Proceedings of

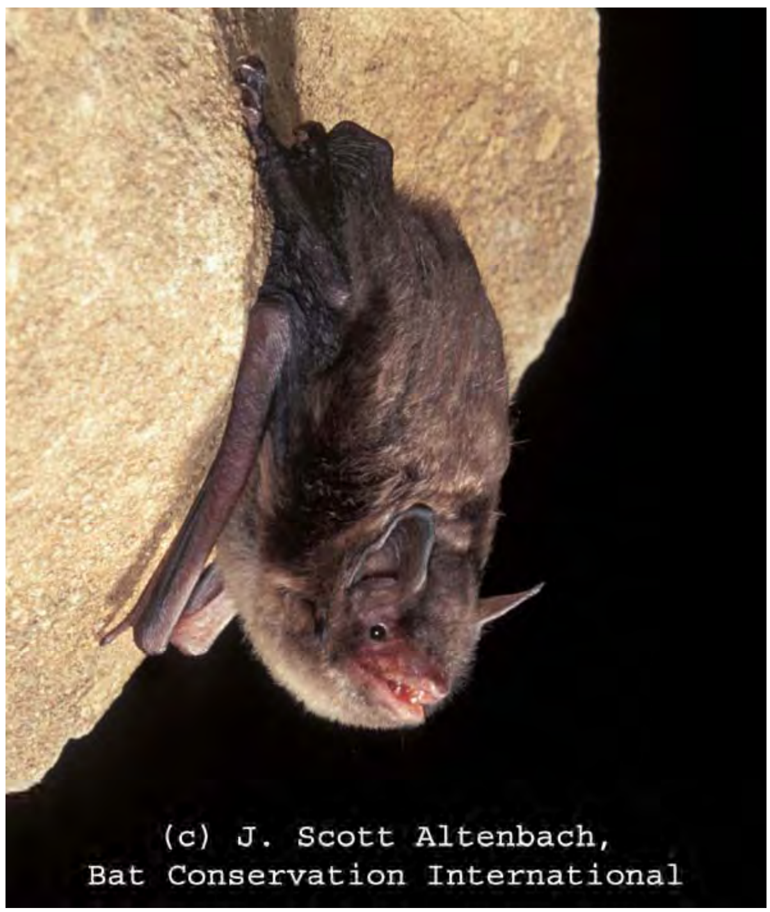
INDIANA BAT & COAL MINING: A TECHNICAL INTERACTIVE FORUM

Held at
Holiday Inn Hurstbourne
Louisville, Kentucky
November 16-18, 2004

U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF SURFACE MINING

SOUTHERN ILLINOIS UNIVERSITY
Carbondale

BAT CONSERVATION
INTERNATIONAL



Edited by:
Kimery C. Vories
Anna Harrington

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Published by
U.S. Department of Interior, Office of Surface Mining, Alton, Illinois
and
Coal Research Center, Southern Illinois University, Carbondale, Illinois

U.S. Department of Interior, Office of Surface Mining, Alton, Illinois
Coal Research Center, Southern Illinois University, Carbondale, Illinois

Printed in the United States of America
8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data
Indiana Bat and Coal Mining: A Technical Interactive Forum (2004: Louisville, Kentucky)
Proceedings of Indiana Bat and Coal Mining: Holiday Inn Hurstbourne, Louisville, Kentucky, November 16-18, 2004/ edited by Kimery C. Vories, Anna Harrington; sponsored by U.S. Dept. of the Interior, Office of Surface Mining and Bat Conservation International, the Kentucky Coal Association, and the Illinois Coal Association, and Coal Research Center, Southern Illinois University at Carbondale.
16. cm.
Includes bibliographical references.
ISBN 1-885189-05-2
1. Bat Conservation–United States Congresses. 2. Indiana Bat–United States Congresses. 3. Coal Mining–United State Congresses. 4. Strip mining–Environmental aspects–United States Congresses. 5. Coal mines and mining–Environmental aspects–United States Congresses. I. Vories, Kimery C. II. Throgmorton, Dianne. III. United States. Office of Surface Mining Reclamation and Enforcement. IV. Bat Conservation International. V. Southern Illinois University at Carbondale. Coal Extraction and Utilization Research Center. VI. Title
SD409.E62 2002
333.75' 153' 0973–dc21

99-38937
CIP

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FOREWORD

On December 15, 1998, the Office of Surface Mining (OSM) signed a Memorandum of Understanding with Bat Conservation International, Inc. in order to establish a framework for cooperative efforts between the two organizations to maintain and increase the conservation of bats and their habitats. Under this agreement, OSM would (1) Consider the conservation of bats and their habitats in the development and implementation of abandoned mine land (AML) reclamation standards and recommendations to States and Indian Tribes; (2) Provide assistance in the development of AML programs to help manage bats and their habitats; (3) For Federal Programs, monitor non-emergency AML shaft and portal areas for bat activity prior to reclamation; (4) As appropriate, require the use of bat gates to seal the shafts of portals where bat habitation is known and would be endangered if sealed otherwise. OSM will encourage the States and Tribes to do the same; and (5) Promote the education of OSM staff, State agencies, and Indian Tribes as to: the beneficial aspects of conserving bats, tested methods to safeguard bat habitat and public health, and ways to mitigate for loss of bat roosts and habitat.

On March 1, 1999, OSM convened its first multi-agency, multi-interest group, steering committee made up of people who have experience in this area in order to initiate planning for a technical interactive forum on the subject of Bat Conservation and Mining.

This forum on the Indiana Bat and Coal Mining is the third in a series of Office of Surface Mining (OSM) sponsored Technical Interactive Forums on Bat Conservation and Mining. The goal of the first forum in 2000 was to establish a national state of the art on Bat Conservation and Mining. The second forum in 2002 was designed to develop a manual on how to best protect important caves and underground mines used by bats through the use of gates and other bat friendly closure devices. The goal of this forum is to focus on how to address the changing needs associated with protecting the Indiana Bat and its habitat in association with surface coal mining.

OSM has become aware of increasing efforts by the U.S. Fish and Wildlife Service to protect the Federally endangered Indiana Bat (*Mysotis sodalis)* and the need to work more closely with State Mining Regulatory Authorities during the permitting, mining, and reclamation activities of surface coal mines that potentially impact Indiana Bat habitat. The information provided by this forum and those that went before it should go a long way in aiding the OSM, the U.S. Fish and Wildlife Service, and the State Regulatory Authorities in their efforts to efficiently and effectively protect and enhance Indiana Bat habitat in association with coal mining activities.

Information provided during the forum showed a dramatic decline in the total number of Indiana bats over the last thirty years nationwide. On a State specific basis, however, the populations are increasing in the northern States and decreasing in the southern States. Because the reasons for these trends in population are unknown, investigations need to be undertaken to determine what if any impact coal mining and reclamation is having on the bat populations.

Kimery C. Vories
Steering Committee Chairperson

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STEERING COMMITTEE RECOMMENDATIONS
INDIANA BAT AND COAL MINING

The following are recommendations made by the Bat Conservation Steering Committee immediately following the end of the forum. The recommendations represent areas that have the potential for future efforts by the committee.

1. We need more information on mitigation success.
2. We need better information on the real impacts in the real world.
3. Resources need to be provided to track the results of mitigation plans at mines.
4. We need better information on specific use of mine areas by Indiana Bats.
5. Each State needs to get all of the affected parties involved in developing State specific plans.
6. U.S. Fish and Wildlife Service needs to put more effort into developing standardization or requirements for habitat evaluation.
7. Need to provide better educational information to the mining industry.
8. Are there States that need Indiana Bat protection plans that are not developing them?
9. We need more information on summer habitat.
10. The U.S. Fish and Wildlife Service can be expected to make very conservative findings until they have more site specific data.
11. The States are in need of consistent guidance from U.S. Fish and Wildlife that has been absent to date.
12. The U.S. Fish and Wildlife Service needs better research to determine actual impacts of mining and reclamation to Indiana bats. The State Mining Authorities are not research organizations. A source of funding needs to be found to plug the information gap.
13. We need better coordination between the State Mining Authorities, U.S. Fish and Wildlife Service, and the Corp of Engineers on Threatened and Endangered Species issues.
14. We need to provide better information on how current activities to protect the Indiana Bat during mining and reclamation are actually helping. Many of the current methods to provide protection seem to be overly conservative.
15. There needs to be a workshop on how to develop Habitat Conservation Plans where we can get the mining industry more involved.
16. How do we get the industry more constructively involved with Indiana Bat protection efforts? What is the possibility of getting the Interstate Mining Compact Commission or Coal Associations involved in State and Industry education.
17. Should consider including all bats of interest in the Habitat Conservation Planning process including Virginia big eared bat and the Gray bat.

WHAT IS A TECHNICAL INTERACTIVE FORUM?

Kimery C. Vories
USDOI Office of Surface Mining
Alton, Illinois

I would like to set the stage for what our expectations should be for this event. This is the third in a series of technical interactive forums cosponsored by OSM on aspects of Bat Conservation and Mining. Copies of these earlier forums are available on OSM's technology transfer CD and at the OSM Exhibit.

The steering committee has worked hard to provide you with the opportunity for a free, frank, and open discussion on the state of the art in protection of the Endangered Indiana Bat in association with coal mining and reclamation.

Our rationale for the format of the technical interactive forum is that, unlike other professional symposia, we measure the success of the event on the ability of the participants to question, comment, challenge, and provide information in addition to that provided by the speakers. We anticipate that, by the end of the event, a consensus will emerge concerning the topics presented and discussed and that the final proceedings will truly represent the state of the art in protecting the Indiana Bat in association with coal mining and reclamation.

During the course of these discussions, we have the opportunity to talk about technical, regional, and local issues, while examining new and existing methods for finding solutions, identifying problems, and resolving controversies. The forum gives us the opportunity to:

- share our experiences and expertise,
- outline our reasons for taking specific actions, and
- give a rationale for our actions.

A basic assumption of the interactive forum is that no person present has all the answers or understands all of the issues. It is also assumed that some of these issues, solutions, and concerns may be very site or region specific. The purpose of the forum is to:

- present you with the best possible ideas and knowledge during each of the sessions, and
- promote the opportunity for questions and discussion by you, the participants.

The format of the forum strives to improve the efficiency of the discussion by:

- providing a copy of the abstract and biography for each speaker that you may want to read beforehand in order to improve your familiarity with the subject matter and the background of the speaker;
- recording the talks and discussions for later inclusion in the post forum publication so that you do not have to worry about taking notes. For this reason, we will require that all participants speak into a microphone during the discussions;
- In order for us to make the most efficient use of time and ensure that you, the participants, have the opportunity to provide questions and comments, we require our session chairpersons to strictly keep to the time schedule;
- A ***green light*** will be displayed at the beginning of the talk. A ***yellow light*** will be displayed for the last 5 minutes of the talk. A ***dim red light*** will be displayed for 30 seconds followed by a ***blinking red light*** that will signal that the talk is over and the speaker has 5 minutes for questions;
- In the post forum publication, issues raised during the discussions will be organized based on similar topic areas and will not identify individual names. All registrants will receive one electronic copy of this proceeding. This publication will be very similar to the proceedings of earlier forums conducted by OSM and are available for your viewing at the OSM exhibit. All of OSM's technical proceedings are available on its technology transfer CD copies of which can be obtained by contacting Kimery C. Vories at (618) 463-6463 x 103 or by e-mail at kvories@osmre.gov.

It is important to remember that there are four separate opportunities for you, the participants, to be heard:

- 5 minutes will be provided for questions at the end of each speaker's talk;
- 30 minutes of participant discussion is provided at the end of each topic session. The chairperson will recognize each participant that wishes to speak and they will be requested to identify themselves and speak into one of the portable microphones so that everyone can hear the question;

- At the end of the forum, we will conduct an open discussion on where we should go from here;
- and finally, a blue forum evaluation form has been provided in your folder. This will help us to evaluate how well we did our job and recommend improvements for future forums or workshops. Please take the time to fill out the yellow evaluation form as the forum progresses and provide any additional comments or ideas. These should be turned in at the registration desk at the end of the forum.

One of the reasons for providing refreshments during the breaks and lunch is to keep people from wandering off and missing the next session. In addition, the breaks and lunch provide a better atmosphere and opportunity for you to meet with and discuss concerns with the speakers or other participants. Please take advantage of the opportunity at break time to visit the exhibits and posters in the break area. When the meeting adjourns today, all participants are invited to a social reception where refreshments will be provided.

Finally, the steering committee and I would like to thank all of the speakers who have been so gracious to help us with this effort and whose only reward has been the virtue of the effort. I would also like to thank each of you, the participants, for your willingness to participate and work with us on this important issue.

Thank you.

Session 1

The Biology and Life History of the Indiana Bat

Session Chairperson:
Ramona Briggeman,
Indiana Division of Fish & Wildlife,
Jasonville, Indiana

National Status of the Indiana Bat
Richard Clawson, Missouri Department of Conservation, Columbia, Missouri

History of the Indiana Bat: Hibernacula
Dr. Virgil Brack, Environmental Solutions & Innovations, Inc., Cincinnati, Ohio

Foraging Ecology of the Endangered Indiana Bat
Dale W. Sparks, John O. Whitaker, Jr., and Christopher M. Ritzi, Department of Life Sciences, Indiana State University, Terre Haute, Indiana

Ecology and Behavior of Indiana Bats at Summer Maternity Roosts
Dr. Allen Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, Michigan

NATIONAL STATUS OF THE INDIANA BAT

Richard L. Clawson
Missouri Department of Conservation
Columbia, Missouri

Abstract

The Indiana bat (*Myotis sodalis*) was officially Federally listed as an endangered species on 11 March 1967. It is a migratory species that is found throughout much of the eastern United States. During winter, Indiana bats occupy suitable underground hibernacula, mostly in caves in karst areas, but also in some abandoned mines. Biennial surveys of the hibernacula are the primary means by which Indiana bat populations are monitored. The current total population is estimated to number slightly below 400,000 bats; this compares to an estimated population of nearly 900,000 bats in the same hibernacula 30 to 40 years ago, when surveys first began. The observed decline is not uniformly distributed throughout the range of the species, however. Hibernating populations in the southern part of the range have declined by 82% in the past 40 years, while those in the northern Midwest and Northeast have increased by 35%. During summer, Indiana bats roost in trees, primarily under the peeling bark of dead trees, and are widely dispersed across the landscape. The densest aggregation of maternity colonies is found in the glaciated portions of the Midwest. Maternity colonies have been found in the heavily forested parts of the range, but their density appears to be much lower than that of the more agricultural areas where forest exists, but it is fragmented.

Introduction

Recovery Efforts

The Indiana bat (*Myotis sodalis*) is a small (7-10 gram) vespertilionid bat, with a geographic range that encompasses much of the eastern United States (Gardner and Cook 2002). The Indiana bat officially was listed as an endangered species on 11 March 1967, among the earliest listings under the Endangered Species Preservation Act, which became law on 15 October 1966. The only critical habitat designated for the Indiana bat (11 caves and two mines in six States) was listed on 24 September 1976. An interim recovery plan was approved in June 1976, and the current *Recovery Plan for the Indiana Bat* was completed and approved in October 1983 (U.S. Fish and Wildlife Service 1983). This document guided recovery efforts through the 1980s and 1990s. During this period, the primary recovery actions centered on protection of winter habitat, monitoring, and research into the life history of the species (especially summer habitat requirements). Over 35 caves and mines that were used as hibernacula were acquired and protected, many with gates or fences, by governmental agencies or private conservation organizations (Currie 2002).

A *Technical Draft of the Revised Indiana Bat Recovery Plan* was completed in October 1996. The purpose of this effort was to incorporate into the plan knowledge about the Indiana bat that had been acquired since 1983, and to respond to the needs of agencies responsible for forest management in the eastern United States. Reviews were received from State agencies, Federal agencies, and private groups throughout the range of the species, and were incorporated into an *Agency Draft Indiana Bat (Myotis sodalis) Revised Recovery Plan* that was completed in March 1999 (U.S. Fish and Wildlife Service 1999). Comments again were solicited and received, however, the process stalled at that point. In March 2005, the US Fish & Wildlife Service will assemble a group of bat biologists, analysts, and experts in risk assessment to participate in a structured decision process concerning the Indiana bat. The results of this process will be used to assist the Recovery Team in the final revision of the plan. The goal of the USFWS is to have the plan completed and approved during 2005. It should be noted that, until it is superseded, the only existing, approved *Recovery Plan for the Indiana Bat* is the one dated October 1983.

Known and Suspected Causes of Decline

Human disturbance of hibernating Indiana bats has long been recognized as a factor in the decline of populations of this bat (U.S. Fish and Wildlife Service 1983). Arousals caused by repeated disturbance force bats to burn their fat reserves during the critical winter hibernation season. A single arousal requires as much fat as 68 days of uninterrupted hibernation (Thomas et al. 1990). Improper gates or other structures at hibernacula have rendered some sites unavailable to the bats, or altered the microclimate sufficiently that winter temperatures became so warm that Indiana bats were unable to survive through winter on their fat reserves (Humphrey 1978, Richter et al. 1993, Tuttle and Kennedy 2002). Natural hazards such as freezing, flooding, and ceiling collapse also have killed hibernating Indiana bats (Hall 1962, Humphrey 1978, Richter et al. 1993).

Population declines also may be caused by factors that affect Indiana bats in summer. Pesticides, for example, may be a factor in survival and reproduction (O'Shea and Clark 2002). Studies of sympatric species indicate that Indiana bats may be exposed to residual levels of banned chlorinated hydrocarbons and currently applied chemicals such as organophosphates and carbamates (McFarland 1998, Schmidt et al. 2002). It also is possible that changes to the landscape affect summer habitat for the species. Land-use practices that alter the extent and quality of riparian, bottomland, and upland forests may have profound effects, either negative or positive, on the roosting and foraging habitat for the Indiana bat.

Distribution

In winter, the Indiana bat hibernates throughout the karst areas of the eastern United States (Gardner and Cook 2002). Most of the hibernacula are caves, but abandoned mines also provide important winter habitat in Illinois, Missouri, New York, Ohio and Pennsylvania. Newly discovered hibernacula occasionally are reported, but those with the largest populations of Indiana bats have been known since the 1960s and 1970s (Clawson 2002). It is important to note that Indiana bats are capable of occupying newly available sites. In Illinois and Ohio, large hibernating populations have become established in mines in which mining activities have ceased in only the past 15 years.

In summer, most female Indiana bats migrate from the hibernacula and form maternity colonies in trees (Gardner and Cook 2002), primarily under the peeling bark of dead trees. Maternity colonies have been found throughout the range of the species. The greatest density of maternity colonies apparently is in the glaciated parts of the Midwest, where the landscape is largely agricultural and the forest that occurs is fragmented. In the portions of the range where the forest is extensive, however, the available evidence suggests that maternity colonies exist in low densities. Male Indiana bats may be found throughout the range during the summer, but many remain near the hibernacula (U.S. Fish and Wildlife Service 1999, Clawson 2002).

Methods

Populations within Indiana bat hibernacula are classified by the number of bats that they contain or have contained (U.S. Fish and Wildlife Service 1983). Because estimates of the size of populations of Indiana bats prior to 1960 were limited to very few sites, the Indiana Bat Recovery Team used population estimates made since 1960 to assign "priority" to hibernacula. There are three categories: Priority One hibernacula contain or have contained populations of at least 30,000 Indiana bats. A Priority Two classification originally was assigned to hibernacula with at least 1,000 but fewer than 30,000 bats (U.S. Fish and Wildlife Service 1983). In recent years, however, the lower limit for Priority Two was decreased to 500 bats in order to include a greater number of sites in recovery efforts (U.S. Fish and Wildlife Service 1999). All other hibernacula were classed as Priority Three. This classification system was developed to focus recovery efforts on the most important hibernacula.

From the early 1980s through the present, mid-winter hibernacula surveys were conducted every other year. Survey data from throughout the range of the Indiana bat were provided by experienced biologists. Usually, these biologists followed the same protocol that I used when estimating the size of winter populations. The estimate of the number of bats present in a cluster was based on the density of the animals within the cluster, taking into consideration that the number of bats in a cluster could vary with temperature, size of population, and location within a hibernaculum. For small clusters, it was possible to count rows and columns of bats and do simple multiplication to determine the number of bats in a cluster. For large, dense clusters, it was necessary to use a ruler to determine packing and then measure dimensions of the cluster. I have recorded packing up to 72 Indiana bat/m and density up to ca. 5,210 bats/m^2 (Clawson 2002). Although most surveys followed the procedure outlined above, at least one state (New York) used a different procedure in which biologists photographed clusters and later counted the bats from the projected images (Hicks and Novak 2002).

Results and Discussion

Over 300 caves, mines, tunnels, and even a hydroelectric dam, in 26 different States, have been occupied by hibernating Indiana bats. The eight Priority One hibernacula are found in three States: Indiana, Kentucky, and

Missouri. There are 69 Priority Two hibernacula in 11 States. The majority of the sites are classed as Priority Three, but these sites contain a low percentage of the overall population of the Indiana bat. For this forum, data were assembled from 14 States and nearly 250 hibernacula throughout the range of the Indiana bat (Table 1). Data were collected from 8 Priority One hibernacula, 69 Priority Two hibernacula, and 170 Priority Three hibernacula.

Population Trends in Hibernacula

Populations of the Indiana bat for various States are summarized, from the earliest surveys to the present, in Table 2. To make the time-line as comparable as possible, all hibernacula are represented in all periods. For example, assume that a cave with 5,000 bats was discovered in 1980. The 5,000 bats are included in the State and regional totals for 1980, but also for the earlier time period, even though that hibernaculum was not surveyed in those years. Although the actual size of the population was not known for the earlier years, the advantage of representing all hibernacula in all periods is that the addition of newly discovered sites does not falsely imply an increase in population.

During this 40-year period, the rangewide population of Indiana bats has declined, but the trends were not the same in all states (Table 2). From the earliest surveys to 1980, the total population decreased by 23%; from 1980 to 1990, it dropped another 30%, and from 1990 to 2003, it was down another 18%. Cumulatively, the total population of Indiana bats has declined by 56% since regular surveys began.

An examination of the data, however, shows that not all State populations have trended downward. From 1960 to the present, the populations in five States have decreased, two State populations had little change, for two States the data are so new that no trends can be determined, and the populations in five States have increased. It is evident that States in one portion of the range have been declining, but States in another part of the range have been increasing in population. In fact, the major losses in population have occurred in the southern portion of the range (Table 2).

From the earliest surveys to 1980, the south regional population declined by 30%; from 1980 to 1990, it dropped an additional 48%, and from 1990 to 2003, it went down another 52%. Overall, the southern population has declined 82% in the past 40 years. This pattern was in stark contrast to what was happening in the northern portion of the range. After a minuscule drop of less than 1% from the earliest surveys to 1980, the north regional population increased 13% from 1980 to 1990, and it rose another 20% from 1990 to 2003. Overall, the population in the northern part of the range has gone up 35% in the past 40 years, but the increases were not enough to offset losses in the south (Table 2).

Strategies for Recovery

The top priority of the recovery effort is research to determine the cause or causes of the decline in population and to determine ways to reverse it, if possible (U. S. Fish and Wildlife Service 1999). It is imperative that we determine the reason for differences in trends among States and between regions. As part of this effort, we must continue to evaluate the effects of climate and microclimate on hibernation through studies such as those of Brack et al. (2002) and Tuttle and Kennedy (2002).

Nearly half of the Priority One and Priority Two hibernacula have been acquired and protected. It is important that we continue to protect hibernacula by preventing human disturbance during the hibernation period and restore abandoned hibernacula where it is feasible to do so. It also is important to continue to monitor populations throughout the range of the species.

We know a great deal about roost selection and summer habitat (see Kurta et al. 2002, Carter et al. 2002, and Miller et al. 2002), but we need to learn much more about the behavior of Indiana bats in maternity colonies, and compare behavior in the core maternity range with that in the heavily forested portions of the range. We need to learn how maternity colonies form and move around the landscape. We need to learn how they respond to habitat alteration and removal. We should take advantage of opportunities to chronicle the effects of various habitat-altering projects when Indiana bats are found during pre-project surveys. What we need most of all are directed studies and management experiments that will advance our understanding of Indiana bat habitat requirements and enable us to develop management prescriptions specifically for this species.

Research also is needed to determine how to manage aboveground habitat for Indiana bats. Guidelines for the management of Indiana bat summer habitat are the object of debate and are somewhat controversial. No one standard has been set and accepted. At this time, therefore, guidelines that have been developed by the Daniel Boone National Forest and the Missouri Department of Conservation may be used as examples to be emulated.

Concluding Remarks

The question of the national status of the endangered Indiana bat does not have a simple answer. Despite severe population losses in the southern portion of the species' range, populations in the northern part of the range have increased. We do not yet know the reason(s) for this disparity. We therefore must direct our efforts towards gaining new insights into the biology, life history, and habitat requirements of the Indiana bat so that we may plan recovery actions and design management strategies for this endangered species.

Acknowledgements

This report would not have been possible without the contributions of numerous biologists throughout the range of the Indiana bat. I thank the following for providing data: J. Belwood, V. Brack Jr., C. Butchkoski, M. Harvey, T. Hemberger, A. Hicks, K. Hudson, J. Kath, J. Kennedy, J. MacGregor, B. Palmer-Ball, R. Reynolds, and C. Stihler. I also thank L. Pruitt and A. King, who are developing a population database for the Indiana bat.

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Table 1. The number of Indiana bat hibernacula for which population estimates are reported, listed by state and classified by priority.

