedling/sapling, 25% pole timber, 25% saw timber and 20% mature forest (i.e., no harvest activity) would meet the habitat needs required to sustain a healthy forest wildlife community (see section 3.1 Forest Habitat Tactical Plan).

Achieving these goals will require a three-phased approach.

- The Information Phase will involve presentation of the Plan to the stakeholders.
- Inventory Phase – After the Plan is approved, an inventory of the structure and composition of the wildlife habitat within the Appalachian Foothills Focus Area will be conducted.
- Planning and Implementation Phase – This phase of the Appalachian Foothills Plan will begin after the Inventory Phase is completed. Planning will involve comparing

existing habitat inventories to planned habitat objectives and determining what adjustments need to be made in the proportions of the various habitat types.

Monitoring and Evaluation: Wildlife monitoring programs are necessary to determine the effectiveness of wildlife management activities. The impact of the Forestland Tactical Plan and the associated Appalachian Foothills Focus Area Plan will be best determined by information collected from an intensive and extensive monitoring program. The monitoring portion of the focus area plans will entail two phases:

- First, a long-term population monitoring program will be established on at least one focus area within each habitat type.
- The second phase of the overall monitoring phase will involve developing a population viability model for the suite of wildlife associated with each of the principal habitat types identified in each of the principal Focus Area Tactical Plans.

Partnerships:
The Division of Wildlife has partnered with The Ohio State University Entomology Department, the U.S. Fish and Wildlife Service, the Wilds, and U.S. Forest Service Athens District to reintroduce the federally and state endangered American burying beetle into its historical range in Ohio. Many of the releases have been and will be within the Appalachian Foothills Focus Area because they offered extensive areas of quality habitat for the beetle.

Unique Habitats Tactical Plan
(CWCS 320-326 of 980)
Priority Conservation Actions for the Unique Habitats Tactical Plan
Goal: To provide the habitat requirements necessary to maintain and enhance existing wildlife communities dependent upon unique habitats.

General Introduction/Background/Needs/Justification**:**
At the time of European settlement, Ohio's landscape was primarily a vast expanse of forest, with a few large grassland and wetland areas. Also scattered throughout the state, in smaller amounts, were other significant habitats, referred to as unique habitats. Ohio's primary unique habitats include: Lake Erie islands, oak savannas, the boreal (snowbelt) community, and caves. There are 21 species (8 mammals, 3 birds, 2 reptiles, 3 amphibians, and 5 endangered invertebrates) dependant on Ohio's unique habitats. Rich and diverse assemblages of flora and fauna are associated with each unique habitat. While quality unique habitat still exists, the quickening pace of development and suburban sprawl threatens to further fragment these areas. In addition to conserving unique habitats, opportunities also exist to enhance man-made structures which simulate natural habitats for some wildlife, such as utilizing mines as hibernacula for the Indiana bat and skyscrapers as nesting sites for peregrine falcons.

Caves - Introduction/Background
Most of Ohio's caves occur in a 40-mile-wide track of land aligned north-south through the middle of the state (Brucker 1979). There are approximately 300 known caves which span the state from Adams County to the Lake Erie Islands.

In addition to naturally formed caves, there are 4,000+ recorded inactive underground mines resulting from mineral extraction. Most of these mines were the product of coal extraction and lie in the

unglaciated region of the state. A few mines, such as the Preble County mine, occur in the glaciated western portion of Ohio and resulted from industrial mineral mining. Of the 4,000+ recorded mines, less than 20% are believed to have external entrances which are still open.

Both natural caves and man-made mines provide critical habitat for wildlife. The features common to most caves include total darkness, relative permanence (in contrast to more ephemeral environments like a forest), and relatively constant environmental conditions (temperature, relative humidity, minimal air flow). Two equally important features are caves' long history of isolation and their uniqueness. No two caves are alike in their physical, environmental, or biological features (Belwood, 1998). While structurally less stable than caves, man-made mines can offer similar microclimates.

There are five mammals, one amphibian, and two endangered invertebrates known to be dependant on caves or mines for a significant portion of their lives. Of the eight, the Allegheny woodrat, Indiana bat, Eastern small-footed bat, Rafinesque's big-eared bat, cave salamander, Ohio cave beetle, and Kramer's cave beetle are state-listed species.

Caves - Needs/Justification

To secure populations of most of Ohio's cave-wildlife species, a minimum of 25% of all caves or quality mines must be protected. This can be accomplished by installing bat-friendly gates in all high quality mine entries and conserving natural buffer zones (a minimum of 200 acres) around the cave or mine entries known to support hibernating bats.

While difficult to enforce, Ohio's Cave Protection Act (Ohio Revised Code 1517.21 to 1517.26) makes it illegal to kill, harm, or disturb any cave life. Human disturbance (resulting from recreational caving, commercialization, and vandalism) is the most serious threat to cave dependant wildlife. Sealing and improper gating also reduces or eliminates the availability of mines to wildlife. In addition, only 1/3 of the known caves and less than 10% of the mines, with open external entrances, have been surveyed. Properly designed and installed gating can provide secure environments for cave-dependant wildlife. Research is needed to determine the habitat specificity of all state-listed invertebrates which occupy caves. Many wildlife species are limited to very specific locations within the cave or mine complex. Research is also needed to better understand the biology and life history of these species and their relationship to the microhabitats which they occupy. Furthermore, opportunities exist to provide quality hibernacula for Indiana bats by enhancing internal features of man-made mines, to simulate the humidity, airflow, and micro-habitat required by these bats, but this has not been well studied or attempted. The feasibility of enhancing these mine features needs to be determined. Additional surveys and research are needed to adequately assess the population status of all cave dwelling bat species. All Ohio bats are insectivores and are known to feed over a variety of habitats including riparian corridors, forests, grasslands and agricultural fields. In addition to protecting caves and mines, lands near cave entrances must be conserved to ensure the bats have adequate areas to feed to increase their fat reserves prior to entering a hibernaculum as well as at spring emergence. While Hobbs (1981) has recorded approximately 88 species and subspecies of invertebrates and 49 species and subspecies of vertebrates in Ohio caves, few scientists study cave life and there may be numerous species yet to be identified or discovered. Efforts to survey and research cave-dependant invertebrates need to be expanded.

Objective: Restore, enhance, and maintain unique habitats that will support viable populations of the 21 wildlife species listed in Appendix 1 of this plan as well as the numerous species with viable, broadly distributed populations also found within these areas.

Approach: To offset habitat losses and sustain viable populations of unique habitat-dependant wildlife will require cooperation of existing landowners and other land managing organizations and agencies.

The Division must:

- Develop and strengthen partnerships with state and federal agencies and non-governmental organizations (such as The Nature Conservancy) who own or manage land to conserve and restore unique habitat
- Provide technical assistance to private landowners who wish to enhance and/or restore unique habitat (W2PM06, W3PM06, W4PM06, and W5PM06)
- Connect fragmented parcels of unique habitat to allow for wildlife movement between areas
- Partner with private landowners to conserve unique habitat-dependant wildlife species through conservation easements, land donation or acquisition (only from willing sellers)
- Continue reintroduction and monitoring efforts for the snowshoe hare (WUNR03) and the Karner blue butterfly (W2NM22)
- Ensure that long-term monitoring of butterflies and moths continues
- Continue to work with Lake Erie Island shoreline residents and businesses to ensure open rock cribs are used in the construction of new or refurbished docks
- Continue research and surveys to determine hibernation, seasonal activity, movement patterns, and foraging behavior of the Lake Erie water snake
- Identify and implement measures to ensure secure nesting sites exist for colonial waterbirds on the Lake Erie islands
- Identify the causes for the decline of the black-crowned night heron populations and reverse the trend, if feasible
- Evaluate the feasibility of providing quality hibernacula for Indiana bats by enhancing internal features of man-made mines
- Initiate surveys to determine the current distribution and abundance of the ermine, southern red-backed vole, woodland jumping mouse, blue-spotted salamander, cave-dwelling bat species and cave-dependant invertebrates
- Continue locating and protecting, with bat-friendly gates, mines and caves serving as hibernation roost sites for Indiana bats and other species (WFNR03 and WANR05) and surveying the population status of all bat species in the Preble County Underground Mine.

Habitat objectives for all the focus areas were developed based on the best information currently available in terms of species-habitat relationships and the population ecology of associated wildlife species. Assumptions were made so that habitat work could proceed toward meeting plan goals and objectives. Clearly, evaluation and monitoring will be required periodically in each focus area for select species of interest to assess the validity of assumptions made during this planning process and to guide

future revisions of these conservation activities. Thus, along with projects designed to attain focus area habitat goals, appropriate surveys and research evaluations need to be developed and implemented to ensure that habitat projects are producing measurable and desirable results for the intended wildlife community.

Tecumseh Forestland Focus Area (Shawnee Focus Area) Tactical Plan
(CWCS 211-214 of 980)

Priority Conservation Actions for the Tecumseh Forestland Focus Area Tactical Plan:
Goal: To provide the habitat requirements necessary to maintain and enhance the existing forest wildlife community within the Tecumseh Focus Area.

Introduction/Background: The hill counties of southeast and southern Ohio currently exhibit the best examples of the forest wildlife habitat that existed in Ohio prior to European settlement.

The Tecumseh Focus Area (Figure 1), located in Scioto and Adams counties, includes Shawnee State Forest (60,179 acres, 75% of the total area), Shawnee State Park (587 acres, less than 1% of the total area), Raven Rock State Nature Preserve (93 acres, less than 1% of the total area), and scattered parcels of private land (19,414 acres, 24% of the total area). While no specific activities are planned for immediately adjacent lands and in holdings that are privately owned, current habitat conditions on these areas will be considered as forest management plans are developed for public lands.