STATE	PRIORITY ONE	PRIORITY TWO	PRIORITY THREE	TOTAL
Alabama --	---	-----	3	3
Arkansas	----- 3 13			16
Illinois --	---	4	4	8
Indiana 3		8	18	29
Kentucky 2		19	39	60
Missouri 3		15	42	60
New Jersey	-----	-----	1	1
New York	-----	6	3	9
Ohio --	---	1	1	2
Pennsylvania --	---	1	4	5
Tennessee --	---	8	9	17
Vermont --	---	-----	1	1
Virginia --	---	3	8	11
West Virginia	----- 1 24			25
Total 8		69	170	247

Table 2. The size of hibernating populations of the Indiana bat by region and state, based upon estimates nearest to the year indicated[a].

	State[b] 1	960/1970	1980	1990	2003
Southern Region	Alabama 35	0	350	350	320
	Arkansas 15	,000	15,000	4,500	2,120
	Kentucky 24	8,100	102,200	78,700	41,500
	Missouri 39	9,000	342,000	150,100	66,800
	Tennessee 20	,100	20,100	16,400	8,900
	Virginia 3,	100	2,500	1,900	1,080
	Subtotal 68	5,650	482,150	251,950	120,720
Northern Region	Illinois 1	4,800	14,800	14,900	30,850
	Indiana 16	0,300	155,200	163,500	183,330
	New Jersey	110	110	110	110
	New York	20,200	21,100	26,800	32,920
	Ohio 15	0	3,600	9,500	9,440
	Pennsylvania 70	0	700	400	790
	Vermont 31	0	310	310	310
	West Virginia	1,500	1,200	6,500	9,700
	Subtotal 19	8,070	197,020	222,020	266,580
Gra	nd total	883,720	679,170	473,970	387,300

[a] Not all surveys occurred exactly in the winter indicated. Population estimates for a particular period were based on the survey nearest to the year indicated, either prior to or subsequent to that year, so that all sites are represented in each period.
[b] States with records of fewer than 100 hibernating Indiana bats are not reported.

THE BIOLOGY AND LIFE HISTORY OF THE INDIANA BAT: HIBERNACULA

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Abstract

Hibernating bats allow their body temperature to approximate that of the surrounding environment. They do not produce heat to stay warm, and as body temperature drops, metabolic processes slow, reducing energy requirements. Energy savings can be dramatic, with metabolic efficiency as a log function of temperature; energy consumption at 41.5°C (active working body temperature) is about 112 times that at 2°C. However, there are physiological constraints on minimum body temperatures. If bats get too cold they must use energy to warm themselves or freeze. At 0.5°C, energy expenditure is four times that at 2°C. Bats arouse (awaken) from hibernation periodically and spontaneously during the season of hibernation. The mean length of the period of hibernation between arousals for the Indiana bat under natural conditions is 13.1 days. Arousal is energy expensive, equivalent to about 65 days of hibernation. There are also other physiological costs of metabolic depression. It is likely bats trade off the costs of metabolic depression with costs of less efficient hibernation, using available energy to minimize the duration and depth of hibernation. During arousal, bats select where they will spend the next period of hibernation. It is probable they use behavior and social interaction to help them make this selection. Indiana bats are known for use of large, complex hibernacula; however, they also vertically stratify above areas with freezing temperatures in small, simple, vertical systems. In the past, temperatures of 4 - 8°C, or more narrowly 3 - 6°C, were widely regarded as optimal for the Indiana bat, but increasing populations in Indiana, which now constitute 45% of the total population, hibernate in areas with mean temperatures of 5 - 8°C. Detailed studies in Ohio, Missouri, and Kentucky indicate use of similar temperatures. The only hibernaculum in Indiana with a temperature <4°C has lost 63% of its population over a 29-year period.

Introduction

There are many reasons for mine closure: re-mining, safety, private developments, construction of infrastructure, and improving water quality. However, in winter, the Indiana bat (*Myotis sodalis*), hibernates in limestone caves and some man-made structures, such as underground mines. Listing of the Indiana bat under the Endangered Species Act entitles the species to protection wherever it is found, including mines.

The purpose of this paper is to provide a basic understanding of the biology of hibernation, its importance to this endangered species, and summarize parameters of the environment used by hibernating Indiana bats.

What is Hibernation and Why is it Important?

Hibernation is a physiological state of hypothermia. Hibernating bats allow their body temperature to approximate ambient temperature, i.e., that of the surrounding environment. In the cold environment of a hibernaculum, bats do not produce heat to stay warm and maintain a normal (i.e., active) body temperature. As body temperature drops, the respiration rate, heart rate, and metabolic processes all slow, resulting in a reduced expenditure of energy. Within physiological constraints, a lower body temperature during hibernation equates to lower energy requirement (Stones and Wiebers 1967). Hibernation is an adaptation that reduces energy expenditures during cold portions of the year when food (i.e., insects) is not available and when (liquid) water may not be available.

Bats enter hibernation in autumn when insects are no longer available and emerge in spring when the insects return. This is called the season of hibernation, and for the Indiana bat is roughly the period November - April. All mammalian hibernators arouse (awaken) from hibernation periodically and spontaneously during the season of hibernation (Lyman et al. 1982). The time (period) between arousals spent in hibernation is called the period of hibernation (or a bout of hibernation). The length of the period of hibernation varies by species and temperature (Brack 1979; Brack and Twente 1985; Twente et al. 1985; Fig. 1). Hardin and Hassel (1970) recorded the average length of the period of hibernation for the Indiana bat under natural conditions as 13.1 days, although the variation in most species is great. For example, the range of the period of hibernation of the little brown myotis is 4 – 83 days ($\bar{X}$ = 19.7 at 6°C) under natural conditions (Brack and Twente 1985) and 1 – 76 days ($\bar{X}$ = 12.7 at 5°C) in the laboratory (Twente et al. 1985).

Physiological Parameters of Hibernation

During hibernation, metabolism is reduced to a fraction of the euthermic metabolic rate. This reduction is commonly explained by a reduction in biochemical reactions, described as a Q10 effect. However, a second mechanism, metabolic inhibition (and suppression of heat production), reduces energy expenditures below that attributable to temperature alone (Geiser 1988, 2004; Snyder and Nestler 1990; Heldmaier and Ruf 1992). The costs of metabolic depression may include oxidative stress, reduced immunocompetence, and perhaps neuronal tissue damages, so trade-offs between the benefits of energy conservation and physiological costs of metabolic depression should cause hibernators to minimize the depth and duration of periods (bouts) of hibernation (Humphries et al. 2003), i.e., bats should hibernate at the highest temperatures they can and still have enough fat to survive.

Energy savings from hibernation can be dramatic and metabolic efficiency is a log function of temperature. Early studies by Hock (1951), though limited in precision, are nevertheless instructive:

- At 10°C, energy expenditures are twice that at 2°C
- At 20°C, energy expenditures are five times that at 10°C
- At 30°C, energy expenditures are five times that at 20°C
- At 37°C, energy expenditures are 1.5 times that at 30°C
- At 41.5°C, energy expenditures are 1.5 times that at 37°C

Total Savings ➔ ➔ ➔ ➔ ➔ 112 times

Thus, while bats should hibernate where it is cold, efficiencies gained at very low temperatures (e.g. <5°C) are disproportionately small because energy expenditures are curvilinear and asymptotic to zero (Geiser 2004). In addition, bats must also avoid freezing (Davis 1970). Hock (1951) also found that at 0.5°C, energy expenditure was four times that at 2°C, because bats were thermoregulating, ostensibly to avoid freezing.

Arousal (warming, being awake, and reentering hibernation) is energy expensive. The amount of time spent awake between periods of hibernation and the frequency of arousal also affect the energy expended during the season of hibernation (Speakman et al., 1991; Thomas, 1995). Arousal represents 80 – 90% of the cost of hibernation and each episode is equivalent to about 65 days of hibernation (Thomas et al. 1990). The cost of arousal also increases at lower temperatures because the bat must warm over a greater range of temperatures to reach working body temperature, and at colder temperatures, heat produced for warming dissipates more rapidly. At temperatures near freezing, bats often appeared to have difficulty warming, and I have observed bats that could not arouse at these temperatures when wet.

In summary, bats face constraints and must hibernate within specific environmental parameters, most notably temperatures that are cold enough to conserve enough energy to survive the winter, but not so cold they freeze or expend additional energy thermoregulating. They must also balance the physiological costs of metabolic depression with hibernating efficiently enough to survive winter (Fig. 2).

Ecological Parameters of Hibernation

During arousal, bats select where they will spend the next period of hibernation, i.e. somewhere that will not be too hot or too cold. A bat can select an area that is the appropriate temperature now, but how can a bat select a location that will have temperatures suitable for hibernation in the future? One mechanism may be social interactions. If bats return to sites they have used successfully in the past, then better sites should be used by more bats. Indeed,

- Across years, bats concentrate use into specific caves and mines
- Across years, bats concentrate use into specific areas of caves or mines
- Within the season of hibernation, larger and larger concentrations of bats hibernate in specific portions of caves and mines

Presumably, areas where bats concentrate are the best, or at least good for hibernation. Raesly and Gates (1987) examined numerous variables to determine which physical feature or attribute of a cave was associated with the location used for hibernation. They found that the best predictor of the use of an area was the presence of other bats.

Hibernacula Used by the Indiana Bat

Indiana bats typically hibernate in areas of caves and mines where temperatures are cold but stable (Fig. 3). Many large populations of hibernating Indiana bats use large cave (or mine) systems. These systems often have large entrances or multiple entrances with differences in elevation to allow an influx of cold winter air. Several variations on this theme were presented by Humphrey (1978). An influx of cold air is necessary to cool the hibernaculum and allow efficient hibernation, but if cold air enters too quickly, the hibernaculum may get too cold. Large complex systems allow air flow, but their volume and complexity often buffer, or slow, changes in temperatures. However, Indiana bats have also been found in a second general type of smaller system (Fig. 4). In these cases, cold air falls through a steep vertical system while bats hibernate above areas affected by freezing temperatures. A dramatic example of this is a cave shaped like a jug; the entrance is a karst window in the mouth to the jug (Fig. 4a). Air falls through the entrance and 23 m to the floor, and then through cracks in the floor. The bats roost high on the ceiling of the jug, to the side of and bypassed by the influx of freezing air.

In the past, temperatures of 4 - 8°C, or perhaps more narrowly 3 - 6°C, during mid-winter were widely regarded as optimal for the Indiana bat (USFWS 1999). Hall (1962), Henshaw and Folk (1966), and Humphrey (1978) stated that mid-winter temperatures of hibernacula used by the Indiana bat were 4 - 5°C, 2 - 3°C, and 4 - 8°C, respectively, but did not provide supporting documentation. However, 25 years of studies in many of the caves in Indiana addressed by Hall (1962) and Humphrey (1978) have documented increasing populations of Indiana bats (Brack et al. 2003) hibernating in areas with mean temperatures of 5 - 8°C (Table 1). The single large population in Indiana hibernating at <4°C has experienced a 63% in 29 years. In Missouri, Myers (1964) found Indiana bats in hibernacula with temperatures of 4.4 - 16.7°C, but considered 7.8°C a mean representative of the species. He provided data on mid-winter temperatures at clusters in three caves that were 5.0 - 9.2°C ($n = 6$; $\bar{X} = 7.1$; $SD = 1.4$). Also in Missouri, Clawson et al. (1980) found that Indiana bats used portions of caves with rock temperatures of 6 - 8°C in late January. Hassell (1967) and Hardin and Hassell (1970) reported mean hibernaculum temperatures of 8.3 and 7.6°C, respectively, for areas used by 90,000 Indiana bats in Bat Cave, Kentucky, although temporal variation was large, including temperatures below freezing. Indiana bats froze in this cave during hibernation (Davis 1970). The largest population of Indiana bats in Ohio (9,500 bats) hibernates in a limestone mine at a mean temperatures of 8.4±1.7°C (Table 1; Brack upubl. data).

Table 1. Temperatures used by Indiana bats hibernating in caves in Indiana and a limestone mine in Ohio. Indiana data are garnered from 25 years of surveys with increasing populations of bats (160%) in caves with temperatures >4°C. As of 2005 only a single large population in Indiana used a hibernaculum at ≤4°C. This population suffered a 63% decline over the past 29 years. Data from Ohio are for the period 1996 to 2002.

Location	% of Population	≤4°C >4	- <5°C	≥5°C
Indiana 45	%	28%	2%	71%
Ohio 2.	5%	<<1%		100%

Hibernation Strategies and Tactics

A variety of trade-offs can be made by individuals and by species of bats to ensure successful hibernation. Some species hibernate in areas that are warm and stable, assuring they will not freeze. However, hibernation at warmer temperatures is less efficient. Species that use this strategy, such as the eastern pipistrelle (*Pipistrellus subflavus*), can offset the cost of less efficient hibernation by arousing less frequently (Fig. 1). Species that hibernate in colder areas face the physiological costs of hibernating at and arousal from lower temperatures, and the ecological cost of an unstable thermal regime and potentially freezing temperatures. The Indiana bat uses areas of moderate temperatures, balancing cold temperatures and thermal stability.

Individual bats can decrease exposure to fluctuating air temperatures by increasing surface contact with the cave (rock) or by increasing contact with other bats. Big brown bats (*Eptesicus fuscus*) and northern myotis (*Myotis* *septentrionalis*) often wedge themselves into tight cracks and crevices, putting most of their body surface area in contact with the cave. The Indiana bat clusters tightly. Beads of moisture often collect on guard hairs of the little brown myotis (*M. lucifugus*) and eastern pipistrelle as they hibernate. This water may act as a thermal sink, dampening fluctuations in air temperature. Finally, individuals may adjust to seasonal temperature changes by making inter- or intra-cave movements. Locations of clusters of Indiana bats change over the season (Clawson et al. 1980; Myers 1964); numerous researchers throughout temperate portions of the world have documented intra-cave and intra-mine movements by many species of bats during the season of hibernation. Whitaker and Rissler (1992) documented winter movements of several species of bats into and out of a mine in Indiana.

Acknowledgements

I thank Andrew King, U.S. Fish and Wildlife Service, and Ramona Briggeman, Indiana Department of Natural Resources, for assistance and patience with requirements of the forum and this paper. I thank Environmental Solutions & Innovations, Inc. (ESI) for support to complete and present the paper, Adam Mann and Jeanette Jaskula (ESI) for technical and logistic assistance, and Jason Duffey (ESI) for discussions on morphology of the two major types of hibernacula. Scott Johnson (Indiana Department of Natural Resources), Keith Dunlap (Indiana Karst Conservancy), Richard Clawson (Missouri Department of Conservation), and Richard Reynolds (Virginia Department of Game and Inland Fisheries) participated in collection of data in hibernacula. Dean Metter and Gary Finni provided inspiration.

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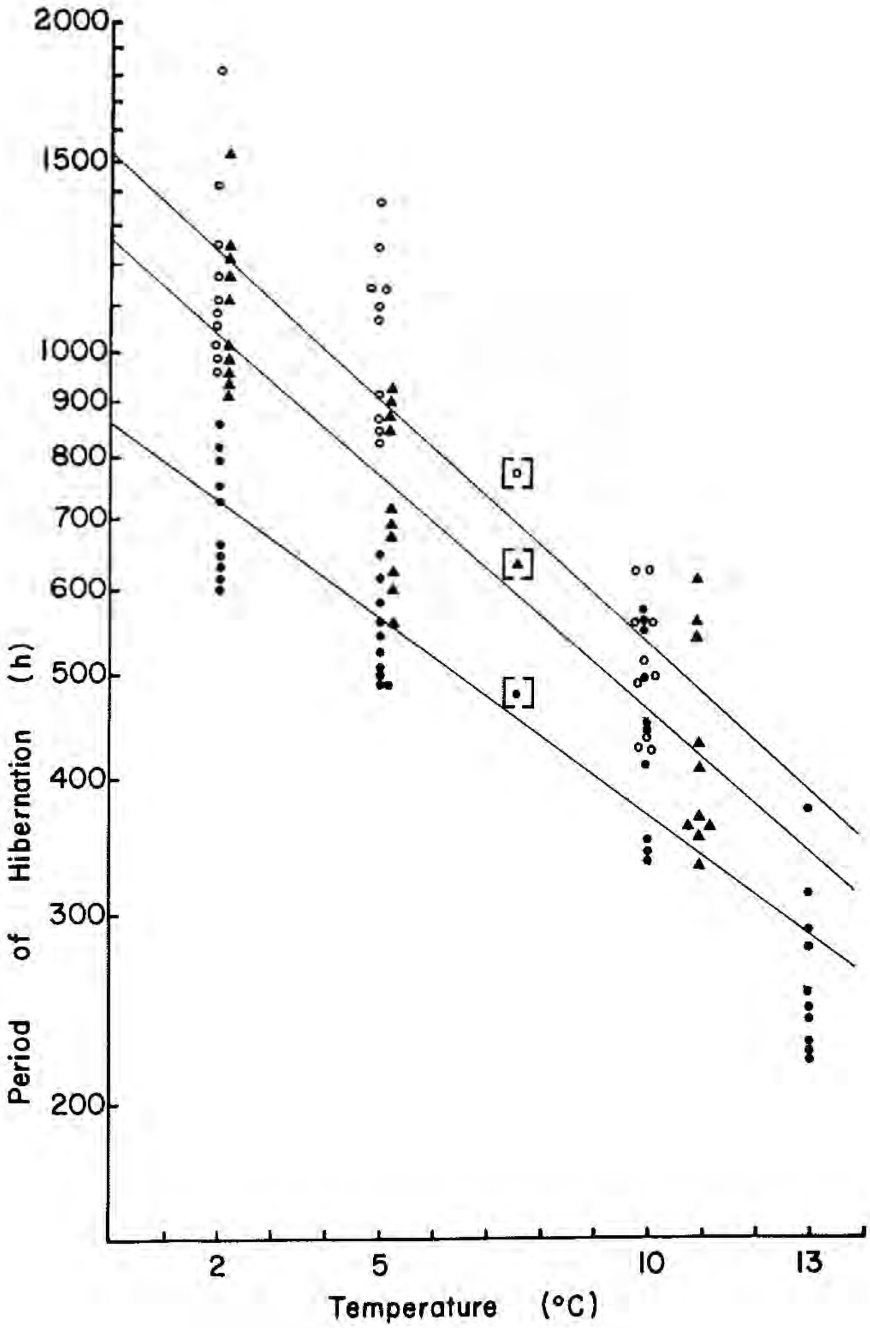


Fig. 1. The 10 longest periods of hibernation at 2, 5, 10, and 13°C for the big brown bat (solid triangles), eastern pipistrelle (solid circle), and little brown myotis (empty circle; from Twenty et al. 1985).

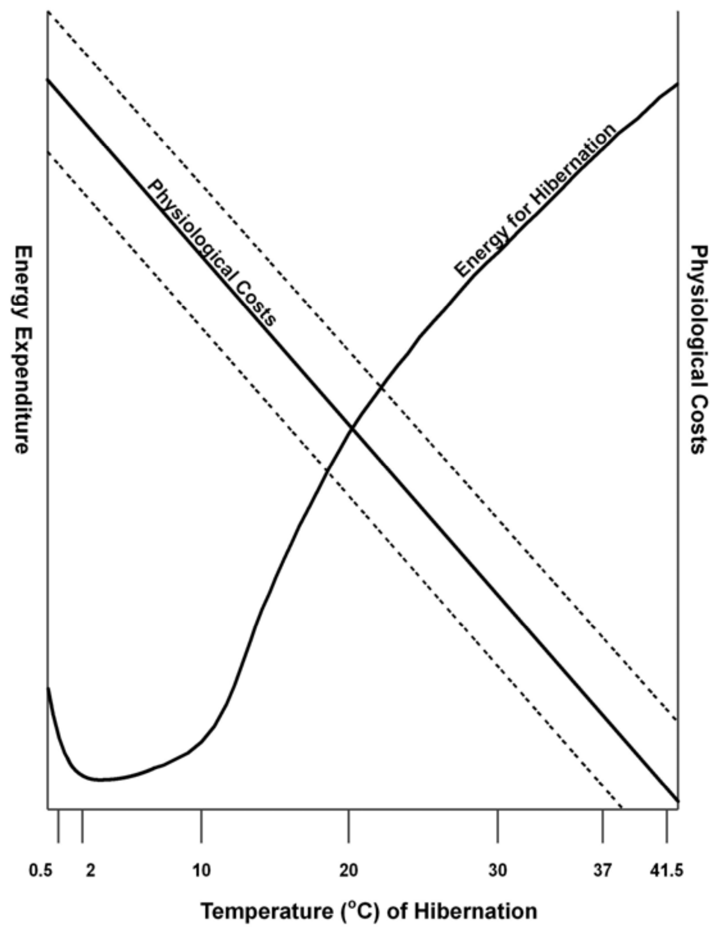


Fig. 2. As body temperature decreases from active (41.5°C) to 2°C, energy savings accrue; below 2°C, energy costs again increase. The "Energy for Hibernation" line reflects relative values (Hock 1951). There are other physiological costs, undefined, that accrue inversely proportional to temperature (Humphries et al., 2003). Placement and slope of the "Physiological Costs" line was arbitrary (it may be concave and curvilinear), but as illustrated by dashed lines, as physiological costs at any temperature increase, benefits of hibernation decrease and the optimum temperature of hibernation increases.

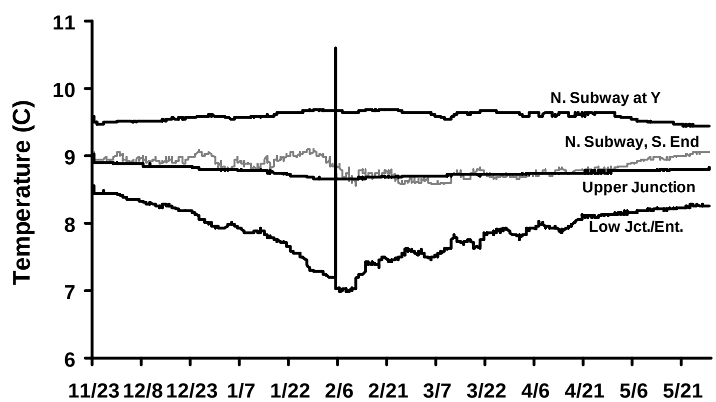
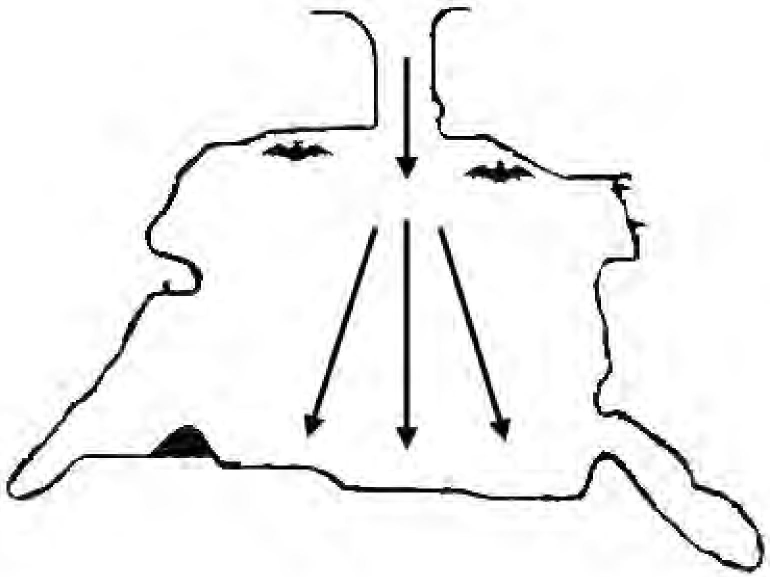


Fig. 3. Temperatures during the season of hibernation at four locations in a cave in Bland County, Virginia. Indiana bats hibernated in the area designated by the lowest line (Low Jct/Ent), illustrating the compromise between using areas that are both cool (allowing more efficient hibernation) and stable (to avoid freezing or an increase in thermoregulatory expenditures). Colder, but more thermally variable, locations were available for hibernation.



(a) (b)

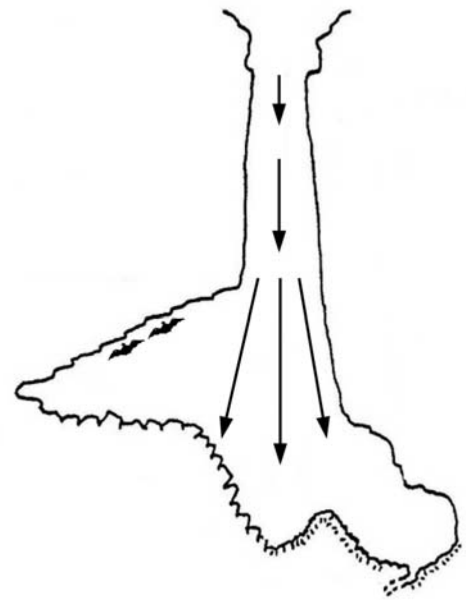


Fig 4. Indiana bats are known for use of large, complex hibernacula (illustrated in Humphrey 1978). However, they also vertically stratify above freezing temperatures in small, simple, vertical systems. In Fig. a, bats hibernate high, and to the side of the entrance of a jug-shaped cave, where cold air falls through a karst window and to the floor. Fig. b shows a variation on this theme.

FORAGING ECOLOGY OF THE ENDANGERED INDIANA BAT

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Abstract

Like most North American bats, the Indiana bat (*Myotis sodalis*) is a nocturnal insectivore. It emerges shortly after sunset and begins feeding on a variety of insects, which are captured and consumed while flying. Its diet varies through time and across the geographic range of the species. The most common foods are beetles, moths, caddisflies, ants, and wasps. Some Indiana bats forage 10 km away from their roost, but most travel less than half that distance. Size of foraging areas varies from 7 to over 3000 ha and bats return to these areas on subsequent nights and years. Formal studies of habitat selection have been conducted in western Illinois and at the Indianapolis International Airport. In both areas, Indiana bats preferentially used woodlands as foraging and commuting areas, although other habitats including old fields and cropland were also used. Near Indianapolis, bats avoided ponds and developed land such as warehouses, shopping centers, and neighborhoods. We suspect the perfect foraging habitat for this species would include forested streams interspersed with grasslands, croplands, or shrublands.