Once inhabited by Shawnee Indians, Shawnee State Forest came into existence in 1922 with the purchase of 5,000 acres of land that had been heavily timbered and ravaged by fire. In the 1930s, six Civilian Conservation Corps camps were located in the forest. During this period, many of the roads were constructed in the then nearly inaccessible area. In 1949, the recreation facilities at Roosevelt Lake were transferred to the Division of Parks. The Roosevelt Game Preserve became a part of the forest in 1951.

Shawnee State Forest is managed to improve the growth, yield and quality of the timber on the area. The habitat needs of the wildlife that inhabit the Forest are considered when timber harvest plans are developed. A wilderness area totaling approximately 8,000 acres has been designated within the Shawnee State Forest where all timber management, habitat manipulation and public motorized travel have been eliminated.

Currently tree age classes in the Tecumseh Focus Area are shifting from less shrub/brush to more pole/mature with a slow but steady shift in tree species composition from oak and hickory dominated stands to maple and tulip poplar stands.

One-hundred-twenty-five species have been identified on Ohio's Native and Naturalized Terrestrial Wildlife Species List as having viable, broadly distributed populations around the state (e.g., robins, chipmunks, etc.). They occur as viable populations in most, if not all, of the focus areas. While these species are obviously part of the wildlife communities in the focus areas, it is not critical to meet the habitat objectives in each focus area to ensure these species continued viability. Therefore, habitat guidelines were developed to address the needs of the species in the Tecumseh Focus Area with more

limited distribution and/or lower population levels. There are 55 species (13 mammals, 30 birds, 7 reptiles and 5 amphibians) in this category found within the Focus Area (See Appendix 1).

Need/Justification: The Division of Wildlife's approach to enhancing and maintaining the highest level of terrestrial wildlife diversity in the state is to use a "focus area" concept to sustain viable populations of as many native species of wildlife as possible. The idea is to concentrate efforts and resources to provide all the necessary habitat requirements in a few, relatively large units of the major habitat types, along with the remnants of several unique habitats, for species that are of limited distribution or have low populations. Several widely separated focus areas for each of the major habitat types (forest, grassland and wetland) have been selected to reduce the risk of extirpation of species from natural disaster, disease outbreak, etc. Typically focus areas are associated with relatively large holdings of public land where future land use practices can be managed.

When considering the needs of several species of forest birds (pileated woodpecker, broadwinged hawk, yellow-throated vireo, worm-eating warbler, cerulean warbler, ovenbird and the American redstart), the literature suggests that the minimum forestland acreage needed before these species would likely be present is 300 acres. A viable population would require at least 200 breeding pairs. In a large forestland area or complex, the most area-sensitive of these avian species, the pileated woodpecker and broad-winged hawk, could be expected to nest at a density of 1 nest per 300 acres. Therefore, conservation areas designed to maintain viable populations of these species would need to have approximately 60,000 acres of suitable forest habitat (200 pairs x 300 acres/pair). The higher the proportion of forest habitat (as opposed to other cover types such as agriculture or post-stripmine grasslands) within the focus area the better with 80% or more being the most desirable. This approach assumes that the needs of less area-sensitive species along with the common, broadly distributed species will be met if the habitat requirements of the most area-sensitive species are provided.

To meet the habitat requirements of all the forest-wildlife species found at Tecumseh, a variety of age and size classes of timber must be distributed throughout the Focus Area. An age/size class distribution of 30% seedling/sapling, 25% pole timber, 25% saw timber and 20% mature forest (i.e., no harvest activity) would meet the habitat needs required to sustain a healthy forest wildlife community (See Forest Habitat Tactical Plan). Based on the best currently available information, this approach (approximately 60,000 acres of forest habitat that comprises at least 80% of a focus area with a mixture of 30%, 25%, 25% and 20% seedlings, poles, saw timber and mature forest respectively) would sustain viable populations of all of Ohio's forest wildlife species with one exception – black bears. The literature suggests that the minimum acreage needed to sustain a viable population of black bears is 224,000 acres. Since this essentially quadruples the size of forest focus areas and since Ohio's bear population is clearly on the rise with substantial suitable, unoccupied habitat throughout the eastern and southern portions of the state, it has been determined not to base forestland focus area size on the needs of black bears. It should also be noted that while there is a reasonable likelihood that populations of species listed in Appendix 1 for this Focus Area will be viable if planned habitat management and restoration efforts are completed in a timely manner, not all species have the same probability of reaching viable levels because their populations may be impacted by factors other than habitat conditions on the Focus Area (e.g., location of Focus Area to species' geographic range or habitat quality and availability on migratory routes and wintering areas).