Introduction

Bat biologists have long focused management and research efforts on the biology of bats in the roost because roosts are widely thought to be the most important factor controlling distribution of bat species (Humphrey 1975). Also, nocturnal telemetry on foraging bats is technologically challenging and man-power intensive. One result of this focus on roost management has been a lack of information about the foraging behaviors of many North American bats. Fortunately, the Indiana bat (*Myotis sodalis*) is an exception, mainly due to its status as a Federally endangered species, although much of this information includes unpublished technical reports and graduate theses. Much of the unpublished information included here results from work we have conducted near the Indianapolis International Airport (IND) since 1997. During this work, we often had difficulty distinguishing between foraging bats and bats conducting other behaviors such as checking and night roosting. Thus, this review will include comments about behaviors of Indiana bat from when they emerge until they return to the roost. We present these data in two major sections: nocturnal behaviors including emergence, habitat selection, night roosting, and return flights; and diet throughout the range.

Nocturnal Behaviors

General Methods

Data on nocturnal activities of free-ranging Indiana bat were first obtained by observing unmarked bats using both vision and ultrasonic detectors in areas where similar species were rare or absent (Cope et al.1974, Humphrey et al. 1977). Almost immediately, researchers began using marking techniques such as reflective tape attached to bands (Humphrey et al.1977) and chemical lights glued directly to the bat (LaVal et al.1977, LaVal and LaVal 1980, Brack 1983) to mark Indiana bats. These early techniques provided good information about behavior near roosts or other centers of activity (Cope et al.1974, Humphrey et al. 1977, LaVal et al.1977, LaVal and LaVal 1980, Brack 1983, Viele et al.2002, Sparks 2003, Sparks et al.2003, Murray and Kurta 2004), but are of limited value when bats fly in cluttered habitats or move rapidly between areas.

Gardner et al. (1991a,b) pioneered use of radiotelemetry to locate roosts and determine foraging ranges of free-ranging Indiana bats during the late 1980s. Radiotelemetry is also useful for documenting landscape-level patterns of habitat use and behavior of individual bats (Gardner et al. 1991a,b, Hobson and Holland 1995, Kiser and Elliot

1996, Butchkoski and Hassinger 2002, Romme' et al. 2002, Brack and Whitaker 2004, Brack et al. 2004, Murray and Kurta 2004, Sparks et al. *In Press*). Radiotelemetry is limited by cost of equipment and personnel, range of transmitters, and telemetry error. We used all of these techniques at IND as well as using thermal imagers and night vision scopes to enhance visual observations. All techniques used to examine nocturnal biology of Indiana bats have inherent biases and potential behavioral impacts.

Nightly Emergence

Indiana bats begin to emerge from roosts shortly after sunset. Studies conducted in Michigan and Illinois noted Indiana bats began leaving their roosts an average of 18-19 minutes after sunset, emergence peaked at 21-26 minutes after sunset, and the average bat left the roost 23-25 minutes after sunset (Viele et al.2002). Timing of first emergence was significantly correlated with the time of sunset and the end of civil twilight. In western Illinois, emergence averaged 21 minutes after sunset and peaked 30-45 minutes after sunset (Gardner et al.1991b). Near Knightstown, Indiana median emergence occurred 38-71 minutes after sunset (Brack 1983). At IND in 1999, we found that average initial emergence began 2.6 minutes after sunset and ranged from 37 minutes before sundown to 22 minutes after sunset (Figure 1), but this result is complicated by interactions between the bats and red-bellied woodpeckers (*Melanerpes carolina*) (Sparks et al. 2003).

Nocturnal Flights

Upon emerging from their roosts, Indiana bats may fly directly to their foraging ranges (Hobson and Holland 1995) or they may forage near roost trees (Murray and Kurta 2004; Sparks, Whitaker, and Ritzi Unpublished). At least some time spent around roosts includes behaviors other than foraging. Checking, a behavior wherein bats return to the roost one or more times after emerging at dusk, has been recorded in Illinois (Gardner et al.1991b), Michigan (Murray and Kurta 2004), and Indiana (Humphrey et al. 1977, Brack 1983, Sparks, Whitaker, and Ritzi Unpublished). At IND, we use large enough crews to allow emergence counts at a roost and simultaneous radiotracking. We frequently record bats near roosts that are not conducting checking behaviors (See Figures 2-4). These data lead us to suspect that most bats conduct an initial foraging bout in the area immediately surrounding their roost, which is why we start collecting triangulations when the bats emerge. Given that some bats never leave the vicinity of the roost (Table 1), it seems likely that most bats do some foraging near their roosts.

Selection of Habitat Types

Indiana bats forage primarily in and around forested habitat (Cope et al.1974, Humphrey et al. 1977, LaVal et al. 1977, LaVal and LaVal 1980, Gardner et al.1991a,b, Hobson and Holland 1995, Kiser and Elliot 1996, Butchkoski and Hassinger 2002, Romme' et al. 2002, Murray and Kurta 2004, Sparks et al. *In Press*). Early studies in Indiana suggested Indiana bats foraged mostly along riparian streams in close proximity to the roost (Cope et al.1974, Humphrey et al. 1977), and frequently foraged above the canopy. Simultaneous studies conducted in Missouri (LaVal et al.1977) indicated that Indiana bats captured at a cave along the Meramec River foraged in more upland situations, although follow-up studies indicated some used floodplain forest (LaVal and LaVal 1980). The results of light-tagging studies conducted near hibernacula in Indiana closely resemble the results from Missouri (Brack 1983). All of these studies provided evidence that once Indiana myotis arrive in their foraging areas they make multiple loops through a relatively small portion of that area. These studies also concluded that Indiana bats forage around and within forested areas, which continues to be supported by recent work.

More recently, radiotelemetry has been the technique of choice for studying the foraging of Indiana bat. Radiotelemetry studies have revealed Indiana bats foraging in areas as far as 10.3 km away from their roosts, although most travel less than half that distance (Table 1). As in the earlier studies, most foraging is associated with wooded areas (Gardner et al.1991a, b, Hobson and Holland 1995, Butchkoski and Hassinger 2002, Romme' et al.2002, Brack and Whitaker 2004, Brack et al. 2004, Murray and Kurta 2004, Sparks et al. *In Press*), although the type of woodland used may vary throughout the range. In western Illinois, floodplain forest was the most preferred habitat type (Gardner et al.1991a,b). Near hibernacula in Kentucky, Missouri and West Virginia as well as at a maternity roost in Pennsylvania, upland forest was extensively used (Hobson and Holland 1995, Kiser and Elliot 1996, Butchkoski and Hassinger 2002, Romme' et al. 2002). In Michigan, forested wetlands were extensively used by a maternity colony, while the bats used floodplain forest primarily as a commuting corridor (Murray and Kurta 2004). Near Indianapolis (Figures 2-4), woodlands are preferentially used over other land covers for both foraging and commuting, although we did not separate these woodlands into habitat types because so little woodland is present (Sparks et al. *In Press*, Sparks, Whitaker, and Ritzi Unpublished).

Given the large and variable distribution (Gardner and Cook 2002, Brack et al. 2002) of the species, it should come as no surprise that differences in foraging habitat have been recorded between different parts of the summer range, or between bats on the maternity range and near hibernacula. Such differences in the type of woodland used by Indiana bats as foraging habitat may be caused by competition with other species (LaVal et al. 1977, Murray and Kurta 2002) or differences in habitat between different sites. For example there are few forested wetlands similar to those used for foraging by Indiana bats in Michigan (Murray and Kurta 2004) in central Indiana where the species has been most intensively studied (Cope et al.1974, Humphrey et al.1977, Brack 1983, Sparks et al *In Press*, Sparks, Whitaker, and Ritzi Unpublished). The fact that bats in Michigan rarely foraged in floodplain forests (Murray and Kurta 2004) may simply be the result of the forested wetlands being an even more preferred habitat type. In addition, competition with other bats in different parts of the range may lead to differences in the habitat used by Indiana bat across the range (LaVal et al. 1977, Murray and Kurta 2002). Indiana bats may limit competition with other species in Indiana by feeding on different prey or at different times (Belwood 1979, Lee 1993, Whitaker 2004). Future studies of the foraging ecology of Indiana bats should continue to explore the impacts of differing landscapes and communities of bats.

Although most authors have commented on the availability and use of different habitats for foraging, formal statistical analysis of habitat used relative to habitat available have been conducted in western Illinois (Gardner et al.1991a,b) and at IND (Sparks et al *In Press*). Gardner et al.(1991a,b) compared the proportions of habitat available within Fishhook Creek Wildlife Area to habitat contained in foraging areas (delineated by 100% Minimum Convex Polygons). They found that floodplain forest was most preferred followed by ponds, oldfields, rowcrops, upland forests, pastures, and other habitats (including developed areas). At IND, comparisons were made at 2 scales. The larger scale compared habitat available within 8.37 km of any roost and habitat contained within foraging areas delineated using 95% MCPs. Indiana bats selected foraging areas containing woodlands significantly more than agriculture, low density residential, open water, and these significantly more than pasture, parks, and commercial lands with high density residential being the least important. At a finer scale, point data were compared to habitats available within the foraging areas. At this scale, woodlands were most preferred and open water least preferred. In both Indiana and Illinois, agricultural fields and oldfields were an important habitat component. In addition at IND, we suspect the bats are frequently foraging along wooded edges, although telemetry error makes this distinction impossible (Sparks et al. *In Press*). We suspect that in heavily forested landscapes such open habitats may provide critical foraging habitat.

Size of foraging areas varies widely, ranging from a core area of 7 ha (Kiser and Elliot 1996) to a home range of 3026 ha (Romme' et al.2002). Although some of these differences are due to differences in techniques and the terrain in which the bats were tracked, the variation seen in other studies also indicates that these differences are real. A major question that needs to be addressed is how foraging areas change as bats change in age and reproductive condition. On the summer range in Illinois, Gardner et al.(1991a) noted that post-lactating females had the largest foraging ranges (438 ha), followed by lactating females (344 ha), adult males (193 ha), juvenile males (177 ha), pregnant females (159 ha) while juvenile females had used the smallest foraging areas (120 ha). Work in Michigan found that lactating bats made longer commutes than pregnant bats, but this difference was not significant (Murray and Kurta 2004). Preliminary analysis of data collected in Pennsylvania (Butchkoski and Hassinger 2002), in Missouri (Romme' et al. 2002), and by us at IND show no clear association between size of foraging area and sex, age, or reproductive class. Fidelity to foraging areas between years by bats in different reproductive classes also suggests differences in the sizes of foraging ranges may be related to factors other than reproductive class. We intend to address this question using data from IND once we have an adequate sample of post-lactating bats. Ultimately, the important question is how individual bats change their behavior throughout a field season. Thus, information about how the same bat uses its foraging habitat during different parts of the year is critical.

Fidelity to Foraging Areas

Colonies of Indiana bats appear to be loyal to a general foraging area within and between years (Cope et al. 1974, Humphrey et al. 1977, Gardner et al.1991a,b, Murray and Kurta 2004). For example, at IND we tracked a total of 43 bats between 1997 and 2004; all these bats foraged in the same general area, although home ranges were distinct (Figure 2).

Available data support the hypothesis that individual Indiana bats are faithful to their foraging areas between years. Gardner et al. (1991a) noted that females returned to roughly the same foraging areas between years regardless of whether these bats were initially captured as juveniles and then retracked as adults (their Figure 2) or if these bats were adults during both seasons they were tracked (their Figure 7). In Michigan, Indiana bats have been recaptured at and tracked to the same sites (Kurta and Murray 2002, Murray and Kurta 2004). At IND, we have had one opportunity to collect data on the same bat in 2 different years (Figure 3). Roosting and foraging habits of this bat were remarkably consistent between years including occasional nocturnal visits to a day roost on the opposite end of the colony's foraging range, despite the fact that the bat was pregnant when tracked in 2003 and lactating in 2004.

In addition to returning to the same general foraging area in subsequent seasons, individual Indiana bats return to the foraging areas during subsequent nights (Gardner et al. 1991a,b, Murray and Kurta 2004). At IND we have found bats move through their foraging habitat so predictably that we are able to move trackers into position prior to the bat moving (Figure 4). We suspect each bat may have several foraging areas that it moves sequentially between in an order determined by food availability, and its current roost.

Night Roosting

After foraging for a period of time, Indiana bats frequently enter a night roost, which is usually located in the core of the foraging area (Butchkoski and Hassinger 2002, Kiser et al. 2002, Murray and Kurta 2004). Most Indiana bats apparently use trees as night roosts (Butchkoski and Hassinger 2002, Murray and Kurta 2004), although they do occasionally use bat boxes (Butchkoski and Hassinger 2002) and bridges (Kiser et al. 2002) as well. At IND, we observed bats night roosting almost exclusively in trees, despite an abundance of bridges. One exception was an individual night roosting in an oldfield without trees. Although we were unable to locate the exact roost, we suspect this bat was roosting in vegetation. Lactating females return multiple times to their day-roosts, or other day roosts between foraging bouts (Butchkoski and Hassinger 2002, Murray and Kurta 2004, Sparks, Whitaker, and Ritzi Unpublished), and at IND this included several bats that entered bat boxes known to also be day roosts. Murray and Kurta (2004) noted that Indiana bats night roosted 0-6 times per night, usually for an average 14 minutes per bout. Murray and Kurta (2004) used a single observer with a radio receiver to document night roost sites by approaching the bat as close as possible. Similar efforts to examine night roosting behavior were made in Pennsylvania (Butchkoski and Hassinger 2002) and by us at IND only to have the bats exit the roosts and either return to foraging or switch roosts. As such, studies of bats night roosting in trees remain a difficult undertaking.

Night roosting remains poorly understood. For Indiana bats, Murray and Kurta (2004) suggested the primary benefits to be resting, digesting newly captured food, and investigation of potential roosts. Because Indiana bats in Michigan occupied isolated roosts spread throughout the study area, they discounted the likelihood of bats using these roosts to exchange information about prey resources, or gain thermal or antipredator benefits from clustering. At Camp Atterbury, Indiana bats do roost in groups under bridges (Kiser et al.2002) where such benefits cannot be ruled out. Bats at Atterbury were also much less sensitive to disturbance than bats at IND (C. M. Ritzi Personal Observation).

Return to the Roost

Although lactating bats frequently return to the roost several times in a night (presumably to nurse pups), bats of other reproductive classes spend most of their nights in their foraging areas (Murray and Kurta 2004) and return to the roost immediately before dawn. Bats in Michigan returned to their roosts 10-40 minutes before daylight. Telemetry at the IND showed that most bats flew directly from distant foraging areas to the roost. On some occasions, however, we observed radio-tagged Indiana bats foraging over cropfields near their roosts in the early morning light. Also, checking behavior is common during the early morning at major roost trees, and may be participated in by numerous bats, even on days prior to nights when few or no bats emerge from the roost.

Food Habits

Diet of the Indiana bat varies across the geographic range of the species, within a season, and even within a single night (reviewed in Murray and Kurta 2002). Variations within the diet may be linked to selection of particular prey items available in a foraging area, selection of foraging areas rich in particular prey items, changes in prey availability across time or geographic space, or a combination of these factors. Although the diet is variable, there are also striking patterns of similarity. Throughout the species range, and across multiple studies conducted over a period of 30 years, the diet of this bat consists primarily of insects belonging to the orders Diptera (flies), Lepidoptera (moths), and Coleoptera (beetles) (Whitaker 1972, 2004, Belwood 1979, Brack 1983, Brack and LaVal 1985, Lee 1993, Kiser and Elliot 1996, Kurta and Whitaker 1998, N. M. Tuttle, Unpublished Data). Two other orders: Trichoptera (caddisflies), and Hymenoptera (wasps and ants), may be the predominant food when locally abundant (Kurta and Whitaker 1998, Murray and Kurta 2002, N. M. Tuttle Unpublished Data, Whitaker 1972). The remaining portion of the diet consists of a wide variety of other insects along with the occasional spiders and mites (Table 2).

Several pest species are included in the diet. With the exception of one site in Michigan (Kurta and Whitaker 1998), mosquitoes (Diptera: Culicidae) represent only a small percent volume of the food consumed by Indiana bats. Indiana bat frequently forage in areas where mosquitoes are abundant. Mosquitoes are small and mostly solitary (except for male mosquitoes that advertise for mates by swarming) making it ecologically inefficient for bats to seek them out as food (Whitaker and Long 1998). Other pests documented in the diet include Asiatic oak weevil, *Cyrtepistomus castaneus*; spotted cucumber beetle (adult form of the southern corn rootworm,) *Diabrotica undecimpunctata*; and Hessian fly, *Mayetoila destructor* (Kiser and Elliot 1996, N. M. Tuttle Unpublished). While the spotted cucumber beetle and Hessian fly occurred only sporadically, the oak weevil was a frequent and sometimes dominant part of the diet at IND (N. M. Tuttle Unpublished). As such, the Indiana bat may be an important agent of biological control on this species. The Hessian fly is a characteristic pest of wheat, which is an uncommon crop in central Indiana. Because the wing venation of the Hessian fly is easily recognized, we encourage those conducting studies of the diet of Indiana bat in parts of the country where wheat is an important crop to be able to identify this serious pest.

As we learn to identify a greater percentage of the diet to the specific level, we expect the proportion of pest species will increase as well. Unfortunately, some studies failed to report the identity of food items below ordinal level. We encourage future researchers to identify food items to the lowest possible taxonomic level as suggested by Whitaker (1988). Lower taxonomic groups can then be lumped as needed for statistical examination.

Acknowledgements

We are indebted to the IND, which has supported our research with a series of grants from 1997-2004. We have obtained additional financial assistance over the years from the Department of Life Sciences, Indiana State University and the Indiana Academy of Science. We also thank J. L. Chew, B. L. Emery, B. L. Everson, B. J. Foster, C. L. Gummer, S. L. Gummer, J. A. Laborda, H. L. MacDonald, S. S. Nard, both other C. M. Ritzis, J. J. Sheets, M. T. Simmons, M. T. Slater, J. K. F. Sparks, E. R. Stinson, R. Wickens, and W. A. Ulrey for their field assistance. Thanks are also extended to our colleagues who have provided intense discussion on these issues particularly: V. Brack, R. L. Clawson, J. E. Gardner, J. R. MacGregor, R. R. Currie, L. Pruitt, S. Pruitt, A. Kurta, J. E. Duchamp, and E. W. Valdez.

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Dale W. Sparks started working with Indiana bats back in 1991 when he was a member of one of Bill Hendricks's field crews. Today his study of Indiana bats near the Indianapolis International Airport is the longest-running and most intense study of its kind. He holds a BS from Murray State University, an MS from Fort Hays State University in Kansas, and a PhD from Indiana State University. While in Kansas, he studied the impact of settlement on the 13 species of bats present in the State, and desperately tried to make the Indiana bat the 14th species. At Indiana State University, he examined the response of bats to the development of suburban Indianapolis.

Table 1. Summary of available data about foraging ranges used by Indiana bat throughout their range.

Source	Location	Maximum Distance (km)	Total Area[1] (ha)	Summary of Techniques Used
Humphrey et al.1977	Indiana	<0.8	1.47-4.54[2]	Observation of spotlighted bats with reflective bands. As such all values are for the entire colony. N=80 bats banded
LaVal et al.1977	Missouri	<2	n/a	Observation of bats with chemical lights from both the ground and a helicopter. N=35 bats
LaVal and LaVal 1980	Missouri	~5	n/a	Observation of bats with chemical lights from both the ground and a helicopter. N=bats
Gardner et al.1991a[2]	Illinois	4.1	89(16-287)	Radio-triangulation w/ 100% minimum convex polygon used to delineate foraging ranges. Distance measured to center of foraging area. N=41 bats. [3]
Hobson and Holland 1995	West Virginia	<1	625	Radio-triangulation, and direct observation approach with a radio receiver with an unspecified method of delineating foraging area. N= 1 bat.
Kiser and Elliot 1996	Kentucky	2.1(0.8-2.85)	144(28-342)	Radio-triangulation w/100% minimum convex polygon used to delineate minimum foraging area. Some bats frequently flew beyond detection range. N=15 bats.
Butchkoski	Pennsylvania	<4.5	(39-112)	Radio-triangulation w/50% Kernal estimator used to delineate major foraging areas, minor foraging areas outlined by hand.
Romme' et al. 2002	Missouri	(1.9-10.3)	(61-3026)	Radio-triangulation w/90% minimum convex polygon used to delineate home ranges. N= 9 bats
Brack and Whitaker 2004	Indiana	194		Radio-triangulation w/95% minimum convex polygon used to delineate home ranges. N=1 bat
Brack et al. 2004	Indiana	95.1(33-226)		Radio-triangulation w/95% minimum convex polygon used to delineate home ranges. N= 4 bats
Murray and Kurta 2004	Michigan	5.2(0.5-4.2)		Radio-telemetry used to closely approach bats-no triangulation. N= 13 bats
Sparks, et al. Unpublished	Indiana	3(0.8-8.4)	412(50-1168)	Radio triangulation w/95% minimum convex polygon used to delineate home ranges. N= 41 bats[4]

[1]Foraging areas include only areas of nocturnal activity, while home ranges include the roost. Mean values are listed followed by the range in parentheses.
[2]Foraging ranges reported during early and mid summer.
[3]Includes bats discussed in Gardner et al.(1991b).
[4]Includes 11 bats reported in Sparks et al (*In Press*), but excludes 2 bats illustrated in figure 1 from which too little data was collected

Table 2. Foods Eaten by Indiana Bats.

% Volume Reported in Study #

Food Item	1	2	3	4	5	6	7	8	9	10
Lepidoptera	0	57	48	83	42	31	23	14	30	22
Coleoptera	24	9	25	8	18	25	17	1	42	27
Diptera	8	18	9	1	10	25	33	26	4	46
Trichoptera	0	3	10	4	20	1	13	55	1	2
Hymenoptera	50	1	3	0	3	3	10	1	2	0
Homoptera	19	1	2	0	6	11	1	T	0	3
Hemiptera	0	T	T	0	1	3	T	T	0	0
Neuroptera	0	0	0	T	T	1	1	1	0	T
Plecoptera	0	0	1	1	0	T	0	T	0	0
Ephemeroptera	0	T	T	0	T	0	T	T	0	0
Orthoptera	0	0	0	0	T	0	0	0	0	0
Phthiraptera	0	0	0	0	0	0	T	0	0	0
Araneida	0	0	T	0	0	0	1	1	0	0
Acari	0	0	0	0	0	0	T	0	0	0
Other	0	11	2	3	1	0	1	0	0	0

Key to studies 1= Whitaker 1972, 2=Belwood 1979, 3=Brack 1983, 4=Brack and LaVal 1985, 5=Lee 1993, 6= Kiser and Elliot 1996, 7=Murray and Kurta 2002, 8=Kurta and Whitaker 1998, 9=Brack and Whitaker 2004, 10=Whitaker 2004.
T= Trace amount reported.