The Tecumseh Focus Area was chosen because Shawnee State Forest, Shawnee State Park and Raven Rock State Nature Preserve comprise nearly 76% of the tract (60,859 acres of 80,273)

(Figure 1) and 77,457 acres (96%) of the 80,000+ acre Focus Area are currently forested (Figure 2). It represents one of the best and largest examples of forest wildlife habitat currently found in the state.

Objective: To establish and maintain quality forest habitat that will support viable populations of the 55 species listed in Appendix 1 of this Plan in addition to the numerous species with viable, broadly distributed populations also found within the Focus Area.

Approach: Achieving this Plan's Goal and Objective will require a three-phased approach:

- The Information Phase will involve presentation of the Plan to the Division of Forestry, Division of Parks and Recreation and the Division of Natural Areas and Preserves to determine their willingness to cooperate with implementation.
- Inventory Phase – After the Plan is approved, an inventory of the structure and composition of the wildlife habitat within the Tecumseh Focus Area will be conducted.
- Planning and Implementation Phase – This phase of the Tecumseh Plan will begin after the Inventory Phase is completed. **Needs/Justification** and determining what adjustments need to be made in the proportions of the various habitat types.

Pennsylvania

Indiana Bat (*Myotis Sodalis*)

IMMEDIATE CONCERN (10.4 CWCS-Priority Mammals)
Status/notes: Federally Endangered; habitat specialist. Global rank G2.
Habitat: Winter - cold caverns and mines; Summer - forests
Reason(s) for concern: Species has experienced drastic declines nationwide due to loss and degradation of hibernation sites.

PA SWAP Ranking factors for the Indian Bat:
(CWCS Table 10.1: Ranking Factors for CWCS-Priority Mammals)

IMMEDIATE CONCERN						
Common Name	Global Rank	State Rank	Current (Legal) Status in PA	PABS Proposed Status[d]	NE Priority	Notes
Indiana or Social Myotis	G2	SUB/S1N	PE	PE	N/A	Federally threatened

Federal State Wildlife Grants (SWG) Progress for the Indiana Bat:
(CWCS Table 10.7: SWG Progress with CWCS-Priority Species)

MAMMALS			
WAP-Priority Species	Project Type/Yr		WAP Species Account
Indiana or Social Myotis	Maternity site protection – WCRA'01	xx – SWG '02	PA Mammal Atlas – SWG '02

Indian Bat Habitat Defined:
(CWCS 12.2 Priority Species Associated with Deciduous/Mixed Forests)
Species Associated Primarily with Second Growth Deciduous Forest:

IMMEDIATE CONCERN	SPECIFIC HABITAT REQUIREMENTS
Indiana Bat ***Myotis sodalist***	Summer-riparian, bottomland or upland forests, old fields and pastures. Winter-caves, mines

Species Associated Primarily with Mature Deciduous Forest:

IMMEDIATE CONCERN	SPECIFIC HABITAT REQUIREMENTS
Indiana Bat ***Myotis sodalist***	Summer-riparian, bottomland or upland forests, old fields and pastures. Winter-caves, mines.

Species Associated Primarily with Mid-successional/Second Growth Mixed Forest:

IMMEDIATE CONCERN	SPECIFIC HABITAT REQUIREMENTS
Indiana Bat ***Myotis sodalis***	Summer-riparian, bottomland or upland forests, old fields and pastures. Winter-caves, mines.

Indiana Bat Association with Specific Deciduous/ Mixed Forest Habitats:
(CWCS Appendix 12.1 - Species/Habitat Associations for Deciduous/Mixed Forest Habitats)
(CWCS Table 12.6: WAP-Priority species-habitat associations for Deciduous (Broadleaf) Terrestrial Forests/Woodlands in Pennsylvania)

Category	Quality	Micro-quality	WAP-Priority Species	Specific Community Type	Physiographic Area*
Mid-successional "Second-growth" Deciduous Forest		Low elevation w/ exposed snags	Indiana Bat		
Mature Deciduous Forest		Low elevation	Indiana Bat		

(CWCS Table 12.7: WAP-Priority species-habitat associations for Mixed (Conifer/Broadleaf) Terrestrial Forests/Woodlands in Pennsylvania)

Category	Specific types	Micro-quality	WAP - Priority Species	Specific Community Type	Physiographic Area*
Mid-successional , "Second Growth "Mixed Forests	Low elevation		Indiana Bat		

Indiana Bat Association with Specific Rock Habitats:
(CWCS 16.1 Location and Condition of Rock Habitats)

- Terrestrial solution caves occur in limestone bedrock and are the most common cave in the state, particularly in the Ridge and Valley physiographic region. A diverse invertebrate community can be found here, as well as several Species of Greatest Conservation Need: the federally endangered Indiana bat; eastern small-footed bat, and; Allegheny woodrat.
- Tectonic caves are formed by subsurface cracks in bedrock and may be associated with sandstone. They are usually dry and also used by bats and woodrats.
- Talus caves are formed in boulder piles where openings occur between rocks. Many reptiles and small- to mid-sized mammals may use these for cover. WAP-Priority species, such as the Indiana bat, eastern small-footed bat, Allegheny woodrat, timber rattlesnake, and the northern copperhead may be found using talus caves and talus slopes.