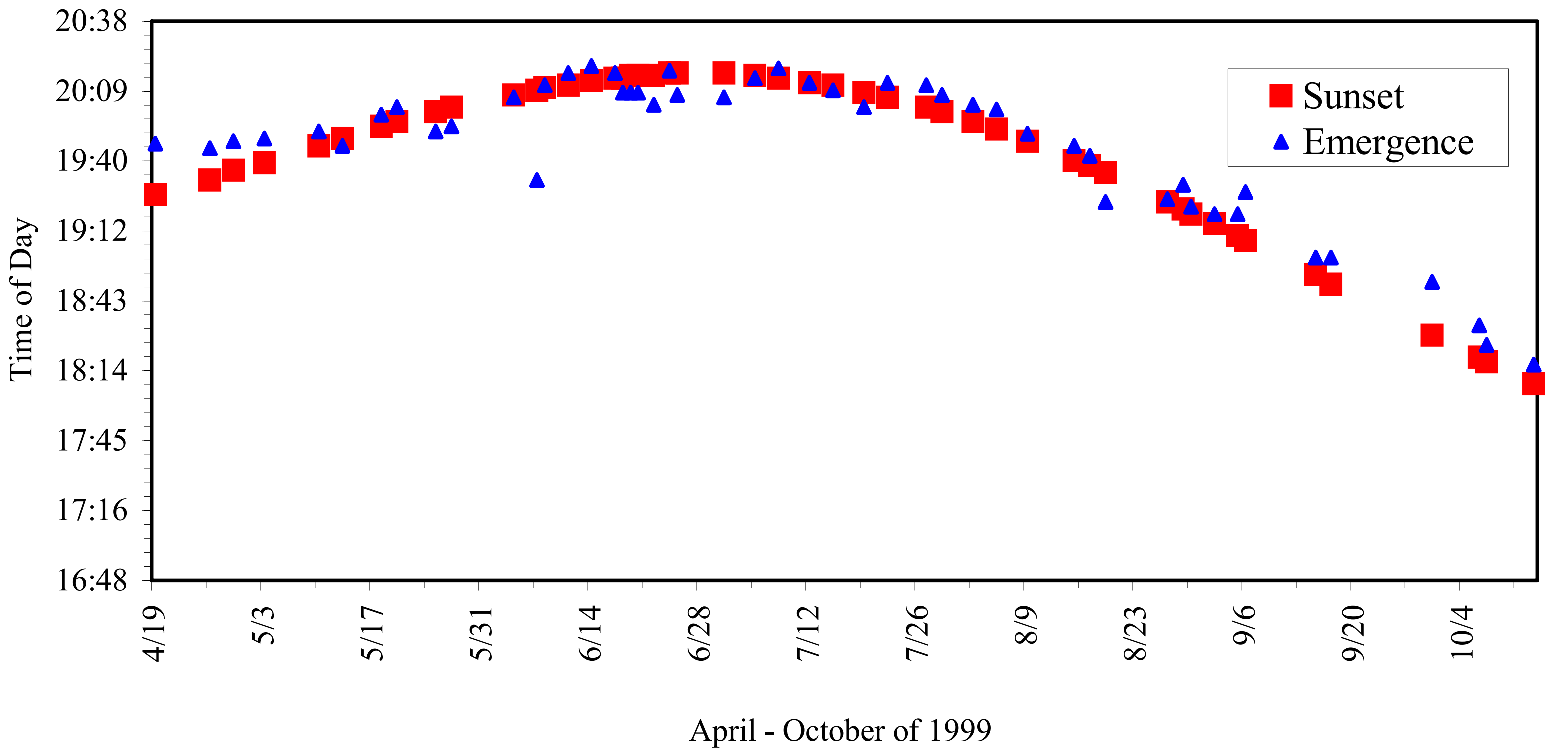

Figure 1. Comparison of times of initial emergence by Indiana bat to sunset at the Indianapolis International Airport in 1999. Time of sunset is indicated by a square and the time the first bat emerged is indicated by a triangle. The circled emergence is an evening when we observed a red-bellied woodpecker chase a bat from the roost

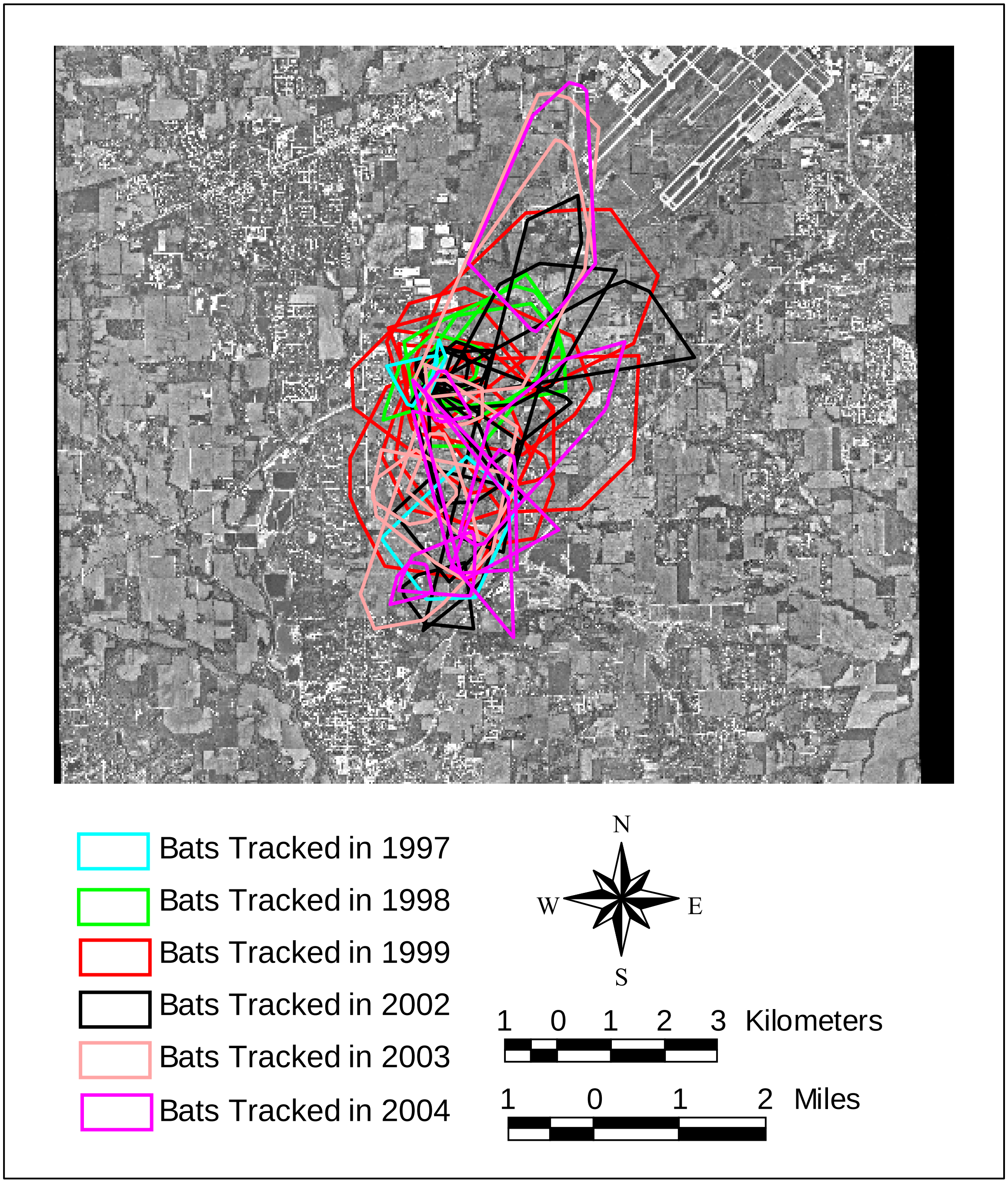

Figure 2. Home Ranges of 43 Indiana bat radiotracked near the Indianapolis International Airport from 1997-2004. Home ranges are illustrated by 95% minimum convex polygons, and each year is color coded.

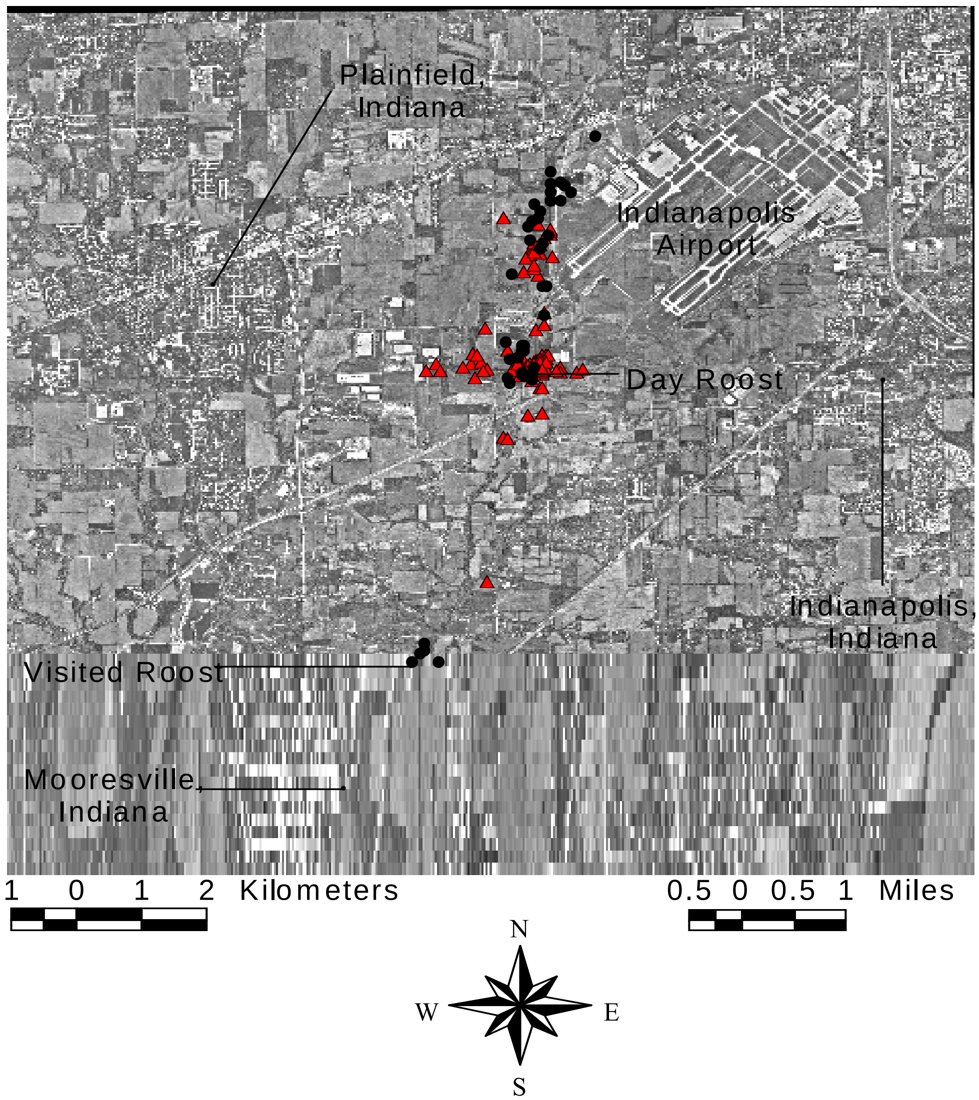

Figure 3. Data collected on the same bat in 2003 (when pregnant) and 2004 (when lactating). Note the overall similarity of the areas used between the 2 years. Also note the telemetry locations south of Interstate Highway-70. Although we were unable to obtain telemetry "fixes" on the bat in 2003 in both years it flew from its roosting area and then roosted in a second roost.

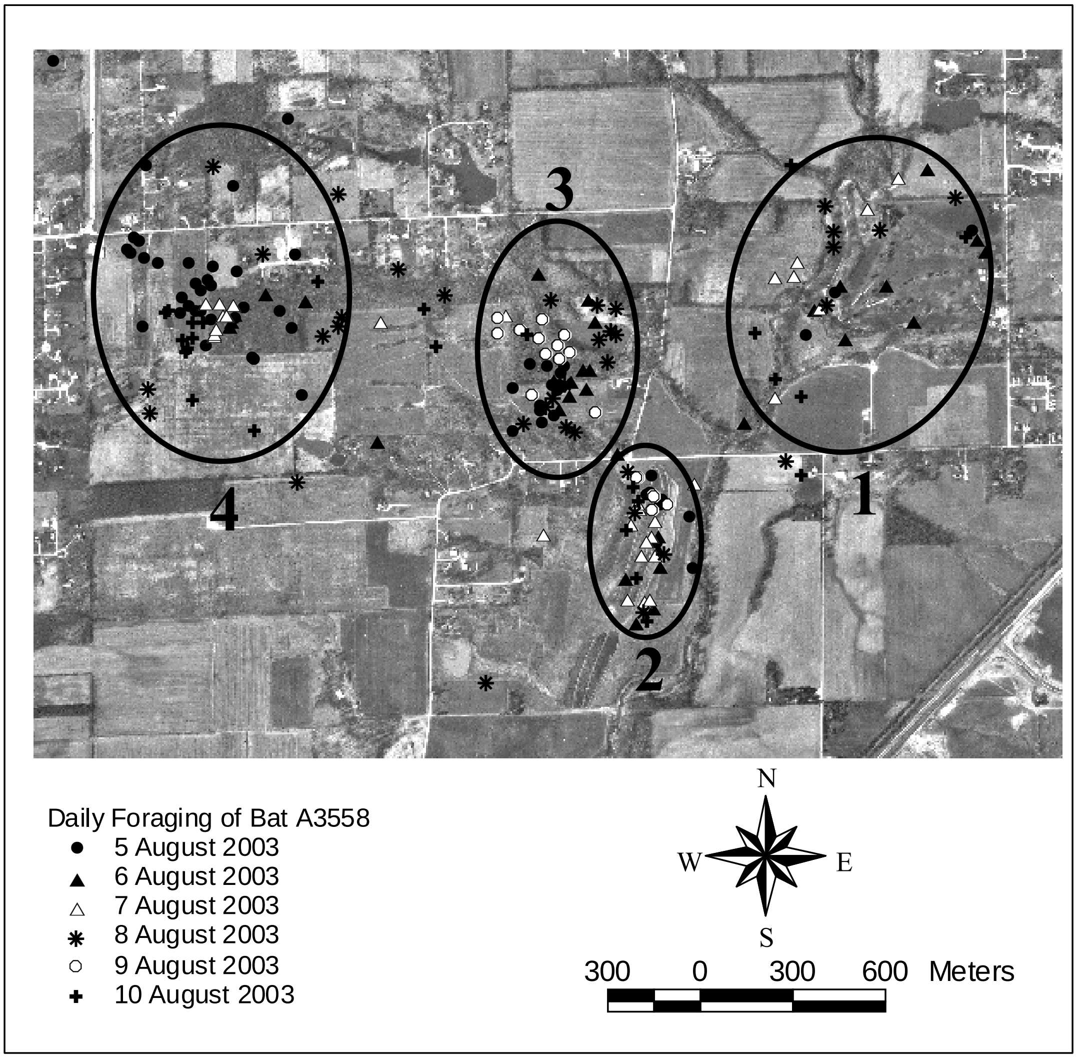

Figure 4. Example of a bat with multiple foraging areas. This bat (a juvenile female) would emerge and forage in the area surrounding its roost (area 1). It would then move south along the East Fork of White Lick Creek until it reached foraging area 2, in a series of constructed wetlands. The bat would then move across a county road and forage for a period near a small pond (area 3) before moving to a final foraging area (4) where it would usually night roost. On 2 nights (white symbols), the bat changed this pattern on 7 August, it passed through, but did not stay in area 3. On 9 August it night roosted in area 3 and never flew to area 4.

ROOSTING ECOLOGY AND BEHAVIOR OF INDIANA BATS (*Myotis sodalis*) IN SUMMER

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Abstract

An analysis of 393 roost trees from 11 States indicates that at least 33 species of tree have been used as roosts by adult female and young Indiana bats (*Myotis sodalis*), although 87% are ash (*Fraxinus*), elm (*Ulmus*), hickory (*Carya*), maple (*Acer*), poplar (*Populus*), and oak (*Quercus*). On average, roost trees are 56% covered by bark, 45 cm in diameter, and 20 m tall; height of the roosting area/exit is about 9 m. Roost trees are larger in diameter than nearby apparently suitable trees, but amount of bark is not a factor in roost selection. Roosts most often are in open sites in agricultural areas with fragmented forests. Indiana bats change trees every 2–3 days, traveling up to 5.2 km between successive roosts, but they are loyal to their home area between years. Adult males use similar roosting sites and species of tree (*n* = 239), but average diameter of trees used by females is 36% greater than that of trees occupied by males. Loss of roost trees may fragment a maternity colony and reduce reproductive success.

Introduction

The Indiana bat (*Myotis sodalis*) originally was listed as endangered because of perceived problems during hibernation. Nevertheless, the population continues to decline, despite restoration and/or protection of all major and many minor hibernacula, suggesting that factors affecting mortality or reproductive success may be operating in summer (Clawson 2002). Little was known about summer roosting habits of female Indiana bats before the advent of miniature radiotransmitters in the 1980s, but since that time, hundreds of Indiana bats have been radiotracked throughout the species' range. The purpose of this report is to summarize data from published and unpublished reports concerning the roosting ecology and behavior of Indiana bats in summer, with an emphasis on females and their young at maternity sites. In addition, I will speculate on the potential effects that loss of a roost tree might have on a colony and its members.

Microhabitat

Female Indiana bats almost invariably occupy trees in summer. Members of a colony may use over 20 different trees during the reproductive season, with individuals constantly switching back and forth (e.g., Kurta et al. 2002; Sparks 2003). Some trees are used more consistently and by a greater number of bats than other trees, and these "focal" or "primary" roosts probably are more important to the colony than "alternate" roosts that are used infrequently and by fewer animals (Barclay and Kurta in press).

Bark or Crevice

The most common roosting site for females in summer is under slabs of exfoliating bark, but the bats occasionally use narrow cracks within trees (Callahan 1993; Carter 2003; Kurta et al. 1993a, 1993b, 2002). For example, crevices in the top of a lightning-struck tree (Gardner et al. 1991) or trees that were snapped by a tornado (Kurta et al. 2002) can shelter maternity colonies. Although other species of bat reside frequently in tree hollows that were created by rot or woodpeckers (Barclay and Kurta in press), such cavities have never been used by maternity colonies of Indiana bats.

Species of Tree

Over 30 species of tree have supplied roosts for female Indiana bats and their young (Table 1), and 87% are various ash (*Fraxinus*; 13%), elm (*Ulmus*; 13%), hickory (*Carya*; 22%), maple (*Acer*; 15%), poplar (*Populus*; 9%), and oak (*Quercus*; 15%). At one time, it appeared that oak and hickory were used more commonly at southern sites (Callahan et al. 1997; Garner et al. 1991), whereas elm, ash, maple, and cottonwood were occupied more often in northern areas (Kurta et al. 1996, 2002; Whitaker and Brack 2002). Recent work, however, shows Indiana bats occupying ash and elm in southern Illinois (Carter 2003) and hickories in Vermont (Palm 2003), so type of tree seems related more to local availability than broad regional preferences. Nonetheless, some common trees, such as American beech (*Fagus grandifolia*), basswood (*Tilia americana*), black cherry (*Prunus serotinus*), box elder (*A. negundo*), and willows (*Salix*) have rarely or never been used, suggesting that they are not suitable for primary roosts.

All roost trees of female Indiana bats at maternity sites are deciduous species, except a few trees recently discovered in the Great Smoky Mountains (Britzke et al. 2003) and in New England (K. Watrous in litt.). Although this may indicate a preference for deciduous trees, it also simply may reflect availability. Maternity roosts of Indiana bats are located most frequently in agricultural areas that once were prairies, savannahs, or deciduous forests, and maternity colonies are almost totally unknown from southern States or the eastern mountains where conifers are more common (Gardner and Cook 2002). Many other species of bat roost in conifers (Barclay and Kurta in press), and Indiana bats use conifers during autumn swarming (Gumbert et al. 2002); consequently, there does not appear to be anything inherently poor about conifers as roosts.

Many species of tree apparently make suitable roosts (Table 1), but some species are preferred. Kurta et al. (1996), for example, demonstrated a preference by Indiana bats for green ash (*F. pennsylvanica*) over silver maple (*A. saccharinum*) in Michigan, and Carter (2003) showed that these bats chose green ash and pin oak (*Q. palustris*) more often than expected based on availability in Illinois. Both studies occurred at sites with very high snag densities. However, if suitable trees are less abundant, other factors that influence roost selection (e.g., canopy cover, exposure to wind, distance to foraging sites, etc.) may mask preferences that were displayed by bats in areas of superabundant roosts.

Living or Dead Trees

Most trees that are occupied by female Indiana bats in summer are dead or nearly so. Indiana bats also occasionally roost under the peeling bark of living trees, most often shagbark (*C. ovata*) or shellbark hickories (*C. lacinosa*), and these trees may be used as alternate roosts during exceptionally warm or wet weather (Callahan et al. 1997; Humphrey et al. 1977). Carter (2003), however, suggests that living trees are used as alternates only when suitable dead trees are not available.

Size of Tree

Roost trees vary in size (Table 2). Although the minimum diameter reported so far is 6.4 cm for a male roost (Gumbert 2001) and 11 cm for a female roost (Britzke 2003), such small trees are never used as primary roosts, and most trees favored by maternity colonies are greater than 22 cm in diameter. For example, average diameter of roost trees (primary and alternate) is 62, 55, and 41 cm for Indiana, Missouri, and Michigan, respectively (Callahan et al. 1997; Kurta and Rice 2002; Whitaker and Brack 2002). Differences in average diameter among States likely reflect differences in species of tree contained in each sample—the Indiana sample is dominated by cottonwood; Missouri, by oak and hickory; and Michigan, by ash. The smallest mean diameter in Table 2 (28 cm) is for five trees in Pennsylvania; however, the primary roost for this colony was a building, and no tree sheltered more than four bats (Butchkoski and Hassinger 2002).

Larger-diameter trees presumably provide thermal advantages and more spaces for more bats to roost in. As in most tree-roosting bats (Barclay and Kurta in press; Hayes 2003), female Indiana bats probably select trees, especially primary roosts, that are larger in diameter than nearby, apparently suitable, but unoccupied trees (Britzke et al. 2003; Kurta et al. 1996 2002; Palm 2003; Sparks 2003). Nevertheless, whether a statistical difference in diameter is detected between roost and randomly selected trees is affected by the definition of a "suitable" or "available" tree. Differences between roosts and random trees have been found when the minimum diameter of available trees is set at 4.5, 10, or 15 cm (Kurta et al. 1996, 2002; Palm 2003; Sparks 2003) but not at 18.5 or 25 cm (Callahan et al. 1997; Carter 2003). Inclusion of small trees in the pool of randomly selected trees seems justified, because there are numerous instances of one or more Indiana bats using them; hence, they are "available" to the bats.

Average heights of roost trees range from 16 to 26 m (Table 2). Variation in height among studies likely reflects species differences in the sample of roost trees but also in the manner in which the trees died. For example, roost trees at one site in Michigan were killed by inundation and had an average height of 25 m, whereas roosts at a second site were snapped by a tornado and averaged only 18 m (Kurta et al. 1996, 2002). Minimum tree heights are 3 m for an alternate roost (Carter 2003) and 3.7 m for a primary roost (Callahan 1993). Absolute height of the roost tree probably is less important than height relative to surrounding trees, because relative height can affect the amount of solar radiation impinging on the tree, ease of finding the tree, and ease of safely approaching the roost while in flight (Barclay and Kurta; in press; Hayes 2003).

Bats often gain air speed when taking flight by dropping from their roost, and a certain height may be needed to do this without hitting the ground or coming within reach of terrestrial predators. Surprisingly, minimum exit height for an alternate roost is only 0.6 m, and for a primary roost, 1.8 m (Callahan 1993). However, mean height of the exit, which is assumed to be the height of the roosting area, is 7–10 m (Table 2); height of the exit is correlated with height of the tree (Kurta et al. 2002). Absolute height of the exit probably is not as important as height relative to surrounding vegetation.

Other Factors Affecting Access and Sunlight

In addition to height, other factors influence the amount of sunlight striking a roost tree and simultaneously impact the ease and safety of access for a flying bat (Barclay and Kurta in press). For example, roosts of the Indiana bat, especially primary roosts, typically are found in open situations, although definitions of "open" vary (Callahan et al. 1997; Carter 2003; Gardner et al. 1991; Kurta et al. 1993b, 1996, 2002; Palm 2003; Sparks 2002). The immediate vicinity of a roost, especially a primary roost, often is open forest, or roosts may occur along the edge of a woodlot, in gaps within a forest, in a copse of dead trees, part of a wooded fenceline, or in grazed woodlands, pastures, or hog lots. When present in denser forests, primary roost trees often extend above the surrounding canopy (e.g., Callahan et al. 1997). Roosts occasionally occur in low-density residential areas with mature trees (Belwood 2002; A. Hicks pers. comm.).

Canopy cover at the base of roost trees is one measure of openness around a roost, but mean values are variable among studies, ranging from <20% to 88% (Table 2). Some variation undoubtedly is related to differences in methodology, but high canopy cover may be associated with use of many living shagbark hickories as alternate roosts. Also, it is important to remember that usual measures of canopy cover reflect conditions at ground level and not necessarily at the height of roosting bats. Carter (2003), for example, estimated canopy cover at roost height to be about half that at ground level.

Access by a flying bat and incident sunlight presumably are decreased by high canopy cover, but both also could be affected negatively by presence on the trunk of living or dead vines, such as wild grape (*Vitis* spp.) or Virginia creeper (*Parthenocissus quinquefolia*). In Michigan, all roost trees discovered so far (n = 74) lacked vines at or above the roosting area, although no comparison was made with randomly selected trees (Kurta and Rice 2002; A. Kurta, unpublished data).

Amount of Bark Remaining

Amount of bark remaining on a tree is another parameter that often is measured, although not always in the same way. Some biologists record the total amount of bark remaining on a tree, whether the bark is suitable for roosting or not (e.g., Callahan et al. 1997), whereas other researchers record only the amount of exfoliating bark under which a bat might roost (e.g., Gardner et al. 1991). The two techniques must be distinguished because they mean different things and could yield different results. For example, a randomly selected tree that recently died may be covered totally by bark and yield a value of 100%; however, the same tree would be totally unsuitable for roosting, because all bark is still tight to the trunk, thus yielding 0% for loose and peeling bark. Although there is potential for confusion, neither the amount of total bark or of exfoliating bark apparently affects roost selection by female Indiana bats (Britzke et al. 2003; Carter 2003; Callahan et al. 1997; Gumbert 2001; Kurta et al. 1996, 2002; Palm 2003).

Sexual Differences

Some adult male Indiana bats form colonies in caves in summer, but most are solitary and roost in trees. Adult males have been radiotracked to 239 trees of 26 species in 8 States (Table 1). Species of tree are similar to those chosen by females. Males at two sites in Kentucky often roosted in pines (Gumbert 2001; Kiser and Elliott 1996), which were abundant in those study areas, but most other males (40%) used elm. Although males roost in trees up to 95 cm in diameter (Kurta and Rice 2002), males accept small trees more often than do females; consequently, mean diameter of trees used by males was 36% less (33 cm; n = 219) than the average for females (Tables 2 and 3). Like the females, males roost primarily under bark and less often in narrow crevices; in addition, two males were tracked to small cavities (Gardner et al. 1991; Gumbert 2001).

Artificial Roosts

Although some species, such as the little brown bat (*M. lucifugus*) and big brown bat (*Eptesicus fuscus*), have the behavioral plasticity to roost in trees, rock crevices, bat houses, or buildings (Barclay and Kurta in press; Hayes 2003), female and juvenile Indiana bats in summer are restricted almost totally to trees. Adult females apparently used a crevice in a utility pole in Illinois (Ritzi et al. in press), and adult males were found under brackets on utility poles in Arkansas (Harvey 2002). There also are a few instances of adult males and juvenile Indiana bats day-roosting under concrete bridges in Indiana (reviewed in Kiser et al. 2002). Although a number of Indiana bats have been captured in buildings during migration (before 15 May or after 15 August; Belwood 2002), only three maternity colonies have been located in buildings. These include an abandoned church in Pennsylvania (Butchkoski and Hassinger 2002), a house in New York (A. Hicks, pers. comm.) and a barn in Iowa (Chenger 2003). Nevertheless, there are almost 400 roost trees for female Indiana bats indicated in Table 1, and probably hundreds of others are described in unpublished reports of consultants and government agencies, suggesting that use of buildings by maternity colonies is uncommon.

Similarly, bat houses rarely are occupied by Indiana bats. Reproductive females from the church in Pennsylvania also used a large picnic-shelter-style bat house as an alternate roost (Butchkoski and Hassinger 2002). Before 2003, the only other records of Indiana bats using bat houses were two, solitary, juvenile males using different bird-house-style bat boxes and a group of females in a rocket box after the reproductive period (Ritzi et al. in press; Carter et al. 2001). However, Ritzi et al. (in press) recently found groups of reproductive females using two bird-house-style bat boxes for prolonged periods. Use of these artificial structures coincided with destruction of two primary roosts, and the authors speculated that portions of the colony were using the boxes as temporary replacements. The boxes had been in place for 11 years before being occupied and were two of 3,204 artificial structures of various styles that had been constructed. Placement of bat houses of current design is not an acceptable alternative to maintaining a supply of suitable dead trees for this endangered species.

Landscape Structure and Macrohabitat

Distance to Environmental Features

Distances from roosts to nearby environmental features rarely were measured. Trees used by a colony in Illinois were closer to unpaved than paved roads and closer to intermittent streams than to perennial streams, although no comparison was made with randomly selected points (Gardner et al. 1991). In Michigan, roost trees were closer to perennial streams than random locations, but there was no difference between roosts and random points in distance to roads of any type or to lakes/ponds (Kurta et al. 2002). Although insectivorous bats typically obtain 20–26% of their daily water from drinking (Kurta et al. 1989, 1990), water sources are ubiquitous in most areas where Indiana bat maternity roosts occur, and distance to water likely does not impact selection of individual trees. At one maternity site in Michigan, for example, average distance from a random point to a perennial stream is only 910 m and to a lake or pond, 541 m (Kurta et al. 2002); these distances are small and energetically insignificant. Although distance to water probably is not a factor in day-to-day roost selection, accessible sources of water might affect location of the home range of a colony on a broader landscape, i.e., colonies may locate in areas of more abundant, accessible sources of water (Carter et al. 2002).

Commuting Corridors

Indiana bats frequently follow tree-lined paths rather than cross large, open areas (Carter 2003; Chenger 2003; Gardner et al. 1991; Murray and Kurta 2004). Therefore, suitable patches of forest may not be available to the bats unless they are connected by a wooded corridor, i.e., a component of suitable habitat may be the connectedness of different forest patches. Unfortunately, biologists do not know how large an open area must be before Indiana bats hesitate or refuse to cross. There are observations of Indiana bats crossing interstate highways (R. Rommé, pers. comm.) or open fields (Brack 1983), but such behavior appears uncommon, relative to observations of the bats foraging in or commuting along wooded sites. Murray and Kurta (2004), for example, showed that Indiana bats increased commuting distance by 55% to follow tree-lined paths, rather than flying over large, agricultural fields, some of which were at least 1-km wide.

Surrounding Habitats

At one time, the Indiana bat was considered a riparian specialist (Humphrey et al. 1977), but this categorization is no longer valid. Maternity roosts of some colonies are primarily in riparian zones (Humphrey et al. 1977), mainly in upland forests (Gardner et al. 1991), or are partly riparian and partly upland (Callahan 1993). Indiana bats in Michigan (Kurta et al. 2002), in contrast, preferred roosting in wetlands; although some roosts were in the floodplain of a major river, most were in low areas not associated with the river. Differences among studies probably reflect the location of intact woods in different agricultural landscapes (Murray and Kurta 2002, 2004).

Presence of Indiana bats is not correlated with high forest cover. Miller et al. (2002) compared macrohabitats surrounding sites where female Indiana bats were caught to sites where they were not caught and found that the percentage of land that was forested did not determine presence of Indiana bats, although occupied sites contained a higher density of large-diameter trees. Similarly, after analyzing a model for predicting habitat suitability, Farmer et al. (2002) concluded that amount of land in forest, number of different habitats available, and area of water were not useful for predicting presence of Indiana bats. They reported, however, that Indiana bats were more likely to occur in areas with a high density of potential roost trees (see also Clark et al. 1987).

Composition of the landscape surrounding a colony's home range was determined for a few maternity colonies. In Missouri, amount of forest within a 3-km radius of four maternity sites varied from 19 to 30%, whereas amount of agricultural land was 58–81% (Callahan 1993). In Illinois, 67% of the land was agricultural, 33% was forested, and 0.1% consisted of farm ponds (Gardner et al. 1991). In Michigan, land cover consisted of 55% agricultural land, 19% wetlands (including lowland hardwood forest), 17% other forests, 6% urban development, and 3% lakes/ponds/rivers (Kurta et al. 2002).

Using GIS, Carter et al. (2002) compared habitats in circles that were 2 km in diameter surrounding all roost trees known in Illinois with habitat surrounding randomly selected locations. Areas around roosts had fewer and smaller urban patches and more and larger patches of closed-canopy deciduous forest compared with random sites. Area and number of patches of coniferous forest did not differ between roosting and random locations, but roosting areas had more patches of water (ponds, lakes, etc.) than random sites. Finally, roosts typically occurred in highly fragmented forests, with roosting areas containing more patches of agriculture than randomly chosen circles.

On a much larger scale, Gardner and Cook (2002) examined land cover in 132 counties in the United States for which there was evidence of reproduction by Indiana bats. Nonforested habitats, primarily agricultural land, made up 75.7% of the total land area in those counties. Deciduous forest covered 20.5% of the land, whereas coniferous forests and mixed coniferous/deciduous woodland occupied 3.4%.

Thus, studies examining roosts used by single colonies, all colonies within a State, or all counties within the United States with evidence of reproduction are consistent in showing that Indiana bats typically reproduce in agricultural areas with fragmented forests and do not usually form colonies in areas of extensive forest. Most females from the major hibernacula in Indiana, Kentucky, and Missouri migrate north for summer, into agricultural landscapes of the Midwest (Garner and Cook 2002; Whitaker and Brack 2002). Similarly, recently discovered colonies in Vermont and New York also occur in agricultural regions with fragmented forests. These bats hibernated in New York and were followed with aircraft as they left hibernation; they ignored nearby forests of the Adirondack Mountains in favor of agricultural areas of the Lake Champlain Valley and southern New York (A. Hicks, pers. comm.). It is tempting to conclude that Indiana bats prefer an open or fragmented landscape, although climate also may play a role, with southern portions of the species' range perhaps too warm and forest-covered mountains too cool for successful reproduction (Brack et al. 2002; Clark et al. 1987; but see Britzke et al. 2003). Additional factors that may contribute to where Indiana bats typically reproduce on the continent are distance from suitable hibernacula, competition for food with other species of bat, and competition with other bats or birds for roosting sites (Clark et al. 1987; Foster and Kurta 1999; Kurta and Foster 1995; Murray and Kurta 2002; Sparks 2003).

Colony Size, Fidelity, and Roost Switching

Size of Maternity Colonies

The number of bats comprising a maternity colony is difficult to determine because colony members are dispersed among various roosts (see below). Most exit counts at primary roosts indicate the presence of at least 20-100 adults.

The mean maximum emergence count after young began to fly is 119 bats (12 studies; Table 2), suggesting a typical maximum of 60–70 adults in a primary roost at any one time.

Intraseasonal Behavior

All colonies use multiple trees during a season and at any one time. However, the exact number is not known, because not every bat in a colony can be tracked simultaneously, especially over an entire season, and because number of trees used by a bat is correlated with number of days that it is radiotracked (Britzke 2003; Gumbert et al. 2002; Kurta et al. 1996, 2002). On any day, a colony is dispersed among numerous trees, with many bats occupying one or more primary roosts, while individuals and small groups reside in different alternate roosts. The number of alternates used on any day probably varies, but bats from one colony occupied at least eight trees on a single day (Carter 2003). Maternity colonies use a minimum of 8–25 different trees in one season (Callahan et al. 1997; Carter 2003; Kurta et al. 1996, 2002; Sparks 2003).

Roost trees are clustered in space (Kurta et al. 1996, 2002), because groups of trees are subjected to the same mortality factors at the same time (e.g., storms, flooding, and disease). Although roosts are clustered, there may be more than one cluster within a home range. Consequently, minimum distance between two trees used by a colony in the same season is 1 m (Kurta et al. 1996), but the maximum is 8.2 km (Kurta et al. 2002).

Indiana bats probably have a fission-fusion society, similar to that of cetaceans and primates (Barclay and Kurta in press; Kurta et al. 2002; Willis and Brigham 2004). In summer, Indiana bats typically change roosts every 2–3 days, with lactating females changing less frequently than pregnant or post-lactating adults and bats roosting in crevices changing less often than those roosting under bark; both males and females apparently change roosts less frequently during cool weather in early spring (Britzke 2003; Carter 2003; Gumbert et al. 2002; Kurta et al. 1996, 2002; Schultes 2002). Individuals or perhaps small groups may change roosts, but the entire colony typically does not shift en masse to a single new tree overnight. Reasons for frequent switching are not understood, but some shifts may be a response to changing weather or changing needs of females in different reproductive conditions, or an attempt by the bats to maintain social contacts or knowledge of alternate roosts (Barclay and Kurta in press).

Indiana bats often do not move to the nearest alternate roost, but average distance moved depends somewhat on habitat. At a site with a superabundance of suitable roosts, mean distance moved was only 74 m (n = 37), but at a different site where potential roosts were less abundant, bats moved an average of 686 m (n = 78; Kurta et al. 1996, 2002). Minimum distance moved overnight is 1 m (Kurta et al. 1996), but the maximum reported so far is 5.8 km (Kurta et al. 2002).

Interannual Fidelity to Roosts and Roosting Areas

Indiana bats display strong between-year fidelity to summer colony areas, roosts, commuting corridors, and foraging sites. For example, 41% of banded adult females at one colony in Michigan were recaptured at or near the initial banding site in subsequent years (Kurta and Murray 2002), and bats from this colony used a wooded fenceline as a commuting corridor for at least 9 years (Winhold et al. in press). Roost trees often are reoccupied by a colony in subsequent seasons, with many examples of trees being used for 2–6 years (Barclay and Kurta in press; Gardner et al. 1991; Gumbert et al. 2002; Humphrey et al. 1977; Kurta et al. 1996, 2002; Sparks 2003).

Although Indiana bats are faithful to their home area, exact roosting sites must change frequently, due to the natural decay of roosts. As an example, one colony in Michigan shifted the focal point of its roosting activity by 2 km in just 3 years but apparently maintained the same home range. Most roosts were located in or near foraging areas or commuting corridors—features of the home range that probably were less ephemeral than individual roosts (Murray and Kurta 2004; Winhold et al. in press).

Loss of a Roost

Biologists know very little with certainty about the effects of loss of a roost tree on Indiana bats or any other species. Impacts likely vary with time of year, reproductive state of the bat, whether the tree is currently occupied, and whether it is a primary or alternate roost. Although Indiana bats may be killed directly during destruction of a roost (Belwood 2002), most effects appear indirect and probably occur on a continuum, from those associated with loss of one alternate roost to those that accompany elimination of all known roost trees and foraging sites (i.e., destruction of the home range).

Loss of a single alternate roost at any time of year probably has little impact on Indiana bats, because the colony has 10–20 other trees to select from, but loss of a primary roost could be detrimental. For example, a colony of big brown bats excluded from a primary roost in a building fragmented, and the bats subsequently experienced a 56% decline in reproductive success (Brigham and Fenton 1986). Reduced reproductive success may be related to stress, poor microclimate in new roosts, a reduced ability to thermoregulate through clustering, or reduced ability to locate profitable food patches through information sharing (Brigham and Fenton 1986; Willis and Brigham 2004). Destruction of a primary roost of Indiana bats also led to fragmentation of the colony (Ritzi et al. in press; Sparks 2003), and it is reasonable to assume that reproductive success was negatively affected, as in the big brown bat (Brigham and Fenton 1986).

As indicated elsewhere (Kurta and Murray 2002; Kurta and Rice 2002), loss of multiple roost trees over winter could be devastating under certain circumstances. If a number of alternate roosts, as well as a primary roost that is favored in early spring, disappear over winter, then the bats would be without suitable shelter when they return in spring. At this time, they are stressed after a lengthy hibernation period, a long migration, and the demands of early pregnancy, but despite the high energetic and nutritional requirements, food (flying insects) is scarce, due to cool and wet weather. The bats' ability to use torpor probably minimizes mortality. However, unusually cold or wet weather negatively impacts the reproductive success of bats of other species that are safely ensconced in their roosts (Grindal et al. 1992; Lewis 1993; Racey 1973; Racey and Swift 1981), and it is reasonable to assume that reproduction by Indiana bats that find their roosts destroyed also is impacted during poor weather and that even average spring conditions may cause problems for homeless animals.

The extent of any harmful effects depends on various factors, including number and quality of trees that are lost, severity of the weather, and how long it takes the bat to discover suitable replacement roosts. The ease of finding replacements likely is affected by the density of suitable large-sized trees within their home range and whether or not foraging sites also have been impacted. Any large-scale modification of habitat that includes destruction of foraging sites would be particularly detrimental, because Indiana bats likely discover their roost trees within foraging areas or along commuting corridors (Murray and Kurta 2004). Consequently, large-scale destruction of habitat eliminates previously used roosts, as well as known sources of food and new roosts.

Final Comments

Biologists have learned much concerning the types of trees occupied by Indiana bats and various facets of their roosting behavior, yet we still do not understand many important aspects of their biology, ranging from reproductive success to the dynamics of a colony. What proportion of females give birth, and what proportion of young reach volancy? How are new roosts located? How do individuals find each other after a roost is destroyed? What is the minimum number of individuals necessary for a viable colony, and is there a maximum size for a colony? How do new colonies form? Do colonies ever expand or contract their home range? What are the benefits of colony membership? What are the effects of colony disruption on the fitness of individuals? Do individuals ever switch colonies? Answers to such questions are unknown but may be crucial for long-term management and recovery of the species.

Over 630 roost trees of Indiana bats have been discovered so far (Tables 2 and 3)—more than for any other species on the continent—and it is time to move beyond simple description of roosting sites (Barclay and Kurta in press). Unfortunately, tree-roosting bats, in general, are difficult to study because of their small body size, secretive nature, large home range, ephemeral roosts, and dispersed colonies. Furthermore, the home range of most maternity colonies of Indiana bats encompasses numerous, small parcels of private land (Kurta and Murray 2002), making any study logistically more difficult than those that occur in extensive, government-owned forests. Nevertheless, innovative field manipulations (e.g., Brigham and Fenton 1986; Willis and Brigham 2004) must occur, for Indiana bats and other tree-roosting species, before biologists will understand how individual bats and colonies interact with the landscape.

Acknowledgments

Previously unpublished observations were obtained with support from the Michigan Department of Natural Resources. Some ideas concerning loss of roosts were formulated during discussions among some members of the Indiana Bat Recovery Team and representatives of the United States Fish and Wildlife Service at a meeting in West

Virginia during July 2004. D. Sparks, K. Watrous, and L. Winhold provided unpublished data, and J. Chenger, C. Elliott, and A. Hill sent unpublished reports and theses. A. Hicks provided information about roosts in the Champlain Valley and arranged a site visit.

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Dr. Allen Kurta's research for the past 27 years has focused on the ecology and behavior of bats, with an emphasis on the Indiana bat. He has published over 50 papers in scientific journals. He is author of Mammals of the Great Lakes Region, co-author of The Bats of Puerto Rico: an Island Focus and a Caribbean Perspective, and editor of the The Indiana Bat: Biology and Management of an Endangered Species. Dr. Kurta is a former Associate Editor of the Journal of Mammalogy, current Feature Editor of Bat Research News, and he has served as a member of the Indiana Bat Recovery Team since 1995. He received a B.S. in Zoology from Michigan State University and a Ph.D. in Biology from Boston University.

Table 1. Species of Tree and Type of Roosting Site Used by Indiana Bats.

Scientific Name	***Common Name***	***Type of Roost***[a]	***Number of trees used by adult females and young***	***Percent of trees used by adult females and young (%)***	***Number of trees used by adult males***	***Percent of trees used by adult males (%)***	***References***[b]
Acer rubrum	Red maple	B, C	7	1.8	13	5.4	2, 3, 9, 12, 13, 16, 17
Acer saccharinum	Silver maple	B	25	6.4	1	0.4	5, 6, 8, 13, 18, 19
Acer saccharum	Sugar maple	B, C	18	4.6	2	0.8	2, 3, 8, 16–19, 21
Acer sp.	Unidentified maple	B	9	2.3	0	0.0	13
Betula alleghaniensis	Yellow birch	?	2	0.5	0	0.0	3, 16
Betula lenta	Sweet birch	B	1	0.3	0	0.0	4
Carya cordiformis	Bitternut hickory	B	3	0.8	1	0.4	8, 11, 18, 19
Carya glabra	Pignut hickory	B	0	0.0	3	1.3	12, 17
Carya lacinosa	Shellbark hickory	B	4	1.0	0	0.0	18, 19
Carya ovata	Shagbark hickory	B	78	19.8	22	9.2	3, 5, 6, 8–13, 16–21
Carya tomentosa	Mockernut hickory	?	0	0.0	7	2.9	9
Celtis occidentalis	Northern hackberry	B	1	0.3	0	0.0	18, 19
Cornus florida	Flowering dogwood	?	0	0.0	4	1.7	9
Fagus grandifolia	American beech	?	1	0.3	0	0.0	3
Fraxinus americana	White ash	C	1	0.3	0	0.0	5
Fraxinus nigra	Black ash	B	4	1.0	3	1.3	13
Fraxinus pennsylvanica	Green ash	B, C	46	11.7	4	1.7	3, 6, 13
Gleditsia triacanthos	Honeylocust B		2	0.5	0	0.0	7
Juglans cinerea	Butternut B		1	0.3	0	0.0	20
Juglans nigra	Black walnut	B	1	0.3	0	0.0	18, 19
Liriodendron tulipifera	Tulip tree	B	1	0.3	6	2.5	9, 15
Ostrya virgiana	Hophornbeam B		1	0.3	0	0.0	20
Oxydendrum arboreum	Sourwood ?		0	0.0	9	3.8	9, 12
Pinus echinata	Shortleaf pine	B	2	0.5	70	29.3	4, 9
Pinus rigida	Pitch pine	B	1	0.3	6	2.5	4, 9
Pinus sp.	Unidentified pine	B	1	0.3	4	1.7	20
Pinus strobus	White pine	B, C	8	2.0	0	0.0	16, 20
Pinus virginiana	Scrub pine	?	0	0.0	15	6.3	9, 12
Platanus occidentalis	Sycamore	C	2	0.5	0	0.0	14, 18, 19
Populus deltoides	Cottonwood	B, C	25	6.4	0	0.0	5, 6, 8, 13 16, 18–21
Populus sp.	Unidentified poplar	B	5	1.3	0	0.0	20
Populus tremuloides	Trembling aspen	B	5	1.3	0	0.0	3, 16
Quercus alba	White oak	B	15	3.8	18	7.5	5, 8, 9, 17, 21

Table 1 continued. Species of Tree and Type of Roosting Site used by Indiana Bats.

Scientific Name	***Common Name***	***Type of Roost***[a]	***Number of trees used by adult females and young***	***Percent of trees used by adult females and young (%)***	***Number of trees used by adult males***	***Percent of trees used by adult males (%)***	***References***[b]
Quercus coccinea	Scarlet oak	?	0	0.0	5	2.1	9, 12
Quercus falcata	Spanish oak	?	0	0.0	1	0.4	9
Quercus imbricaria	Shingle oak	B	0	0.0	1	0.4	8
Quercus palustris	Pin oak	B	8	2.0	0	0.0	5
Quercus prinus	Chestnut oak	?	0	0.0	6	2.5	9
Quercus rubra	Red oak	B	30	7.6	9	3.8	2, 4, 5, 8, 9, 12, 13, 21
Quercus sp.	Unidentified oak	B	3	0.8	0	0.0	20
Quercus stellata	Post oak	B	3	0.8	2	0.8	8
Quercus velutina	Black oak	B	0	0.0	2	0.8	9, 17
Robinia psuedoacacia	Black locust	B, C	12	3.1	0	0.0	3, 20
Sassafras albidium	Sassafras B	, Ca	0	0.0	2	0.8	8
Tilia americana	Basswood B		1	0.3	0	0.0	20
Tsuga canadensis	Eastern hemlock	B	3	0.8	0	0.0	3, 4, 20
Ulmus americana	American elm	B	35	8.9	14	5.9	2, 3, 8, 9, 13, 16–22
Ulmus rubra	Slippery elm	B, C	9	2.3	9	3.8	2, 7, 8, 9, 13, 21
Ulmus sp.	Unidentified elm	B	8	2.0	0	0.0	6
Unidentified		B	11	2.8	0	0.0	6, 13
Total			393	100.0	239	100.0	

[a] Type of roost: B = under bark; C = in crevice; and Ca = in cavity. Not all references indicated specifically which species of tree provided a bark vs. a crevice roost.

[b] References are: 1, Belwood, 2002; 2, Butchkoski and Hassinger, 2002; 3, Britzke, 2003; 4, Britzke et al, 2003; 5, Callahan, 1993; 6, Carter, 2003; 7, Chenger, 2003; 8, Gardner et al., 1991; 9, Gumbert, 2001; 10, Harvey, 2002; 11, Humphrey and Cope, 1976; 12, Kiser and Elliott, 1996; 13, Kurta and Rice, 2002; 14, Kurta et al., 1993b; 15, A. Kurta, unpubl. data; 16, Palm, 2003; 17, Schultes, 2002; 18, Sparks, 2003; 19, D. Sparks in litt.; 20, K. Watrous in litt.; 21, Whitaker and Brack, 2002; and 22, L. Winhold in litt.

Table 2. Means or ranges (*n*) for roost parameters and roosting behavior of adult female and/or young Indiana bats in various studies. All means, except switching frequency, were rounded to the nearest whole number to facilitate comparison. Means were taken from the indicated references or calculated based on tabulated data contained in each reference.

Location/parameter	***Diameter of tree (cm)***	***Height of tree (m)***	***Height of exit or roosting area (m)***	***Bark remaining (%)[a]***	***Canopy cover (%)***	***Switching frequency (1/days)***	***Largest exit count***	***Reference***
Illinois	39 (47)	18 (47)	10 (47)	47 (47)	36 (47)		107[b]	Car ter, 2003
Illinois	37 (48)						95	Gardner et al., 1991
Illinois	56 (1)	16 (1)	5 (1)				95	Kurta et al., 1993b
Indiana							51	Humphrey et al., 1977
Indiana	47 (27)	23 (27)	9 (25)				146	Sparks, 2003
Indiana	62 (17)						384	Whitaker and Brack, 2002
Michigan	41 (23)	25 (23)	10 (23)		0–20 (23)[c]	2.9 (37)	45	Foster and Kurta, 1999; Kurta et al., 1996
Michigan	42 (38)	18 (38)	10 (34)		31 (35)	2.4 (108)	54	Kurta et al., 2002; A. Kurta, unpubl. data
Michigan	43 (3)	26 (3)	16 (3)	60 (3)	54 (3)		34	L. Winhold in litt.
Missouri	54 (38)			73 (21)	67 (38)		132	Callahan, 1993; Callahan et al., 1997
New York, Vermont[d]	46 (31)	19 (34)				4.8 (?)[e]	43	Britzke, 2003
New York, Vermont	48 (50)	21 (50)	7 (18)				270	K. Watrous in litt.
Pennsylvania	28 (5)	20 (5)	8 (5)	51 (5)			4[f]	Butchkoski and Hassinger, 2002
North Carolina, Tennessee	46 (8)	18 (8)		46 (18)		5.7 (?)[e]	81	Britzke et al., 2003
Ohio	38 (2)	21 (1)						Belwood, 2002
Vermont	50 (20)			77 (13)	88 (20)		209[b]	Pal m, 2003
Average ± SE[g]	45 ± 2	20 ± 1	9 ± 1	59 ± 5	50 ± 10	4 ± 0.8	119 ± 31	
Number of studies	15	11	8	6	6	4	12	
Number of trees	359 23	1 14	1	88	128			

[a] Total bark on tree, not just loose and peeling.
[b] Count occurred before young were flying and was not used in calculation of mean.
[c] A liberal value of 20% was used when calculating the overall mean.
[d] Trees were located primarily in April and early May; all other studies were mid-May to mid-August.
[e] Longer residency may be related to increased use of torpor caused by cool temperatures of early spring and in mountainous areas (Britzke, 2003).
[f] No tree was a primary roost, so value was not used in calculation of overall mean.
[g] Calculations of overall average and SE used the unweighted values from the various studies. Weighting each study, based on the number of trees, gave very similar results.

Table 3. Means or ranges (*n*) for roost parameters and roosting behavior of adult male Indiana bats in various studies. All means, except switching frequency, were rounded to the nearest whole number to facilitate comparison. Means were taken from the indicated references or calculated based on tabulated data in each reference.