Man-made caverns, such as deep coal mine shafts or abandoned tunnels, also are inhabited by rock-associated wildlife. Surveys conducted by the Pennsylvania Game Commission indicate the importance of man-made sites: of the rock hibernacula sampled by the Game Commission, 77 percent of limestone mines, 100 percent of other types of mines, 81 percent of vehicle tunnels, and 100 percent of other types of tunnels were occupied by bats. Other man-made structures were occupied 92 percent of the time (Hart 2001). As mentioned previously, this is likely an artifact of historic use of rock habitats, but it does indicate that these man-made sights can contribute significantly to the conservation of WAP-

Priority species (CWCS 16.1 Location and Condition of Rock Habitats). (CWCS 16.3 Rock-Associated Wildlife Species)

(CWCS Table 16.2: WAP-Priority species associated with rock habitats (caves, rocky outcrops, talus slopes, mines and tunnels) in Pennsylvania)

IMMEDIATE CONCERN	SPECIFIC HABITAT REQUIREMENTS
Indiana Bat *Myotis sodalis*	Summer-riparian, bottomland or upland forests, old fields and pastures. Winter-caves, mines

Indiana Bat Association with Specific Rock Habitats:
(CWCS Appendix 16.1 Species/Habitat Associations for Rock Habitats)
(CWCS Table 16.4 Specific species/habitat associations for rock-associated, WAP-Priority species in Pennsylvania)

Category	Dom Veg	Micro-quality	WAP-Priority Species	Specific Type	Physio Area*
Cliff, rock outcrop		Cold caves/mines w/air flow	Indiana Bat	Mines with 3-6°C (37-43°F) temps	

PA Statewide Priority Conservation Actions – Deciduous/Mixed Forests:
(CWCS 12.6 Statewide Priority Conservation Actions – Deciduous/Mixed Forests)

- Comprehensive Forest Management Planning
- Landowner Outreach and Technical Assistance
- Targeted Management of Mature Forest Tracts
- Maintain Structural Diversity of Forests
- Identify and Manage Large Blocks of Core Forest

Statewide Priority Conservation Actions – Species Associated with Deciduous/Mixed Forests:
(CWCS 12.8 Statewide Priority Conservation Actions – Species Associated with Deciduous/Mixed Forests)

- Education Efforts Relating to Species of Greatest Conservation Need
- Develop Multi-Species Management Guidance
- Presence/absence Surveys of Forest-Associated Species
- Management/Recovery Planning of Priority Species
- Improved Monitoring of Forest-associated Species
- Identify Critical Foraging Areas
- Identify Key Migration Corridors
- Identify Priority Activity (roosting/nesting/denning) Sites

Statewide Priority Conservation Actions – Rock Habitats:
(CWCS 16.6 Statewide Priority Conservation Actions – Rock Habitats)
Level 1 - highest priority over the next 1-5 years:

- Ensure Adequate Protection of High-Priority Caves

- Identify High-Priority Rock Outcrops/Cliff/Talus Habitats

Level 2-priority over the next 5-10 years:

- Develop a Statewide Management Plan for Rock Cliff/Outcrop/Talus Habitats
- Creation of Suitable Habitat During Mine Reclamation

Tennessee

Indiana Bat (*Myotis Sodalis)*

Taxa: Mammal

Indiana Bat Status:

(Appendix A: 4)

Federal Status: Endangered

State Status: Endangered

Species of Greatest Conservation Need (SGCN): Tier 3

Critically imperiled in state; 5 or fewer occurrences statewide

Indiana Bat Location and Habitat Defined:

(Appendix C)

Interior Low Plateau

- Western Highland Rim
- Penneroyal Plain
- Outer Central Basin
- Eastern Highland Rim

Cumberland Plateau & Mountains

- Sequatchie Valley
- Cumberland Plateau
- Cumberland Mountains
- Black Mountains

Ridge & Valley

- Sandstone Hills
- Rolling Limestone Hills
- Holston Valley
- Bristol Valley

Southern Blue Ridge

- Unicoi Mountains
- Unaka Mountains

(Appendix A: 35)

Terrestrial Habitat Preference Type:

- Central and Southern Appalachian Spruce-Fir Forest
- Southern Appalachian Low Mountain Pine Forest
- Southern Appalachian Montane Pine Forest and Woodland
- Allegheny-Cumberland Dry Oak Forest and Woodland
- Central and Southern Appalachian Northern Hardwood Forest
- Southern Interior Low Plateau Dry Oak Forest
- South-Central Interior Mesophytic Forest
- Southern and Central Appalachian Cove Forest

- Southern and Central Appalachian Oak Forest
- Appalachian Hemlock-Hardwood Forest
- Central Interior Highlands and Appalachian Sinkhole and Depression Pond
- Southern and Central Appalachian Bog and Fen
- South-Central Interior Large Floodplain
- South-Central Interior Small Stream and Riparian
- Converted Wetland (Riverine)
- Converted Wetland (Lacustrine)

Conservation Process – Issues and Actions for the Indiana Bat:
(Appendix A: 158)
Source of Stress:

- Forest Type Conversion
- Incompatible Forestry Practices
- Incompatible Row Crop Agricultural Practices

(TNCWCS: 147)
Priority Terrestrial Conservation Actions by Source of Stress:
Forest Type Conversion

- Coordinate planning for land acquisition among agencies and NGO's.
- Coordinate planning for easement acquisition among agencies and NGO's
- Utilize government-funded incentive programs for landowners to restore/manage forests.
- Acquire priority tracts of habitat for GCN species

Incompatible Forestry Practices

- Coordinate planning for land acquisition among agencies and NGO's.
- Coordinate planning for easement acquisition among agencies and NGO's.
- Utilize government-funded incentive programs for landowners to restore/manage forests.
- Develop formal management agreements with landowners.

Incompatible Row Crop Agricultural Practices

- Propose legislation to expand government funded incentive programs.
- Develop strategic alliance with Farm Bureau, NRCS, FSA, and others.
- Utilize government-funded incentive programs for landowners to improve/protect water quality.
- Restore pastures, fields, and other agricultural lands.

Virginia

Indiana Bat (*Myotis Sodalis*)

Taxa: Mammal

Indiana Bat Status:
(Chapter 7:3)
State list: Endangered

State Rank: Tier 1

Indiana Bat Location and Habitat Defined:
Chapter 6 – Blue Ridge Mountains
Chapter 7 – Northern Ridge and Valley
Chapter 2 – Subterranean Habitat Types: Cave
Chapter 8 – The Northern Cumberland Mountains
Chapter 9 – The Southern Cumberland Mountains

Description of Essential Habitat:
This species requires caves with cool stable temperatures (Whitaker and Hamilton, 1998). More specifically, R. J. Reynolds (DGIF, pers. comm.) states that essential habitat includes caves with high humidity and stable temperatures (3-10°C), and that Indiana myotis is often associated with old saltpeter mines (Chapter 7:3).

Deciduous forest species of greatest conservation need in the Ridge and Valley
Special Habitat Needs: Snags in sunlight (breeding) (Table 7.9).

Mixed forest species of greatest conservation need in the Ridge and Valley.
Special Habitat Needs: Snags in sunlight (breeding) (Table 7.11).

Herbaceous habitat species of greatest conservation need in the Ridge and Valley.
Special Habitat Needs: Uses solitary sunlit snags in summer (Table 7.13).

Wooded wetland species of greatest conservation need in the Ridge and Valley.
Special Habitat Needs: Colonies in snags in sunlight; forages in wet or dry forest (Table 7.20).

Cave species of greatest conservation need in the Ridge and Valley.
Special Habitat Needs: Limestone caves (hibernation) (Table 7.79).

Forest generalist species of greatest conservation need in the Northern Cumberlands. “Open woods”
Special Habitat Needs: Snags in sunlight (breeding) (Table 8.4).
Herbaceous habitat species of greatest conservation need in the Northern Cumberlands.
Special Habitat Needs: Uses solitary sunlit snags in summer (Table 8.9).

Conservation Process – Issues and Actions for the Indiana Bat:

(Chapter 7 — The Northern Ridge and Valley)
No conservation actions were identified by Mammal TAC (2004). USFWS (1983d) identify several in the recovery plan. These include: prevent disturbance to hibernacula; protect, maintain, and restore foraging and nursery areas; and carry out a public information campaign. For detailed conservation actions, see USFWS (1983d).

(Chapter 8 — The Northern Cumberland Mountains)
No conservation actions were identified by Mammal TAC (2004). USFWS (1983a) identify several in the recovery plan. These include preventing disturbance to hibernacula; protecting, and restoring foraging and nursery areas; and a public information campaign. For detailed conservation actions, see USFWS (1983a).

(Appendix J:6)
TAC Research and Monitoring Needs:

- Assess possible effects of wind energy projects
- Evaluate the effects of pesticides on this species and its prey
- Identify and monitor important cave abiotic factors
- Locate and characterize summer maternity colonies
- Maintain current monitoring efforts

West Virginia

Indiana Bat (*Myotis Sodalis)*

(CWCS 5E-Mammals 35 - 37)

Taxa: Mammals

Indiana Bat Status:

The ranks and information in the chart below reflect the rarity of the Indiana Bat in West Virginia. This species is listed as endangered by the U.S. Fish and Wildlife Service.