Location/ parameter	*Diameter of tree (cm)*	*Height of tree (m)*	*Height of exit or roosting area (m)*	*Bark remaning (%)*[a]	*Canopy cover (%)*	*Switching frequency (1/days)*	*Reference*
Illinois	32 (18)						Gardner et al., 1991
Indiana	38 (12)			10–70(9)[b]	49		Whitaker and Brack, 2002
Iowa	43 (1)	20 (1)	13 (1)				Chenger, 2003
Kentucky[c]	31 (169)	15 (169)			58(169)	2.2 (463)	Gumbert, 2001; Gumbert et al., 2002
Kentucky	31 (8)			61 (8)		2.7 (30)	Kiser and Elliot, 1996
Michigan	37 (9)	21 (9)	9 (9)				Kurta and Rice, 2002
Ohio	32 (14)	16 (14)		56 (14)	81 (14)	2.3 (?)	Schultes, 2002
Pennsylvania	20 (2)	18 (2)	9 (2)	53 (2)			Butchkoski and Hassinger, 2002
Average ± SE[d]	33 ± 2	18 ± 1	10 ± 1	57 ± 1	63 ± 10	2.4 ± 0.2	
Number of studies	8 5 3			3 3		3	
Number of trees	219 18	9	12	25 12	8		

[a] Total bark on tree, not just exfoliating.
[b] Not used in calculation of mean.
[c] Data collected from April through October; all others apparently were mid-May to mid-August. Data from Gumbert (2001) are confounded slightly with trees used by adult females (7.6% of bats located were female) and by multiple counting of trees (9.2%) used in more than one season (spring, summer, autumn).
[d] Calculations of overall average and SE used the unweighted values from the various studies. Weighting each study, based on the number of trees, gave very similar results.

Session 2

Field Techniques for Biological Assessment

Session Chairperson:
Andy King
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Conducting Mist Net Surveys for the Endangered Indiana Bat
James Kiser, Daniel Boone National Forest, Stearns Ranger District, Whitley City, Kentucky and John R. MacGregor, Kentucky Department of Fish and Wildlife Resources, Frankfort, Kentucky

Acoustic Surveys of Bats in the Eastern United States
Dr. Eric Britzke, East Arkansas Community College, Forrest City, Arkansas

Indiana Bat Radio Tracking and Telemetry Studies: Getting Started FIGURE
Cal Butchkoski, Pennsylvania State Game Commission, Petersburg, Pennsylvania

Summer Habitat Assessment
Dr. Timothy C. Carter, Department of Zoology, Southern Illinois University, Carbondale, Illinois

Field Techniques for Biological Assessment: Assessment of Potential Hibernacula and Swarming/Staging Habitat
Dr. Virgil Brack, Environmental Innovations & Solutions, LLC, Cincinnati, Ohio

Interpreting Indiana Bat Survey Results: A U.S. Fish and Wildlife Service Perspective
Andy King, U.S. Fish & Wildlife Service, Bloomington, Indiana

INDIANA BAT (*MYOTIS SODALIS*) MIST NET SURVEYS FOR COAL MINING ACTIVITIES

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Abstract

The use of mist nets to catch bats can be traced back to as early as 1932. Prior to that time, and for many years thereafter, the primary method of documenting bats during the summer was by shooting them as they flew. The Endangered Species Preservation Act, a precursor to the Endangered Species Act of 1973, was passed on October 15, 1966, and the Indiana bat and several other bat species have been subsequently listed as Endangered. During the early 1990's, the Indiana Bat Recovery Team, in coordination with the U.S. Fish and Wildlife Service, developed standardized netting guidelines that set criteria for conducting presence/probable absence surveys for the Indiana bat. The interpretation of these guidelines (March 1999 Agency Draft Indiana Bat Revised Recovery Plan), an examination of their overall effectiveness, and information on how to choose net sites on mining projects within different physiographic regions are presented here. Upper slope and ridgetop roads and water-filled road-ruts have proven to be optimal net site conditions for capturing Indiana bats in the coalfields of eastern Kentucky, Virginia, and West Virginia, while stream corridors and roads through bottomland hardwood forest are more appropriate in western Kentucky, Indiana, and Illinois. Various kinds of hardware and nets are currently in use and this paper shows how to erect these setups to maximize bat captures. Appropriate photographic and written documentation of survey results is crucial for preparing reports and distribution maps for different species. Some pre-mining activities can bias Indiana bat survey results by altering surface habitats by preventing a biologist from locating and sampling appropriate net sites.

Introduction

Historic Survey Methodology

Prior to the 1980's, bat surveys were primarily connected with research projects, the collection of museum specimens, and for gathering general distribution and natural history data. More recent bat surveys, especially those focusing on the Indiana bat (*Myotis sodalis*), have been conducted to satisfy requirements imposed by various U. S. Fish and Wildlife Service Field Offices under the Endangered Species Act (ESA). Before the enactment of the Endangered Species Preservation Act (a precursor to ESA) in October 1966, and the subsequent listing of some bats as endangered, the primary bat survey method was to shoot bats at dusk as they flew (Merriam 1884; Mumford and Calvert 1960; Mumford and Zimmerman 1963; Easterla 1965; Barbour and Davis 1969). The shotgun method was used by Mumford and Calvert (1960) to document the first pregnant female Indiana bat as she flew along the edge of a northern Indiana woodlot. Mumford and Whitaker (1982) indicated that a few Indiana bats had been shot along small streams having wooded banks, in open grazed woodlots composed of scattered deciduous trees, and over a lake. The shotgun method eventually disappeared in areas where protected bat species occurred and biologists began to rely more heavily on mist nets.

The use of mist nets to capture bats was adopted from ornithologists (Barbour and Davis 1969; Gardner et al. 1989), and early references of using nets at caves extends back much earlier. Poole (1932), as cited in Barbour and Davis (1969), captured 65 Keen's Myotis (*M. keenii = M. septentrionalis*) in one night from a net stretched across a cave passage in Pennsylvania. Numerous accounts of using mist nets to capture bats appeared in Barbour and Davis (1969). Mumford and Whitaker (1982) learned about the swarming behavior of the Indiana bat by netting the entrances to Indiana caves during August. Barbour and Davis (1969) discussed the use of Japanese mist net to document a variety of bat species, especially those species flying late in the evening, and elaborated on how to net outside of cave entrances. Early mist net use typically involved a single net stretched between two objects.

Humphrey et al. (1977) were among the first researchers to use multiple nets stacked on top of each other. They employed a hand winch, ropes, and pulleys to raise and lower the nets. Between 1977 and 1989, numerous researchers successful used similar mist netting systems to survey free-flying bats. All of these systems were expensive to construct, difficult to assemble and position in the field, and time-consuming to assemble and disassemble (Cope et al. 1978; Brack 1979; Clawson 1986; Clark et al. 1987). Kunz and Kurta (1988) stacked two mist nets by supporting the ends with poles. They diagramed how mist nets could be erected in different configurations to maximize bat captures. Possibly, the greatest contribution to mist netting was made by Gardner et al. (1989) when they developed portable netting system that used interlocking poles, pulley ropes, guy ropes, tension rope, and mist nets. This system was very effective at capturing bats and could be erected very easily compared to other methods. Today, researchers have made numerous variations to the system developed by Gardner et al. (1989), but the use of interlocking poles and pulley ropes has remained a constant.

<u>History of Mist Net Surveys for Coal Mining Projects</u>

Harvey and Kennedy (1981) conducted the first mist net survey for a coal related project, a solvent refined coal demonstration plant [SCR-1], at Newman, Daviess County, Kentucky. This survey resulted in the first documentation of Indiana bat reproduction in the Commonwealth. The capture of an adult male Indiana bat on October 15, 1992, over a water-filled road-rut at Railroad Gap, Harlan County, Kentucky (Campbell et al., 1992) was important because it initiated conversations between the authors and Carol Moore, Department of Surface Mining Reclamation Enforcement (DSMRE), about the potential for Indiana bats using nearby areas proposed to be surface mined for coal. In June 1994, a lactating female Indiana bat was captured over a woodland pond on the Daniel Boone National Forest in Bath County, Kentucky (Huie, 2002). This demonstrated that maternity habitat for the species was indeed present in the Eastern Kentucky Coalfields, and soon afterward State and Federal regulatory agencies began to require bat surveys to meet ESA requirements. Serious mist net surveys at proposed surface mining sites started during summer of 1995 for those mining permits within close proximity of known hibernacula on Pine Mountain, Letcher and Harlan Counties. Surveys completed that year resulted in the capture of three juvenile male Indiana bats over water-filled road-ruts at two widely separated sites, Big Laurel Creek and Big Black Mountain, in Harlan County (Kiser 1995; Bryan and Gumbert 1995). Indiana bats subsequently have been captured during the summer on numerous proposed mining permits in six Kentucky counties including Harlan and Perry (Richard Wahrer pers. comm. 2004), Letcher (Kiser et al. 1999), Owsley (Libby et al. 2002), and Breathitt and Magoffin (Joel Beverly pers. comm. 2004).

Current Methodology

Protection and Enhancement Plans & Mist Netting Guidelines

The capture of Indiana bats on proposed coal mining permits in Kentucky prompted DSMRE, the Kentucky Department of Fish and Wildlife Resources, and the U. S. Fish and Wildlife Service (USFWS) Cookeville (Tennessee) Field Office to develop criteria to minimize impacts to the species. Specific issues covered here included the potential take of an Indiana bat, long-term and short term habitat replacement during reclamation, and an outlined general sequence of events to follow when a permit applicant is notified of potential impact to the species (DSMRE 1997). Due to the inflexibility of some of the guidelines in the original protection enhancement plan (i.e. with stream buffer issues), and to better address unique mining permit areas, the agencies reinitiated discussions to write a revised set of guidelines (Wahrer 2001). The revised document ["Guidelines for the Development of Protection and Enhancement Plans for the Indiana bat (*Myotis sodalis*) November 1, 2000"] outlines when a protection and enhancement plan is needed, or when mist net surveys can be used to survey for presence/probable absence of Indiana bats on proposed mining permits (DSMRE, 2000). The mist netting protocol in DSMRE (2000) follows the methods described in the "Agency Draft Indiana bat (*Myotis sodalis*) Revised Recovery Plan, March 1999" (USFWS 1999).

Mist netting guidelines found in Appendix II of USFWS (1999) provide the only mist net survey protocol accepted for presence/probable absence Indiana bat summer surveys. The guidelines designate the time period of 15 May to 15 August as the netting season for determining if the Indiana bat is using a given area during summer. Good sense should be used when netting from 15 May – 1 June due to variations in forest conditions and weather. In portions of the Indiana bat range overstory trees that usually provide well-defined travel corridors are not leafed out enough to restrict bats to the corridors, and cool rainy weather often adversely affects early season surveys by reducing insect and bat activity. Equipment used for mist net surveys includes nets and supporting hardware. The guidelines require that mist nets be of the finest, lowest visibility mesh commercially available. The best nets currently on the market are made of 2 ply, 50 denier nylon (denoted as 50/2) with a mesh size of 1½ to 1¾ inches. Additional field equipment to support nets is not specified in the guidelines and may vary depending on type of habitat and site conditions. Gardner et al. (1989) and the following Netting Equipment section will provide additional information on nets and supporting hardware.

The USFWS (1999) guidelines vaguely discuss net placement at a site. According to the guidelines, nets should be placed perpendicularly across travel corridors such as streams, roads, and logging trails. Nets should be stacked to extend from near the ground or stream surface to the bottom of overhanging canopy to block bat foraging and travel corridors. The guidelines do allow for sites to be netted where a corridor is not present (e.g. small woodland ponds and grassy openings), which would require net placement modifications. Net placement will be discussed in more detail in later sections of this paper.

The most frequently asked questions by engineering firms and coal companies involve just how many survey sites will be needed to meet ESA requirements. This issue is dealt with in the "Recommended Net Site Spacing" section of the USFWS (1999) guidelines and is outlined for stream corridors and non-corridor land tracts. For projects involving stream corridors, one net site per 1 km (0.6 miles) of stream is required. Non-corridor land tracts require two net sites per 1 square km (247 acres) of forested habitat. The USFWS often requires the same level of effort (one net site per 1 km) for other linear projects such as roads and utility line corridors as for stream corridors, but surveyors need to consult on such projects with the appropriate USFWS field office prior to initiating field surveys. Pre-survey coordination with the appropriate reviewing agency is suggested for every survey conducted to meet ESA requirements, and in some states is required. In Kentucky, a study plan is required by DSMRE before conducting an Indiana bat survey for proposed mining permits. This study plan generally contains the location and mining permit application number, a brief description of habitat at the site, number and type of mist net sites (e.g. road-rut, stream, road corridor), including photographs and map locations, proposed sample methodology, and names and resumes of biologists proposed to conduct the survey.

According to the USFWS (1999) guidelines, the minimum level of effort at each mist net site should consist of: 1) At least three net nights [one net set (two or more nets supported by poles on each side) for one night = one net night]; 2) A minimum of two net locations at each site and erected at least 30 m (98.4 feet) apart, especially in linear habitat such as a stream or road corridor; 3) A minimum of two nights of netting at each mist net site; 4) Sampling starts at sunset and extends for at least 5 hours; 5) Each net should be checked approximately every 20 minutes; and 6) No disturbance near the nets other than to check and remove bats. Typically, two net sets are erected at each site on two different nights to meet the three net nights of effort and the minimum of two nights of sampling. Two nets can be set within 30 m (98.4 feet) if they don't interfere with each other (i.e. one net over a road corridor and the other across a woodland pond next to the road). In the eastern time zone mist nets are generally erected prior to dark, collapsed until dusk (usually between 2045 h and 2115 h), and opened up to catch bats until about 0200 h. Each net is checked approximately every 20 minutes, except when erected over water and then they are monitored every 5 to 10 minutes depending on activity. This monitoring effort is to reduce the risk of bats drowning or being eaten by fish and frogs.

Although Indiana bats have been captured at the onset of thunderstorms and during misty rain events, such captures are very uncommon and thought to have resulted from bats attempting to get out of the weather by returning to roost trees. Because weather and moonlight can affect Indiana bat capture success, the USFWS (1999) guidelines designate minimal weather conditions that need to occur in order for a survey to be valid. The guidelines are not specific about precipitation, but long periods of rain should be considered inappropriate netting conditions. If it starts raining at any time during your survey and then stops within 30 minutes, you can continue netting, but a time extension should be added to your night. However, if the rain is intermittent throughout the night then netting should be canceled and the night not counted towards the survey. Another type of precipitation that affects bat capture is fog. If fog is heavy enough that it settles on the nets, and makes them difficult to see from a short distance away, then it is too much precipitation to capture bats. Fog normally doesn't become this dense until near the end of the five hour period. Temperature is also a major factor in capture success and the 10 ^{o}C (50.0^{o}

F) minimum listed in the guidelines should be strictly followed. We have noted a drop-off in bat activity once the temperature drops below about 12 ^{o}C (53.6^{o} F). Netting activities should not occur during strong winds and good judgment needs to be used. If your nets are pushed outwards, like a flag fully extended, then wind conditions are prohibiting bat capture.

Moonlight can also affect bat capture and is discussed in the USFWS (1999) guidelines. When the moon is ½-full or greater it is best to set nets in more forested areas where the canopy can block much of the light. More open netting sites such as open road corridors ponds in fields and large stream corridors are best netted on nights where the moon is less than ½ full. When nets are set over roads and larger rivers and the moon is ½ full or greater, most of the captured bats are caught near the ends of the nets close to the forest.

Some biologists have questioned the recommended netting effort (net nights/site) and netting season (April 15 – August 15) outlined in the USFWS (1999) guidelines. Based on field data some tweaking of these guidelines may be appropriate. Surveys that have met USFWS requirements have been most successful in documenting the presence of Indiana bats in regions where maternity sites are present but much of the local landscape is non-forested (Kiser et al. 2002). However, surveys that have met or even exceeded the suggested netting effort near known maternity roost trees in heavily forested regions such as eastern Kentucky have often failed to yield the species (E. Britzke and J. MacGregor, unpublished data). One likely reason for the discrepancy in capture success is that in less forested areas bat travel is largely restricted to the cover of riparian corridors, fencerows, and woodlots, whereas in heavily forested areas bats can fly throughout the forest and are less restricted to riparian corridors, forested road corridors, and tree lines where mist netting is more feasible.

The netting season outlined in USFWS (1999) guidelines designate the time period of 15 May – 15 August to determine if the Indiana is using the area during the summer. Some biologists have argued that this time-frame should be reduced to 1 June – 1 August because netting conducted in May is often very unproductive. In some portions of the Indiana bat summer range, trees do not fully leaf out to provide good bat capture corridors until late May. In addition, weather conditions during May, especially in more northern areas and in the Southern Appalachian Mountains, are often marginal for capturing bats. In these areas it is very common for night-time temperatures during May to drop below 10^{o} C (50.0^{o} F) between dusk and midnight. Mist netting is often rained out in May and potential water sources, including ponds and water-filled road-ruts, are used less by bats because water is not limited. The time period from 1 August – 15 August is a great time to capture bats, but the interpretation of data collected during August is difficult because many species, including the Indiana bat, have started leaving their summer habitat. The optimal period for documenting maternity use of an area by Indiana bats extends from mid-June to mid-July, extending from the time when females are heavily pregnant or lactating to the time when juveniles are just starting to fly.

Netting Equipment

The art of conducting active-season surveys for bats has evolved during the past quarter-century with advances in technology (i.e. acoustical detectors) and mist netting techniques. Gardner et al. (1989) introduced the concept of using poles, pulley ropes, tension rope, and guy ropes to erect mist nets into the forest canopy where bats fly. Since 1989 many minor modifications have been implemented into the supporting hardware for convenience and efficiency in setting up this system. Along with changes in the system, nets have also changed, not for improving bat capture success but due to changing laws to protect birds from unscrupulous harvest. The use of supporting hardware and mist nets are discussed in detail below.

Supporting Hardware

Many types of hardware for supporting mist nets are now in use by biologists with the basic principle still following Gardner et al. (1989). The method presented here has been very successful and is just one of several variations used. Like Gardner et al. (1989) we use 1 1/4-inch diameter interlocking poles to support our mist nets. During the past 10 years we have switched from heavier gauge steel radio-antennae masts to lighter thin-walled aluminum top rails from chain-link fencing to support mist nets. The chain-link fence top railing comes in 10 ½ -foot long sections. These poles weigh much less than antenna mast poles and can be carried much more easily into remote areas. Each set of interlocking poles is slipped down over a 36-inch long piece of ¾-inch diameter rebar that has been pounded into the ground to a depth of 12 – 18 inches. Except in areas with loose alluvial soil or bedrock, the rebar will easily support two interlocking poles [approximately 20 feet high] and the accompanying nets without requiring either guy ropes or tension rope. If three or more interlocking poles are used in high canopy situations, guy ropes attached to the tops of the poles and coming off at a 45^{o} angles are necessary to prevent them from falling and to maintain tension on the top net.

Gardner et al. (1989) drilled holes through interlocking poles and used eye rings to attach pulley ropes. We use water hose clamps and C-rings to attach pulley ropes to the poles (Fig. 1). This setup allows us to move them up and down on the pole to accommodate different lengths of pulley ropes. Non-stretch ropes with pulleys are used to raise and lower the nets. The pulleys must be substantial enough to allow the ropes to move freely. Some biologists (i.e. Mark Gumbert pers. comm. 2002) have suggested that the pulleys themselves may allow the pole ropes to twist, often entangling and destroying mist nets. The use of ropes without pulleys does indeed seem to eliminate this twisting, and we now recommend using ropes that pass directly through the C-rings (Fig. 2). Nets are attached to the pulley ropes by metal shower-curtain rings (Fig. 3). The top strand of the first net placed on the pulley rope should be attached through the knot on the pulley rope to prevent the entire net from sliding to the bottom of the rope. Shower-curtain rings allow nets to be placed on the pulley ropes much quicker than older techniques. Shower-curtain rings can also be used to provide more slack on the bottom strands of the net, if it is lowered down near the ground to prevent bats from flying underneath the net. By interlinking several shower curtain-rings to the bottom of the pole and attaching the end ring through the bottom loop of the net (Fig. 4), it allows the bottom of the net to be at ground or water level while maintaining the consistency of the tension throughout higher sections of net.

Mist Nets

Some researchers may have access to monofilament nets, but most of us use regular nylon nets, the only commercially available nets that can adequately capture bats. These nets are constructed with 50/2-denier nylon and have a mesh size of 38 mm (1 1/2 inches). Each net is 2.6 meters high, and has 5 horizontal main lines with loops on each end, resulting in an arrangement with 4 shelves, or bags, when the net is deployed. The type of net most appropriate for capturing bats has reduced bags. Nets having large bags (pockets) create almost a double layer effect and allow for easier detection by bats. Nets without bags are also unacceptable since bats often hit the net and slide downwards into the bags. Mist nets are commercially available in 2.6, 6, 9, 12, and 18 meter lengths. The 6 meter and 9 meter nets are the most commonly used sizes for Indiana bat surveys in eastern Kentucky. These easily block most stream and road corridors in mountainous regions where most mine permit surveys occur. The 2.6 meter trail nets are usually only used to survey cave entrances and mine portals where harp traps are impractical, but may also be used over narrow ATV trails. Longer nets such as 12 and 18 meters are used primarily over large streams and embayment areas along the margins of lakes and reservoirs. We use these lengths very rarely because they tend to sag in the middle, and this is really a problem once moisture settles on the net.

Conducting a Survey

Once you have identified your survey objectives, determined the amount of effort required, obtained appropriate state and federal collecting permits to complete survey, and assembled the necessary equipment, it is time to locate mist net sites and conduct the survey. When it comes to selecting mist net sites and placing nets at a site nothing can substitute for experience. The following sections will discuss mist net site selection, net placement, and pre-survey habitat modifications.

Net Site Selection

The approach to use when selecting net sites is different from merely conducting a habitat assessment for the Indiana bat. Romme et al. (1995) and Farmer et al. (2002) identified criteria important for summer habitat and developed habitat suitability indices for the Indiana bat that applied to the species core range. Currently, no habitat suitability index is available for the heavily forested, mountainous portion of the species range such as eastern Kentucky, southwestern Virginia, West Virginia, and southeastern Ohio where much of the coal is mined. A habitat assessment evaluates the entire project area, where as net site selection focuses on individual sites. Occasionally, a project area will contain excellent Indiana bat habitat and provide no potential netting sites. This occurs on contour mining permits where no previous surface mining activities have occurred. Unlike habitat assessment, the art of selecting mist net sites is dependent on the presence of conditions that either attract or force the Indiana bat to fly low enough to be caught. Selection of mist net sites is affected by physiographic region, local topography, project area location, project size, the presence of water and/or closed canopy corridors (streams and roads), and weather.

Knowing the characteristics of the physiographic region where the project is located can be vital in understanding the types of net sites that might be available. The "lay of the land" has a tremendous affect on human use and bat use of a particular area. In western Kentucky, where much of the landscape is flat to rolling, most of the remaining forest is found in riparian and wetland areas. Due to flooding concerns much of this forest was saved from agriculture and thus provides suitable Indiana bat habitat and netting sites. Although water is not limiting in this area, the general lack of forest cover largely restricts the bats to areas along the streams. Travel corridors are limited in highly fragmented landscape, which can provide for better capture success. The opposite occurs in eastern Kentucky where most of the flat land that people could develop is located in the river valleys. Much of the riparian forest and wide valley bottoms have been cleared and converted into residential areas leaving most of the slopes and ridgetops in forest. Most undisturbed streams are small, high gradient and do not provide well-defined flight corridors for bats to use.

The mountainous terrain may also affect specific habitat requirements of the Indiana bat. Due to limited solar exposure on steep slopes and river valleys, we hypothesize that more favorable Indiana bat roosting conditions occur on upper slopes and ridgetops due to the longer periods of solar exposure required at maternity roost trees (Kurta et al. 2002; USFWS 1999; Callahan et al. 1997). Kurta et al. (2002) found that roosting areas in Michigan typically received more than 10 hours of sunlight each day; such conditions occur almost nowhere in mountainous terrain except on ridgetops and upper slopes. Both Kiser and Elliott (1996) and Gumbert (2001) found spring and autumn roosting Indiana bats did indeed favor ridgetops and upper slopes. If roost trees are largely restricted to these areas, access to drinking water may be a limiting factor due to headwater stream channels that are obstructed by dense shrubs. This could help explain why capture success of bats (including the Indiana bat) in nets set over upland water-filled road-ruts and small ponds in eastern Kentucky is high.

The location and size of project area is important for locating potential mist net sites. In mountainous terrain, proposed mining permits for sites located on the lower slopes generally have only three choices for mist net sites: stream corridors; road corridors; and oxbow ponds. Although stream corridors and low-lying road corridors in non-mountainous terrain may be excellent places to capture Indiana bats, only two individuals have been captured on proposed mining permits at these types of sites in eastern Kentucky (Beverly pers. comm. 2004). Proposed mining permits on upper slopes and ridges normally provide a variety of small woodland ponds and road corridors or ATV trails with water-filled road-ruts. The majority of the Indiana bats captured in eastern Kentucky during the summer months have been taken in such habitats. Some of the smaller project areas may contain potential habitat but provide no reasonable mist net sites, but suitable numbers of sites can usually be located on the large surface mine permit areas.

Early surveys for the Indiana bat focused on streams, riparian forest, and adjacent wetlands because of early observations and captures in low lying terrain of Indiana and elsewhere in the Midwest (Humphrey et al. 1977). Mist net sites along streams having nice canopy cover created by intact riparian forest still remain good capture sites for the Indiana bat in non-mountainous terrain. Based on capture data from eastern Kentucky, upland wildlife ponds and water-filled road-ruts have the highest capture success for bats - especially rare species - and provide optimal netting sites for upland projects. MacGregor and Kiser (1995) reported that their highest capture success, 12.03 bats/net night (373 bats/31 net nights) occurred over upland ponds. Capture success over water-filled road-ruts was also high at 10.00 bats/net night (480 bats/48 net nights) and resulted in the capture of more rare bats. Netting efforts over streams produced 8.17 bats/net night (392 bats/48 net nights) and only yielded one rare bat species, the gray bat (*Myotis grisescens*). On the Wayne National Forest in southeastern Ohio, mist netting during three summers, involving 232 net nights of effort, captured the most bats (7.21 bats/net night in 33 nights) over upland ponds. The remaining survey effort was almost evenly divided between streams (100 nights) and upland road-ruts (99 nights) with 3.45 and 3.00 bats/net night captured, respectively. Upland ponds in forested settings, woods road corridors, and roads or trails at the edges of grassy openings provide the best opportunity for catching Indiana bats. This data shows that netting upland ponds and water-filled road-ruts is very productive and successful in capturing Indiana bats during the summer in hilly to mountainous forested terrain.

Current and seasonal weather affects bat capture results at various types of sites. Netting success over water-filled road-ruts is much lower following a daily rain event and also during seasons where monthly precipitation is higher than normal. Capture success over water-filled road-ruts and upland ponds on the Wayne National Forest during a wet year dropped nearly 1.5 bats/net night, and 1.0 bats/net night, respectively, in comparison with dry years. Even with the influence of above normal precipitation during the summer, the upland ponds remained the most productive capture sites. If a project contains a variety of net sites, one should select stream sites and dry road corridors to survey following daytime rains and save upland ponds and water-filled road-ruts for days without precipitation.

Net Placement

Once a suitable site is selected, correct net placement becomes crucial for a successful bat survey. Kunz and Kurta (1988) provide several diagrams of net placement and configuration and discuss how to erect nets over water. They emphasize placing the bottom of each net very close to water to prevent bats from flying under the sets and selecting sites with calm water and overhanging tree branches that funnel bats downward. Net placement is a science and experience will improve a person's ability to successfully capture bats. On the basis of more than 500 nights of mist netting experience, we provide some placement techniques below that have proven to be successful in capturing bats.

Some type of corridor (e.g. a road, stream, or trail) is usually present at the great majority of sites sampled by bat biologists. Regardless of where these sites are located, they must have overhanging tree branches closing to within 9 meters of the surface that forces most bats to fly downward where they can be captured in nets. The only exception to this rule is when a pond or a large water-filled road-rut is present and no other water source is available to the local bat fauna. Some biologists prefer areas with high canopy cover where they can place 9 meter high or higher net sets. However, we have found that portions of corridors where the canopy is lower, approximately 6 meters high, can also be netted quite successfully for Indiana bats. When netting corridors, the net poles and the ends of the nets should extend into the forest on both sides to prevent bats from flying along the edges of the corridor and zipping around the nets.

Net sets placed at the junction of two roads or the confluence of two streams are typically more productive than those set up anywhere else along a corridor because they funnel bats traveling from more than two directions. However, these sites often may have no canopy cover. In these cases, a surveyor should place net sets across each road or stream as close as possible to the junction and where adequate canopy cover is present.

Other areas along corridors that provide better capture opportunities include bends in streams and rivers, curves in roads, water-filled road-ruts, areas near caves and abandoned mine portals, and forest roads adjacent to or leading to ponds. We have often noted that nets erected across bends in streams and rivers or curves in roads appear to capture greater numbers of bats than nets that block straight corridors. We believe this is because the bats have less reaction time once the net is detected and avoidance of net is reduced. When netting a water-filled road-rut or pond, the bottom of the lowermost net should be just above the water's surface. Canopy cover is not as important at these type of sites, but side closure along the corridor is crucial or the bats will obtain water by flying parallel to the net set [we have observed this numerous times while watching net sets through night vision goggles]. The majority of Indiana bats captured in eastern Kentucky have been from net sets located over water-filled road-ruts.

Netting across corridors near caves, abandoned mines, and even concrete bridges can be effective ways to take advantage of night roosting behavior exhibited by the Indiana bat (Kiser et al. 2002; Ormsbee et al. In Press). Although nets can be placed across nearly any type of travel corridor near caves and abandoned mines, it is imperative that they be set up immediately beside any concrete bridge that has deposits of guano stuck to the underside and is suspected of being used as a night roost by Indiana bats. A net set that was erected across a stream in Indiana approximately 100 meters downstream from a concrete bridge known to be used as a night roost by more than a dozen Indiana bats failed to capture the species, but when the net was placed next to the bridge several individuals of each of 5 species (including Indiana bats) were captured. Nets placed across road corridors and stream corridors near abandoned mine portals during the summer can sometimes capture bats in large numbers. These bats may be swarming early or simply using the abandoned mines as night roosts.

Pre-Survey Habitat Modifications

The modification of surface habitat on proposed mine permit areas by the permittees or their associates occurs very frequently and usually makes locating appropriate net sites and conducting valid pre-mining surveys difficult. The most common pre-survey habitat modifications that occur on proposed mining permits in Kentucky and Virginia involve the removal of timber and elimination of would be netting sites, especially ridgetop and upper slope road corridors. In addition, some stream corridors may be converted into logging roads or become filled with sediment. These disturbances not only alter potential Indiana bat habitat by affecting roost trees, eliminating water (road-ruts), and changing insect diversity, but also eliminate or degrade mist net sites. When most of a proposed permit has been high-graded for the best logs, and the woodland roads have been widened into two-lane roads, Indiana bats may still be present but there are no places left to successfully conduct required surveys. Indiana bats have been captured during mining permit surveys in eastern Kentucky either adjacent to or within ¼ mile of areas where timber was recently harvested using high-grade techniques. By opening up the forest and leaving large numbers of non-merchantable or less valuable trees - some of which may have been damaged - the logging activities prior to permitting mine sites may actually attract Indiana bats to permit areas. In situations where potential habitat occurs without netting sites, surveyors should either mist net the closest good site(s) to the permit (and be ready to use radio-telemetry if an Indiana bat is captured), obtain a written statement from the mining company that if an Indiana bat is captured off-permit area they will assume it is also using the permit area, or assume presence and complete a protection and enhancement plan (PEP).

Documentation

Documenting the results of an Indiana bat survey is one of the most important aspects of mist netting. Good written and photographic documentation of the habitat, site selection, net placement, weather conditions, and survey results are irreplaceable when final reports to fulfill ESA requirements are being completed.

Written Documentation

Documenting the results of a survey on paper is very important and is often under-appreciated until it comes time to prepare a report or a publication. Some biologists prefer to maintain a field journal which contains a day by day account of their biological efforts. The majority of biologists conducting surveys as part of a consulting project have developed field data sheets (Fig. 5). The use of data sheets allows for easier access to and reproduction of survey results when preparing a report. Regardless of what type of written documentation is used, there are several data items that always need to be recorded. Site information should include location (state, county, nearest community, road and/or stream name, and topographic quadrangle and/or latitude and longitude), date, observers, time started and finished, habitat, nets erected, bat species captured, weather, sky condition, moon phase, and wind. Bat captures are generally recorded by the time of capture and species name; other data recorded for each bat includes age (adult or juvenile), sex (male or female), reproductive condition (pregnant, lactating, post-lactating, or non-reproductive for females; and scrotal or non-scrotal testes for males), mass, forearm length, capture height, and which net the bat was caught in (if multiple sets are used). If the bat is banded with numbered bands, this is recorded for future reference in case the bat is ever recaptured; it is our opinion that Indiana bats captured during mine permit surveys should always be banded. Other information that may or may not appear on data sheets may include whether or not guano, hair, and tissue samples were collected.

Weather information is generally recorded hourly and includes temperature, sky condition (clear, partly cloudy, mostly cloudy, cloudy), precipitation (rain, drizzle, thunderstorm, fog), and wind. The Beaufort Wind Scale is used to determine wind speed and is generally recorded on data sheets by code number. By recording weather hourly it allows reviewers to determine if and how bat capture may have been affected by the weather.

Photographic Documentation

Documenting site conditions and species captured should be done with photographs. The use of such photographs in final reports is recommended to show the quality of sites surveyed and to enable a person to verify species identifications, if questions arise. Normally, the authors use either ISO 100 or 200 film to photograph habitat, net site selections, and species, but digital cameras can also be used. When photographing habitats and site characteristics conditions, we recommend choosing even lighting conditions (evenings, early mornings, or overcast days) without patches of harsh sunlight and shadow, and including a large enough frame to show the corridor and adjacent forest. The use of flash, while great for closeups of individual bats, is not recommended for photographing habitat and net sites.

The use of a manual 35 mm or digital camera with a macro-lens (capable of taking close-up photos) and an on-camera flash unit is suggested for photographing a bat in hand. For film cameras, the shutter speed should be set at 1/125 second and the lens aperture (which determines the depth of field) should be set at f-11 or smaller. For systems without automatic flash exposure, multiple images should be taken while changing the aperture setting to f-8 and f-16 [photographers refer to this as "bracketing"]. When photographing bats, be sure to focus on the eyes and face of the bat with the aid of a flashlight, but remove the flashlight prior to taking the photograph so as not to cause the colors in the photograph to be altered by the yellow to orange cast from the flashlight beam [Note: this is by far the most common mistake made by people who photograph bats for documentation; the other common mistake is to try and focus too close with a lens that is not designed for such use, which causes the picture to be out of focus].

Once you are familiar with your camera and ready to photograph a bat, you need to know what the main characters are that should be documented. We always take a photograph of the entire bat (facing the camera) to show overall size and color. The bat should be secured gently by another person who grasps each wing near the wrist and places it against his/her chest (Fig. 6), preferably with a solid grayish-colored shirt as a background (for accurate color rendition). Additional photographs of diagnostic characteristics should be obtained, and for the Indiana bat that would include the face, keeled calcar, and dorsal fur coloration (Fig. 7 – 8). If the animal is lactating or pregnant, a close-up photo of the abdominal area while also showing the keeled calcar provides a great photo, if the identification and/or reproductive condition is ever questioned (Fig. 9). If a bat is photographed that was also banded, photograph the side of the bat containing the band. This may help differentiate between multiple bats photographed on the same night. Photographs are only as good as the data associated with them, so when you get photographs back from a film lab be sure to label them properly. We label all of our photographs by writing the date, species and band number (if banded), county and state, and project name on them with permanent ink.

Acknowledgments

We thank the U.S. Forest Service, Daniel Boone National Forest and Kentucky Department of Fish and Wildlife Resources for allowing us to participate in the meeting "Indiana Bat and Coal Mining: A Technical Interactive Forum." We acknowledge the U. S. Forest Service, Kentucky Department of Fish and Wildlife Resources, Kentucky State Nature Preserves Commission, The Nature Conservancy – Kentucky Chapter, Department of Surface Mining Reclamation Enforcement, East Kentucky Power Cooperative, Eco-Tech, Incorporated, Environmental Solutions and Innovations, Incorporated, Appalachian Technical Services, Incorporated, Apogee Environmental Consultants, Incorporated, Copperhead Consulting, Gress Engineering, and many other coal companies and engineering firms, for providing bat capture data or providing the authors the opportunity to conduct mist net surveys for the Indiana bat during the past 14 years. We acknowledge J. Beverly, V. Brack, Jr., E. Britzke, H. Bryan, D. Dourson, M. Gumbert, T. Hagman, K. Huie, R. Kiser, L. S. Meade, B. Palmer-Ball, P. Sewell, the late L. E. Meade, and many others who have contributed much information pertaining to the bat fauna of eastern Kentucky during the past decade.

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James Kiser is the District Wildlife Biologist on the Stearns Ranger District, Daniel Boone National Forest. He has been working with bats since 1990 with private environmental consulting firms and the U.S. Forest Service. During this period, he has focused much of his time conducting surveys for the Federally endangered Indiana bat. These efforts have been extensive, resulting in over 525 nights of mist netting in 13 eastern and Midwestern States. Much of this effort was for ESA compliance on coal mining projects in Kentucky, Virginia, and West Virginia. He has also been involved in large scale bat survey projects on Government managed property, including the Cherokee (Tennessee), Daniel Boone (Kentucky), Finger Lakes (New York), Green Mountain (Vermont), Monongahela (West Virginia), and Wayne (Ohio) National Forests, Land Between the Lakes (Kentucky), Fort Campbell Military Installation (Kentucky & Tennessee), Camp Atterbury (Indiana), and Camp Dawson (West Virginia). Many of these projects required the use of radio-telemetry to locate roost trees.

Figure 1. How to use water hose clamps and C-rings to attach pulley ropes to poles.

Figure 2. Use of rope with ends tied together and run directly through C-ring to prevent rope twisting.

Figure 3. Nets attached to pulley ropes with metal shower-curtain rings.

Figure 4. Several shower-curtain rings being used to provide additional slack in bottom strands of net.

Figure 5. Bat capture data sheet used for mist net surveys (provided by Mark Gumbert)

Site #____________________ Project/Firm____________________________________/_______________________________________

Date____________________________

Location____

____

County_____________________________________ State_________________ Quad_______________________________________

Quadrant___________________________

GPS: N____________________ W_____________________ Waypoint #___________ Observers:

____

#	Time	Species	Age	Sex / Repr.	Wt. (g)	Fa / Pp (mm)	Net / Height	Guano	KY F&W Band #	Freq. #
1				/		/	/			
2				/		/	/			
3				/		/	/			
4				/		/	/			
5				/		/	/			
6				/		/	/			
7				/		/	/			
8				/		/	/			
9				/		/	/			
10				/		/	/			
11				/		/	/			
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20				/		/	/			
21				/		/	/			
22				/		/	/			
23				/		/	/			
24				/		/	/			
25				/		/	/			
26				/		/	/			
27				/		/	/			
28				/		/	/			
29				/		/	/			

Moon Phase		
	Rise	Set
Moon		
Sun		

Time	Temp (F)	Sky	Wind	# of Bats
Av.				

Sky Code	
0	Clear
1	Few clouds
2	Partly cloudy
3	Cloudy or overcast
4	Fog or smoke
5	Drizzle or light rain
6	Thunder Storm

Beauford Wind Code	
0	Calm (0 mph)
1	Light wind (1-3 mph)
2	Light breeze (4-7 mph)
3	Gentle breeze (8-12 mph)
4	Moderate breeze (13-18 mph)

Figure 5 cont.

Net Site Diagram:

Other species:

Dominant Vegetation

1.______________________________

2.______________________________

3.______________________________

4.______________________________

5.______________________________

Net Site Habitat(s) / Net Identifier			
Habitat	A	B	C
River			
Stream			
Pond			
Road rut			
Corridor			
Cave			
Mine			
Total			

# of poles X net length

A	=	_______	x	_______
B	=	_______	x	_______
C	=	_______	x	_______
D	=	_______	x	_______

Comments:

____

____

____

Figure 6. Position used to hold bats for photographic documentation

Figure 7. Example of photograph showing facial characteristics of an Indiana bat.


Figure 8. Example of photograph showing hind foot and calcar characteristics of an Indiana bat.


Figure 9. Example of photograph showing reproductive characteristics of a female Indiana bat.

ACOUSTIC SURVEYS OF BATS IN THE EASTERN UNITED STATES

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Abstract

Ultrasonic detectors have been employed to study a variety of different aspects of bat ecology. Common studies involve using detectors to quantify bat activity in an area or to identify bats using their echolocation calls. Bat activity is compared across habitat treatments to investigate factors influencing bat use. While quantification of bat activity is commonly accepted, acoustic identification of bats in the eastern United States is not widely accepted. Initial efforts of acoustic identification showed the ability to identify some species, but members of the genus *Myotis* showed much lower accuracy rates. The genus *Myotis* is particularly important as there are two Federally endangered species the gray bat (*Myotis grisescens*) and the Indiana bat (*Myotis sodalis*) are present within the eastern United States. Recent research has provided the ability to accurately identify all six species of *Myotis* present in the eastern United States. Statistical approaches provide classification rates that are used to quantify the probability of a species being present at a site, without depending on experience of the researchers. However, many factors still need to be addressed before widespread use of acoustic identification is undertaken. First, classification rates from the statistical models need to be verified using an independent data set to ensure that classification rates are consistent. Additionally, the impact of structure of the habitat on the detectability, ability, and accuracy rates of echolocation calls needs to be studied. Finally, research is needed on the most effective sampling protocols using ultrasonic detectors. Unfortunately, the ease of use of the Anabat system allows for researchers to start collecting data without the background on the appropriate uses and limitations of this system for the study of bat ecology. Current effort should be made to design studies and interpret results in accordance with the current limitations of this technology. Once appropriate limits can be determined, ultrasonic detectors can be effectively employed to increase our knowledge of the ecology of bats throughout the eastern United States.

Keywords: Anabat, echolocation, sampling, ultrasonic detectors

Introduction

In the late 1700's, Leonardo Spallinizinni showed that bats could navigate in the dark unimpaired without vision, but lost ability to navigate when their ears were plugged. It was not until the 1930's, when Don Griffin used equipment capable to detecting sounds above the range of human hearing (ultrasound), that bats were shown to be using echolocation to navigate (Griffin 1958). Early ultrasonic detectors were too cumbersome and expensive to be in widespread use. It was not until advances in technology resulted in smaller and less expensive detectors that use of ultrasonic detectors for the study of bats exploded in popularity.

Calls are single sound emissions produced by bats and call sequences are series of calls produced by a single bat (Fenton 1999; O'Farrell et al. 1999). Echolocation calls of bats are divided into threes phases based on the conditions in which they are produced. Bats produce search phase calls as they search for potential prey items and while they orient to their surroundings. These calls are produced at regular intervals (about 10 calls / second) and represent ~ 90% of the calls produced by bats. Acoustic identification of bats is typically focused on use of search phase calls due to their consistency in structure within a species and differences in structure among species. As a bat detects a potential prey item, it produces calls with an initial jump in frequency range (bandwidth) called approach phase calls. As approach phase continues, bandwidth, duration, and time between calls decrease. Immediately prior to prey capture, the bats produce a feeding buzz where calls continue to decrease in bandwidth, duration, and time between calls. At the end of the feeding buzz a bat may produce 200 calls / second. Bats produce search phase calls shortly after prey capture. The three phases of bat echolocation are not distinct types, but represent a continuum of call structures produced by bats. Bats also produce these phases whenever they approach another object (e.g. landing site, water surface, another bat, etc.).

The Use of Utrasonic Detectors in Bat Echolocation

Bats in the eastern United States typically produce echolocation calls with ultrasonic frequencies that are above the range of human hearing (>20 kHz), although the hoary bat (*Lasiurus cinereus*) produces human audible echolocation calls. Therefore, ultrasonic detectors have been developed to allow researchers to study bat echolocation. Today ultrasonic detectors are generally classified into four types based on the technique used for getting the ultrasound ready for analysis. These detectors are heterodyne, frequency division, time expansion, and direct recording. Time expansion and direct recording systems are sometime combined, but I have separated them due to their differences in capabilities of the two systems. Each system has its own advantages and disadvantages for the study of bat echolocation. The Anabat bat detector system (Titley Electornics, www.titley.com.au) is a system that uses frequency division for sound analysis. The Anabat system is a versatile system that can be used in a number of sampling designs (Britzke 2004). Because of its widespread use and our current state of knowledge, the rest of this paper will focus on work with the Anabat system; however, general topics discussed can easily be applied to other types of ultrasonic detectors.

Different Type of Study Designs - Recording Methodologies

Ultrasonic detectors can be deployed either actively (researcher present) or passively (researcher absent). Active monitoring involves moving the ultrasonic detector around in an attempt to maximize the possibility of detecting a bat in an area and to follow a detected bat to increase the length of the call sequence. It can be done at a specific site (e.g. near a mist net site) or can be used to sample a large area by moving the detector along a transect. Active recording has the advantage of having higher call quality and longer call sequences, but is limited by the need to have a researcher present for recording (Britzke 2004). Alternatively, passive recording involves setting the ultrasonic detector up and letting the equipment automatically save the detected echolocation calls. Passive recording permits the simultaneous sampling of a number of sites, thereby providing increased comparability in habitat use studies. However, increased comparability among sites comes at the cost of lower call quality. Passive sampling is well suited for sites in which a more complete picture of bats activity is needed such as a pond that cannot be effectively netted, large river, etc. Recording methodology used in a study should depend on the equipment available, the number of researchers present, and the objectives of the sampling.

Acoustic Identification

Acoustic identification involves comparing an unknown call to a known species call library. Qualitative identification is accomplished through visual comparison of an unknown call to a call library. With experience, qualitative identification allows for quick and generally accurate species identification; however, this approach is dependent on the experience of the researcher with the call repertoire of the species present in the community and the members of the bat community present in the study area. Accuracy rates have been shown to be variable both within (O'Farrell 1999) and among researchers (O'Farrell et al. 1999). In fact, Betts (1998) showed an inverse relationship with those people that had higher confidence in their qualitative identifications actually had lower accuracy rates. This lack of consistency in identification rates seems to limit comparability among studies.

Quantitative identification is an objective method for acoustic identification that uses statistical procedures to classify unknown calls based on comparison with a call library. Generally, this approach uses discriminant function analysis (Britzke 2003; Krusic and Neefus 1996; Parsons and Jones 2000) or neural networks (Broders et al. 2004; Burnett and Masters 1999; Parsons and Jones 2000) to identify unknown call sequences. Quantitative identification allows for repeatable (both within the same individual as well as among researchers) identification, but requires more time in terms of analysis before call sequences can be identified.

Few studies have examined the acoustic identification of bats in the eastern United States. Commonly acoustic identification is most contentious when discussing the acoustic identification of the members of this genus. This genus is of increased interest due to the presence of the two Federally endangered species within it (gray bat, *Myotis grisescens*; Indiana bat, *Myotis sodalis*). While several studies have shown the ability to identify some species of *Myotis* (Britzke et al. 2002; Broders et al. 2004; O'Farrell 1999), Britzke (2003) has demonstrated the ability to accurately identify all six species of *Myotis* in the eastern United States.

Classification rates are rarely below 100%, thereby signifying uncertainty in species identifications of call sequences. However, classification rates from quantitative models and the number of call sequences identified as each species statistically determine probability of presence of each species at a site (Britzke et al. 2002). For example, species A is correctly identified 90% of the time and misclassified as Species B 10% of the time and vice versa, so a sequence identified as species B could be correctly classified species B or misclassified species A. However, if there are five call sequences identified as species B and none of species A, the probability is that those five calls are not misclassified species A call sequences but represent presence of species B with a known probability. The number of call sequences required to determine species presence at a site increases as the misclassification rates increase. This approach is a conservative approach as a single bat produces about 10 / second (or 36,000 calls / hour of foraging or commuting). If a species is using the area, a number of call sequences should be recorded. The requirement that multiple call sequences must be recorded before a species is identified as present at the site, seems a prudent limitation of the methodology.

With the quantified probability of presence or absence at a site, acoustic surveys for Indiana bats can be conducted with increased confidence. Studies have shown that bat species presence is best supported by use of both capture techniques and acoustic methods (Murray et al. 1999, O'Farrell and Gannon 1999). Thus, added use of ultrasonic detectors in surveys for Indiana bats would provide the potential for increasing the effectiveness of surveys. These increase surveys should improve and direct our effort in conservation of this species.

Recommendations for Further Study

Implementation of ultrasonic detectors for the study of bats opens up a large number of research possibilities. However, until further research is conducted to determine appropriate limitations of this technology, current applications should be restricted. Below is a list of the major topics that identify the types of issues that need to be addressed before ultrasonic detectors can be deployed at a large scale to study bat ecology.

Type of Ultrasonic Detector

Different types of ultrasonic detectors retain different amounts of incoming signal. Frequency division detectors have been shown to permit accurate identification of bats in the eastern United States (Britzke 2003). Time expansion and direct recording detectors retain the more complete signal, but do so at a cost of increased computer resources. Research is needed to see if the additional information provided by the other two systems improves classification rates achieved using frequency division systems. Any differences in classification rates must then be weighed against the costs of the use of the system to determine the appropriate detector type for study objectives.

Geographic Variation

Previous research has shown an impact of geographic variation on echolocation calls (Barclay et al. 1999; Thomas et al. 1987), thereby prompting recommendations that a known call library must be recorded from the same geographic area in which the acoustic identifications will be attempted. However, these studies had small samples sizes, differences in recording methods, or other uncontrolled factors that may be responsible for differences observed. Recently, two studies with large sample sizes showed that large call libraries from a small area would contain most of the call repertoire exhibited by a species throughout its range (Murray et al. 2001; O'Farrell et al. 2000). In fact, Indiana bats in 2 regions of the country were acoustically identified before any known calls were collected in those areas (pers. obs.). Thus, as call libraries become available, efforts can be shifted to other research topics without continued recording of call libraries for specific areas.

Habitat

Most known call libraries include call sequences that were recorded from bats flying in open areas. This maximizes the time bats can be followed, thereby increasing the chance of obtaining high quality echolocation calls. Researchers commonly want to use calls collected in this manner to identify sequences recorded in a variety of different habitat types despite studies showing an impact of habitat on the structure of echolocation calls of some bats (Kalko and Schnitzler 1993; Obrist 1995; Tibbels 2002). Calls produced by bats in open areas exhibit the longest duration and the smallest frequency range exhibited by the species. However, when an individual encounters structural clutter (i.e., limbs, leaves, other bats), calls generally get shorter in duration and exhibit the largest bandwidth of the species (similar to shift undertaken during approach phase calls). The resulting change in echolocation call structure depends on many factors including: species, distance to the clutter, and presence of conspecifics.

While there is a predicted relationship between echolocation call characteristics and the amount of structural clutter encountered by bats, the extent of change in echolocation call structure is poorly known. Tibbels (2001) showed that three species of bats in the eastern United States showed a significant impact of habitat type on echolocation call parameters. However, these results were not totally as predicted, as the species best adapted for foraging in clutter showed the greatest change in parameters values. These results illustrate the need to examine the effect of habitat type on acoustic identification more closely. Additionally, variation due to habitat should be compared to other sources of variation (both intraspecific and interspecifc) to determine the impact of habitat structure on acoustic identification of bats.