Priority	Global Rank	State Rank	USFWS	Mon Forest	Jeff Forest	IUCN Rank	NE Tech Comm	Trend
1*	G2	S1	LE	X	X	EN A1c	X	Increasing

Indiana Bat Location, Record Status and Habitat Defined:

(CWCS 4F-Habitats)

The following table places known occurrences of the Indiana Bat into watersheds, gives the ages of the records (recent is within 20 years), and indicates whether the sites are under public or private ownership. The number of records is not indicated in this table. Each watershed listed may have more than one record for the species. Sites listed are hibernacula and maternity colonies.

Habitat: Indiana Bats hibernate in caves which provide suitable hibernaculum conditions. These caves usually have fairly stable winter temperatures ranging from 2.8 to 6.1 oC (37 to 43 oF) and a high relative humidity (66 percent to 95 percent). During the summer, females form small maternity colonies under the loose bark of trees. Males also utilize trees, forming small colonies in hollow trees or under loose bark. Feeding areas for the Indiana Bat consist of wooded habitats, both along river corridors and in upland forests.

Watershed	Record Type	Ownership
Cacapon	Historic	Private
Cheat	Recent	Private
		Public
Coal	Recent	Private
Elk	Recent	Private
		Public
Greenbrier	Recent Historic	Private
Lower New	Recent	Public
South Branch Potomac	Recent Historic	Private
		Public
Tygart Valley	Recent	Private
Upper New	Recent	Private

SPECIES IN GREATEST NEED OF CONSERVATION

OAK/HICKORY AND DRY/MESIC OAK FOREST

Scientific Name Common Name

Myotis sodalist **Indiana Bat**

SPECIES IN GREATEST NEED OF CONSERVATION

MIXED MESOPHYTIC FOREST

Scientific Name Common Name

Myotis sodalist **Indiana Bat**

SPECIES IN GREATEST NEED OF CONSERVATION

HEMLOCK FOREST

Scientific Name Common Name

Myotis sodalist **Indiana Bat**

SPECIES IN GREATEST NEED OF CONSERVATION

Successional Deciduous Forests

Scientific Name Common Name

Myotis sodalist **Indiana Bat**

Hemlock Forests Description:

Hemlock Forests are upland evergreen forests found on cool aspects such as ravines and north slopes throughout much of the state, and as an extensive type on the plateaus near the Gauley River. These forests

are dominated by Hemlock, but are often mixed with the deciduous trees of the Northern Hardwoods Forest type. Giant Rhododendron is a common tall shrub species in many stands. Herb layers are typically sparse. Hemlock Forests are under immediate and severe threat from the Hemlock Woolly Adelgid, a sap sucking insect that can kill their host. Many trees have already been killed in the state and the infestation is moving south and west from the Eastern Panhandle. Prospects for the continued existence of significant Hemlock stands are not good. This is a very threatened system with no current Adelgid control available for large areas of trees.

Mixed Mesophytic Forest Description:
Mixed Mesophytic Forests are upland deciduous forests and are dominated by a mixture of trees adapted to moist, fertile soils, usually found at lower elevations than Northern Hardwoods Forests. Co-dominant trees include Sugar Maple, Basswood, Buckeye, White Ash, Tulip Poplar, Umbrella Magnolia, Slippery Elm, Beech, Red Oak, Shagbark Hickory and Black Birch. There is often
a lush and diverse herbaceous layer including many spring ephemerals.

Oak/Hickory and Dry/Mesic Oak Forest Description:
Oak/Hickory and Dry/Mesic Oak Forests occur at middle to lower elevations throughout the state. Soils are usually somewhat less acidic and more fertile compared to the oak/heath forests, but are drier than the mixed mesophytic forest type. Dominant trees include Red Oak, Black Oak, Chestnut Oak, Pignut Hickory, Mockernut Hickory, Shagbark Hickory, White Ash, Black Gum and Red Maple. Heath shrubs may be present but are not as abundant as in the Oak/Heath Forest type. The herb layer ranges from sparse to moderate but is often quite diverse.

Successional Deciduous Forest Description:
Successional Deciduous Forests are upland deciduous forests occurring throughout the state, which develop after clearing or other catastrophic disturbances (e.g. fire). These are often monocultures, the dominant species depending on elevation and moisture regime. Distinct subtypes include Quaking Aspen at high elevations, and Tulip Poplar and Black Locust at lower and middle elevations.

Subterranean Habitats Description:
This class includes any underground areas used by species as habitat. In West Virginia there are many hundreds of limestone caves and a small number of sandstone caves. In addition, a number of abandoned deep mines have openings allowing colonization by some cave dwellers such as bats and salamanders.

The caves of the state harbor an incredible array of invertebrate species, many of which are restricted to only a few caves. Eighty-seven globally rare invertebrate SGNC are listed in the introduction to the Cave Invertebrate Fact Sheets found in Section 5-F of this plan. In addition, a number of vertebrate SGNC depend on caves for either part or all of their habitat requirements.
Caves have often been looked at as a threat to livestock and people and a number of entrances, particularly in sink holes, have been filled either intentionally or as a convenient place to dispose of household and other trash. Some caves have been lost to quarrying and the hydrologic regime altered in others. Many cave invertebrates are either aquatic or rely on organic matter carried into the cave by hydrologic forces (streams, ground water or surface flow). Aquifers providing caves with water are poorly documented and once identified will require landscape scale planning to ameliorate any negative influences. Many caves have been gated to prevent the entry of recreational (or other) users to prevent the disruption of breeding or hibernating SGNC bats.

Significant losses of some bat species have occurred in the past and many gated caves show a relatively rapid positive population response to the decreased disturbance during critical periods. There has been a direct loss of caves in the state and considerable alteration to the habitat in others. Assessing the presence of SGNC species and their requirements is ongoing but considerable work is yet required for this nationally significant

habitat type in the state. Some cave dwelling species are found in aquatic systems within caves and others are terrestrial. No classification system is currently being used to separate habitat within caves and such a system may not be needed. The habitat class itself may be adequate, since essentially all conservation of cave species will likely be done on a cave by cave basis (sites) rather than trying to conserve a number of caves across the range of caves occurring in the state (habitat). The conservation of caves with aquatic systems necessitates management planning

Decision Making Process - Needs and Actions for the Indiana Bat:
Each category discussed in this section is important to the conservation of the Indiana Bat. Because there is inadequate information on the distribution and status of the Indiana Bat in West Virginia, the first step in its conservation is to gain a better understanding of its distribution, migration patterns and habitat use. Needs and actions for each category are outlined below.
Bolded text indicates primary actions required to identify conservation needs of the Indiana Bat.

Category	Need	Action
Data	Standardize data collection protocols to allow integration with other data.	**Develop and implement standardized protocols, associated forms, databases, instruction and training.**
	Public access to general bat information.	**Publish *Bats of West Virginia*.**
		Provide general bat data, such as distribution maps, on the internet.
	GIS layer of bat data.	**Create a GIS layer of bat data using existing and newly gathered data.**

Category	Need	Action
Surveys	Additional potential hibernacula sites need to be surveyed.	**Select caves based on structure, proximity to existing known hibernacula and reports from cavers.**
	Additional maternity sites need to be surveyed.	**Conduct mist net surveys at water sources and in travel corridors in areas suitable for Indiana Bat maternity colonies. Band Indiana Bats to determine where bats of specific maternity colonies hibernate.**
	Historic sites need to be revisited.	Historic hibernacula will be visited to determine if bats are still present at the sites and to note any habitat changes.

Category	Need	Action
Monitoring	Existing sites need to be monitored.	Monitor to document changes in the populations or habitat, and to monitor any potential threats. Significant hibernacula will be monitored biennially, while minor hibernacula will be monitored on a less frequent basis. Maternity sites will also be monitored.
	Microclimate data at hibernacula needs to be collected.	Place temperature loggers at Indiana Bat hibernacula.

Category	Need	Action
Research	Information on Indiana Bat movements, activities outside of the hibernacula and roosts need to be obtained to analyze habitat use.	**Utilize acoustic monitoring and/or radio-telemetry to track and locate roost trees, foraging areas and summer habitat.**
	Impacts of wind turbines and other large structures on all bat species needs to be determined.	**Monitor wind turbine and cell tower sites routinely to recover bat carcasses to provide information on mortality rates and whether high mortality is affected by seasonal changes, weather patterns, etc.**
	Hair isotope studies.	**Collect and analyze hair samples from female Indiana Bats in hibernacula to determine approximate summer locations and migration distances.**
	Genetics of WV Indiana Bat populations need to be examined to determine how they relate to other populations in the East.	**Coordinate with the U.S. Fish and Wildlife Service, state agencies, U.S. Forest Service and other surveyors to collect tissue samples from Indiana Bats for genetic information.**

Conservation Process – Issues and Actions for the Indiana Bat:

There several conservation issues associated with the Indiana Bat and its habitat. This section outlines the issues and the appropriate actions required to address the issues. **Bolded** actions are actions for initial implementation. Habitat loss includes effects from housing and commercial development, dam construction, road construction, mining and quarry activities, acid precipitation, utility corridors and sites, and oil and gas drilling. Water quantity and quality issues include stream channel modification, dam construction, wetland draining and filling activities, water use, acid precipitation, acid mine drainage, erosion and sedimentation, chemical pollution, nutrient loads and solid waste.

Issues	Actions
Habitat Loss	**Coordination**, Education, Management
Forest Health	**Coordination**, Education, Management
Water Quantity and Quality	**Education**, Coordination, Management
Over Collection	
Management Conflicts	
Invasive Species	
Damaging Recreation	**Acquisition**, Coordination
Data Protection	**Legislation/Regulation**