Sampling Design

Currently, bat researchers may place detectors near net sets that are erected following mist netting guidelines (U. S. Fish and Wildlife Service 1999). However, this eliminates the advantages of the ultrasonic detectors in their ability to effectively sample sites that cannot be sampled using captured techniques (lakes, large rivers, open fields, etc). Future research is needed into development of effective sampling protocols for use of ultrasonic detectors (Hayes 2000). Development of a sampling protocol using ultrasonic detectors depends on a variety of factors such as study objectives (presence/absence vs. habitat use), habitats to be sampled, the duration of recording within a night, and the numbers of nights to conduct the sample. For example, researchers conducting habitat use studies place a single detector in each stand type to be compared, however, initial research suggest that variation in bat activity present within a habitat stand. Initial efforts suggest that the more highly cluttered a habitat (i.e., forested) the more variation in bat activity there is within the stand. This translates into the need for multiple detectors in a single habitat stand to adequately sample bat activity within the stand (Britzke 2003). With the ability to acoustically identify bats, emphasis should be placed on determining sampling protocol using ultrasonic detectors that effectively uses this technology to it greatest benefit.

Regional Identification Models

Large call libraries include many species, some of which may not be present in a study area. Removal of species not present in the area is attractive as it would likely increase the accuracy rates of the remaining species, particularly for those species that are misclassified with the removed species. However, the removal of this species would result in loss of the ability to identify the calls of this species if they were detected. Because female Indiana bats were not thought to occur in the southern Appalachians and in New England before 2000, we could have removed them from the identification model. However, their removal would have resulted in them not being detected despite their presence in these areas. Benefits of removing a species from the list for species identification must be weighed against the knowledge of the distribution of bats in an area. Without a vast dataset on the distribution of bats in the area, species should be left in the identification model for potential identification.

Learning Curve

With any new technique or piece of equipment there is a learning curve to achieve appropriate use. Use of ultrasonic detectors requires many steps. The amount of time and training required to correctly setup, record, and analyze detected echolocation calls varies considerably among different detector types. Detector placement can greatly impact the number of files recorded and/or the quality of the recorded calls. Problems can be minimized by keeping in mind that the detector is sampling a cone in front of the microphone. Appropriate recording is done when the cone is oriented to sample the area that bats are expected to utilize. For example, a cone should be placed parallel to a flight corridor, thereby maximizing the amount of time a bat is within the detection cone of the microphone. A beginning researcher must take time to set up and record in a variety of different areas. They should then examine recorded echolocation calls to determine suitable detector placements for future surveys.

Those that attempt to use ultrasonic detectors for acoustic identification experience a steep learning curve. The shape of the curve depends on such factors as the species present in the project area and the identification method used. Some areas contain bat species that are readily identifiable with minimal training. However, in areas with multiple species of *Myotis* present (or potentially present), identification requires more experience. For qualitative identification, the learning curve is very steep as the researcher must learn the entire repertoire of each species present. Quantitative identification greatly reduces the learning curve for the identification stage in this process. Quantitative identification permits comparability among studies as all studies experience the same accuracy rates, independent of differences in experience with researchers in identification. Ultrasonic detectors, like any other piece of equipment, require hands on experience to operate properly. There are many steps in the process of acoustic identification and it should be noted that each step requires time and effort to properly learn.

Current Status

The lack of a complete, final picture on the use of ultrasonic detectors should not nullify the application of this powerful technique for the study of bat ecology. However, caution should be used in appropriate application of this technology (Barclay 1999). Due to limitations of our knowledge of ultrasonic detectors (and ultrasonic detectors themselves), it is imperative that effort be placed into developing appropriate study designs and acknowledging limitations of this technique before the research is conducted. However, this does not mean that ultrasonic detectors cannot be effectively used to improve studies of bat ecology and distribution. For example, ultrasonic detectors can be used to pre-screen sites before mist netting as there are commonly more potential net sites than can be sampled. Instead of simply using researcher experience, ultrasonic detectors can be deployed to record bat activity at a number of sites. Recorded files are then analyzed with the resulting information from this sampling used to develop a prioritized list of mist netting effort. This can be done without definite acoustic identifications being made. As our knowledge on acoustic identification grows, this basic use of ultrasonic detectors can be expanded.

Due to the newness of ultrasonic detectors, studies using them are often more highly criticized than studies that use traditional capture techniques. This is unfortunate as capture techniques are widely known to have inherent biases. Correct use of capture techniques requires experience in mist net placement, handling and identification of captured bats; traits very similar to studies using ultrasonic detectors. The more accurate picture of the species presence is revealed when both capture techniques and ultrasonic detectors are used and should support the limited use of ultrasonic detectors. Better data on species community presence (and increased support for non presence determinations) serves to improve the decision making process. With the basic understanding of limitations of the use of ultrasonic detectors for the study of bats, there is now a need for researchers and regulatory agency staff to determine the appropriate uses of ultrasonic detectors in bat surveys.

Acknowledgements

My research on the echolocation of bats has been funded by the Arkansas Game and Fish Commission, National Park Service, New York State Department of Environmental Conservation, Southwest Missouri State University, Tennessee Technological University, Tennessee Wildlife Resources Agency, and U.S. Forest Service. This work has benefited from numerous researchers throughout the eastern United States who have helped by providing access to bats and/or assisted with recording of known calls, especially R. Currie, J. MacGregor, M. Gumbert, M. Harvey, A. Hicks, J. Kiser, S. Loeb, K. Murray, L. Robbins, A. Tibbels, and S. von Oettingen. Finally, I would like to thank the numerous bat researchers who have improved the quality of this work through countless discussions.

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Dr. Eric Britzke has studied the ecology of bats since 1995. He received his Ph.D. from Tennessee Technological University in May 2003. His dissertation was entitled, "*Use Of Ultrasonic Detectors For Acoustic Identification And Study Of Bat Ecology In The Eastern United States*." As part of the study on acoustic identification, he has traveled throughout the eastern United States to record known calls from a variety of different species to assess variation in echolocation calls. This has resulted in a large known call library for bats from throughout the eastern United States (Vermont to Michigan to Arkansas to Florida). In addition to work with ultrasonic detectors, he has been involved with capturing bats and using radio telemetry to locate bat roost trees in New York, Vermont, Kentucky, North Carolina, Tennessee, and Arkansas.

INDIANA BAT (*Myotis sodalis*) RADIO TRACKING AND TELEMETRY STUDIES – GETTING STARTED

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Abstract

Radio tracking of Indiana bats (*Myotis sodalis*) can provide a wealth of insight into foraging, roosting, travel routes, behavior, and migration information. The success of a project depends on planning, personnel training, equipment familiarization, animal handling, data management, and, in some cases, trial and error. Transmitters used vary from ~0.35g (10 day battery) to ~0.52g (21 day battery). The accepted rule is to keep the weight of the attached device under 5% of the bat's body weight. This rule often has been exceeded for projects that require the 21-day battery, but always keeping transmitter weight under 10% of the bat's body weight. Detailed summer habitat studies require a field staff of three or more people equipped with vehicles, field packs, telemetry receivers/antennas, two-way radios, Global Positioning System (GPS) units, field maps, compasses, and data forms. Two manned stations are needed for rough triangulation, with three or more preferred to validate the animal's location. Field triangulation should be checked in the field, either manually on a field map or with the use of a portable computer with Geographic Information System (GIS) software. A field team leader is needed to monitor triangulation fixes, to recognize errors, and to relocate stations to obtain the best possible geometry for triangulation. Field data can be processed with triangulation software programs to obtain point locations, error estimates, and home range estimates. Long distance spring migration studies, in which attempts are made to track Indiana bats from hibernacula to summer habitats, do not allow for the collection of detailed location information. In these studies, aircraft and a ground support crew are needed. Ideally, both the aircraft and surface vehicles should be outfitted with receivers/antennas, portable computers, GIS software, GPS units and two-way radios. Each mobile station tracks its location in real time on the computer and ground personnel keep notes on estimated locations of the migrating animals. Extensive testing and troubleshooting of these mobile stations is required. The New York Department of Environmental Conservation has been successful in using this technique where bats traveled <50 km from hibernacula.

Introduction

The detailed physics, electronics, engineering, and other variables of telemetry are beyond the scope of this author's knowledge. However, as a user of the equipment I will attempt to explain some of the basics learned through trial and error.

Radio telemetry is the process used to track animal movements using a transmitter attached to an animal and receiver/antenna to detect the transmitter's signal. Triangulation involves using two or more (preferably three or more) known receiver locations that are obtaining a signal and are capable of communicating with each other. The stations simultaneously use a compass to get a signal direction (making certain to avoid magnetic distortions by backing away from electronics and metal objects) by sighting the compass along the direction the antenna is pointing. Compass azimuths drawn from each receiver location should converge. Various difficulties can occur, such as the signal bouncing off landscape objects, giving a false direction, or phase cancellation, where two signals are received out of phase and cancel each other out, resulting in no signal being heard when the transmitter is in direct line of sight. Changing location or using three or more receiver stations for triangulation will usually eliminate these problems.

Bat telemetry is challenging for several reasons. The bats are small, the transmitters are correspondingly small with weak signals, most of the work is at night, and you are often working with a fast-moving target. For a successful project it is important that field personnel be familiar with all equipment and able to quickly and reliably obtain necessary data. To do so requires testing of equipment and training of personnel. Both equipment and personnel should be tested in the field prior to a project's start. There are a host of equipment suppliers. A good starting point is a biotelemetry website (http://www.biotelem.org) which includes links to equipment manufactures, software, online papers, and references.

Receivers

Receivers are tuned to a frequency range (MHz) when purchased. Both the transmitters and antennas must be tuned within the frequency range of the receiver you intend to use. Multiple transmitters of specific frequencies can be programmed for your receiver allowing you to identify the animal by its detection frequency. Labeling all receivers, transmitters, and antennas with their tuned frequencies is recommended. Your study area should also be queried for other telemetry projects to avoid frequency conflicts with those projects.

The receiver can be a scanning or non-scanning type. Generally the scanning receivers are more expensive. Non-scanning receivers need to be adjusted manually (using knobs and/or buttons) to fine tune to a specific transmitter's frequency. Scanning receivers usually provide the option to enter specific transmitter frequencies that can then be scanned for detection.

The receiver detects direction through the antenna. When the antenna is pointed directly at the transmitter the signal is more intense. The intensity is indicated to the operator through sound, but other manufacturer options can include a display meter, LED lights or other visual display. Within several meters of the transmitter, the antenna can be disconnected and the receiver itself used to find a roosting bat or dropped transmitter. If you think you are very close to the transmitter and you cannot get a direction with the antenna, always consider the option of removing the antenna to see if you get a signal with the receiver alone.

A scanning receiver worth investigating but not listed on the biotelemetry website is the R-1000 by Communications Specialists, Inc. (http://www.com-spec.com).

Antennas

Antennas must be tuned to the frequencies of your transmitters and receiver. Make certain that the frequency range of your antennas encompasses the frequencies of your transmitters.

A variety of directional antennas can be used with the receiver and are attached using a coaxial cable. Cable mounts may vary so make certain the connections are compatible. In general, the more elements on the antenna, the more gain and directional specificity the antenna will have. More elements also create a larger antenna. Because of their compact size, 2-element (H-antenna), and 3-element (yagi) collapsible antennas are usually used in bat fieldwork. Yagis generally allow you to get a direction more quickly, but are more cumbersome in dense vegetation than the H-antennas. For more precise directions, consider using 3-element collapsible antennas for triangulation.

Antennas can be handheld or mounted on masts. FAA approval is needed for mounting on aircraft. Manufacturer's specifications should be consulted when mounting on masts, vehicles or aircraft. Mounting techniques on vehicles vary. Special mounts can be made, rigged onto roof racks or secured on the inside of a door with the mast extending out of a partially closed window. In any event, the antenna mast should be secure for trouble free driving. Antennas are connected to the receiver with a coaxial cable. If mixing receiver/antenna manufacturers, make certain the connections on the coaxial cable are compatible and that the length of the cable is adequate for your application.

Directional antennas have a front that is used to get the strongest signal. The rear of the antenna will also receive a signal that is usually not as strong. Once a direction is suspected, the antenna should be rotated 180º to verify the correct direction.

Transmitters

Because of weight, transmitters are by far the most limiting factor in Indiana bat telemetry. The accepted rule is to keep the weight of the attached device under 5% of the bat's body weight. This rule has often been exceeded for projects that require a 21-day battery, but always keeping the transmitter weight under 10% of the bat's body weight. Transmitters used weigh from ~0.35g (10 day battery) to ~0.52g (21 day battery). Custom orders can alter the life of these transmitters by varying the pulse rates and by making the pulse rates more temperature sensitive as well as position sensitive (vertical or horizontal). Consult with the manufacturer for custom options.

The author currently knows of two manufacturers of these small transmitters. Holohil Systems Ltd. (http://www.holohil.com) in Canada offers a selection ranging from10-day transmitters weighing .35g (LB-2N) to 21+ day transmitters weighing .52g (LB-2). Titley Electronics (http://www.titley.com.au) in Australia offers comparable .35g (LTM) and .5g (LT1) transmitters. It is important to make certain that the manufacturer offers these small transmitters in the frequency range of your receiver. Recovered transmitters can be refurbished for a nominal price.

Transmitters are attached with glue. Using scissors, remove a small patch of fur from the mid-dorsal region (between shoulder blades), then glue the transmitter to the bat's skin with a latex, medical adhesive (Skin-Bond Cement, Smith & Nephew, Inc., Largo, Florida). Glue is applied to the bat and to the transmitter and then joined to form a secure bond according to manufacturer recommendations.

Discussion - Which transmitter to use when?

In general this is a judgment call based on the project and the condition of the bat in question. In my experience, reproductive female Indiana bats on summer habitats will usually groom the transmitter off within 10 days. Also, after parturition the females are lighter and have greater energy demands. For these reasons, I use the lighter transmitters for the summer work. Before transmitters under .4g became available, we used the larger transmitters with no ill effects noticed, but for summer work there is no gain on our part with the heavier transmitter.

As described below, we have a project involving tracking female bats by aircraft from hibernacula to summer habitats. It may take days or weeks for these animals to reach their summer territories. In these cases, use 21 day transmitters and select heavier (>7g) animals leaving the hibernacula. This necessitates stretching the 5% rule. Another issue is scanning for transmitters from the air. Scanning for a large number of transmitters is challenging. Depending on flight speed, you may only have 10 or 15 seconds of detection time on a transmitter. The cycle time for scanning through more than 5 transmitter frequencies may cause you to miss a transmitter. For this reason, we plan to use all transmitters set on the same frequency to avoid losses due to scanning. Another issue is that the crystals used in these transmitters are not entirely precise, requiring over-ordering to get enough transmitters of the same frequency. Transmitter frequencies are tested to select those closest to one another for use in the project.

Aircraft

If your budget allows, aircraft can be used in certain projects. They can also be helpful in finding lost animals. If equipped and ready for telemetry, they may be more cost-effective than ground searches. Assistance for outfitting an aircraft can be obtained through your telemetry equipment manufacturer. They can often provide FAA-approved mounts for specific aircraft. In general, an antenna is attached to the struts below each wing with cables running to a switch box. Antennas are usually angled down ~30º from horizontal. The switch box attaches the two antennas to the receiver and has a middle setting on which you can listen to both antennas for a signal. Once a signal is heard the operator switches from one antenna to the other to see which antenna has the signal. The pilot then circles in to the signal to get a general location of the transmitter. Ground crews can follow up and obtain precise locations. It is useful to have a laptop with GIS software (maps) connected to a GPS unit to provide real-time tracking of the aircraft's location. An example of relatively inexpensive software with statewide maps can be found at www.maptech.com. Two-way radio communication is also needed when directing a ground crew.

It should be noted that laptops, GPS units, cable routing, and other electronics should be thoroughly tested with the transmitters that will be used. This enables you to get a reliable detection distance off each wing. This distance will vary with flight altitude, electronics, antenna placement, terrain, leaf-out, and possibly even the cable routings. Old cables should be routinely replaced. Never crush cables in doors or windows. Poor connections and damaged cables will lessen reception quality. It may also be necessary to move or change equipment to lessen interference. Hopefully you will be able to get 2.4 km (1.5 mi.) or more off each wing. If this is the case you will be able to cover a 4.8-km (3 mi.) swath when searching for transmitters. Usual flight altitudes vary from ~300 – 600 m (~1,000 to 2,000 ft.) above the ground. When flying, a dummy transmitter should always be available on the ground to make certain the system is working properly.

A resource for aircraft outfitting is *Procedures for the Use of Aircraft in Wildlife Telemetry Studies* (Gilmer et al. 1981). A printable online version is available on the Advanced Telemetry Solutions Inc. website at: http://www.atstrack.com/Support/Literature/Aircraft.pdf .

Ground Crew

Depending on your project, a ground crew may be the only personnel needed. Tasks for the ground crew include, animal handling, triangulation to get locations/data points, locating roosts, monitoring behavior, support for aerial searches, and data entry. It's important that they be well trained in using the equipment and materials provided. This includes map and compass skills. The number of people needed depends on your project. If only identifying roosts, one person may be all that is needed. To collect location information using triangulation, two people will be required to obtain rough locations with three or more needed to verify triangulation locations. We often provide several days of training for new personnel. Suggested equipment and materials include:

1. Vehicle with mast-mounted antenna (use the same detachable antenna or provide another for quick use on foot).
2. Receiver and antenna cables (have spare cables).
3. Two-way radios for communication.
4. GPS unit for entering location information. GPS units should be configured to display location data in a selected datum (NAD27, WGS84, etc) and units (decimal degrees, UTM, etc). These units should match those you will be using to process the data.
5. Field maps. Maps (Fig. 1) should have a grid with the same datum and units as GPS settings. This allows field personnel to plot their locations from GPS readings.
6. Compass with magnetic declination setting. For processing, it is usually best to record azimuths from true north. This allows you to pre-set your local magnetic declination on all field compasses.
7. Light that is head-mounted for easy use and a back-up emergency light.
8. Spare batteries for all electronics and lights.
9. Data forms, pencils, straight edge, etc. for recording data such as triangulation marks, roost trees, etc. Data must be recorded in the format used by the processing software.
10. Reflective tape used to mark all equipment so that it is easily seen or found at night.
11. Duct tape for emergency repairs.
12. Flagging tape to identify field locations requiring a return trip.
13. Rain gear and plastic garbage bags to protect electronics and surveyor when caught in rain while on foot.
14. Field pack for carrying equipment.
15. Bat "nightly schedule." A map and timeline can be provided to the crew to summarize the night's work (Fig. 2). The crewmembers label general locations on the map and provide a timeline of the bat's activities. This is especially helpful during the analysis of telemetry data.
16. Laptop with GIS software for checking triangulation data in field. This is especially helpful if a team leader is working from a vehicle and is in radio contact with triangulation crew or if the crew is following an animal in an unfamiliar area. The laptop/software is used for general navigation, to check triangulation data or possibly even enter data as it is reported. Triangulation monitoring can also be accomplished by hand with a field map, straight edge, and compass when all personnel are on foot. Team leaders can identify problems and relocate field personnel to get the best possible triangulations. The laptop should be capable of connecting to the GPS receiver for real-time location information.
17. Power source for laptop. Most laptop batteries will not last through the night. If working from a vehicle, a power inverter is usually needed.
18. Timepiece. Needed to record time for triangulation marks.

Software for Processing Data

When conducting triangulation to plot data points, a software program will be needed. The stations' (locations from which signal directions are recorded) data are grouped by target transmitter and time of record. Station data is read by the software from a spreadsheet or database. It is important to know the formats of the software you intend to use so that data collection can be formatted for that specific software. The software plots the two or more station locations on a grid, draws the compass azimuth reading from each station and plots a location point using various location estimators. If three or more stations are used, it should also estimate an error (usually in meters or hectares). For identifying foraging areas, we generally strive for errors of less than one hectare.

Some programs also offer home range analysis tools such as minimum convex polygons and kernel estimators for utilization distribution. In addition to software listed on the biotelemetry website, others include Ecological Software Solutions (http://www.ecostats.com/software/software.htm), and Missouri's GTM v2.3.6 (Sartwell, 2002). The GTM program computes triangulation and has various analysis tools including kernel estimators. Once data points are estimated, further analysis can also be addressed by importing into Geographic Information Systems such as ArcView or ArcGIS (Environmental Systems Research Institute, Redlands, California).

Putting It All Together

Assuming the field crew, equipment, data collection, and software all mesh together, you are ready to tackle the project. It is important to have a recognized goal. This can be as general as locating roosts, or as specific as looking at utilization distribution on the landscape or even travel lanes.

A Practical Example - Documenting An Indiana Bat's Foraging Area

The field crew has managed to keep track of a radio-tagged bat after capture in a church attic roost and within the first few nights has identified the bat's nightly routine and found locations effective for conducting triangulation. Over a period of eight nights, the three-person crew has collected ~980 individual detection readings, many of which are time-marks collected at five minutes intervals. Some of the readings are individual station records, used to get an idea of the bat's general direction. Coordinated time-marks result when all stations communicate through 2-way radios and simultaneously record of the direction of a signal from known coordinates. These readings are then entered into a spreadsheet and grouped by date and time, which will allow them to generate a point by triangulation. The spreadsheet is then imported into a triangulation program. In this case, GTM v2.3.6 (Sartwell 2002) is used. By using the software's tools, some readings are found to be unusable for triangulation (not synchronized with other stations) and some have too large of an error. However, from those 980 individual readings, 192 good data points are generated. These data points are also grouped as traveling or major foraging area locations and imported into ArcView. Using ArcView's animal-movement extension (Hooge and Eichenlaub 1997), minimum convex polygons (MCP) are created for all points and for major foraging area points (Fig. 3). We want to look at the utilization distribution (UD) within the major foraging area, so, once again using the animal movement extension, a fixed kernel estimate is generated for 50, 75, and 95 percents for the major foraging area points. Portions of this data, along with the field crew's notes, are then used to create a bat activity schedule with core foraging areas of 50% UD (Fig. 4). Figure 5 illustrates primary foraging area cores for 12 Indiana bats and 8 little brown bats at our study site at Canoe Creek in Blair County, Pennsylvania. At that site, primary foraging cores for Indiana bats are located on intermittent streams and dry forested hillsides, while cores for little brown bats are located on and adjacent to major bodies of water (river and lake). A primary foraging area is where an individual bat spent most of its time foraging. Both Indiana bats and little brown bats also had detached, secondary foraging areas where less time was spent.

Spring Migration Telemetry

A relatively new application of Indiana bat telemetry is the attempt to track migrating females from hibernacula to summer maternity sites. In Pennsylvania, several ground-tracking attempts using aircraft as backup were unsuccessful, with bats out-distancing the ground crew and no contact from follow-up air searches (Sanders and Chenger 2000, Butchkoski 2004). The Pennsylvania bats, from 2 hibernation locations, appear to be heading in an easterly direction and were lost >50 km from the hibernacula.

The New York Department of Environmental Conservation (NYDEC) has successfully used aircraft as the primary tracking tool in following Indiana bats from 2 different hibernacula. The animals are primarily dropping into the Lake Champlain valley of Vermont (19 detected of 24 released) and the lower Hudson River valley of New York (11 detected of 20 released) with travel distances of <50 km from the hibernacula (A. Hicks *pers. comm.*). Pennsylvania is planning another migration study using aircraft as the primary tracking tool in the spring of 2005. In past years, the main female Indiana bat exodus from hibernacula has taken place in mid-April at the start of a warm high-pressure system with daytime temperatures >20°C and nighttime lows >10°C. Hibernacula are trapped at this time and bats are radio-tagged. Optimally, bats will be released the same evening with an aircraft overhead. However, in the New York projects, bats were successfully fed and held until the next evening when the aircraft was available. Upon release, directions that bats are heading are monitored from the aircraft and air searches are conducted the next day to find the roosting bats. This intensive procedure is repeated until the final roosts are found.

Working with Indiana bats exiting hibernacula requires special consideration in animal handling. Lethal temperatures of 34-35° C were reported for Indiana bats taken from caves by Henshaw and Folk (1966). This may seem surprising based on average summer roost temperatures of 36.5ºC (Butchkoski and Hassinger 2002) and skin temperatures of 35-40ºC (Kurta et al. 1996). However, some mortality of Indiana bats occurred with the NYDEC projects when the animals were held at room temperature after exiting the cold hibernacula temperatures (A. Hicks pers. comm.). It is possible that overheating contributed to the mortality. The bats may require gradual acclimation to warmer temperatures. It is recommended that captive bats always be kept in a cool location. If bats must be held until the next evening when an aircraft will be available, they can be fed meal worms, wax worms or crickets (while in a cool environment), then placed back in the cold hibernacula in a protected enclosure until the next evening.

Conclusion

Radio-telemetry has the potential to gather valuable information for management of Indiana bats. It also has the potential to report inaccurate information. Limitations of the equipment should always be considered. When the researcher observes something unusual, it should be double-checked by more intensive study. For example, in the summer of 2004 the author's field crew identified a female Indiana bat that appeared to be spending a significant amount of time foraging over a wheat field. Although not impossible, this was an unusual occurrence at the research site and required verification. Getting good geometry for triangulation would require access to some private lands. The landowner was contacted, permission obtained, and the next evening the crew was in place to monitor the activity. The bat did not move onto that area until the next evening, but the crew was still prepared. With better station locations, we were able to determine that the animal was foraging on a forested hillside rather than the wheat field. The crew still insisted that the animal was over the field on the night in question, but continued monitoring on that private land never documented the suggested scenario. Indiana bats generally forage in wooded areas (Butchkoski and Hassinger 2002, Brack 1983, Gardner et al. 1991, LaVal et al. 1997, Murray and Kurta 2002). Also, through repositioning and more accurate telemetry it was noted that the bat was foraging farther (~5.5 km) from the day roost than any other bat studied at the site. Previously the farthest distance was 4.5 km (Butchkoski and Hassinger 2002). Most Indiana bats in Illinois forage within 2 km of their roost (Gardner et al. 1991) and within 3.5 km in Michigan (Murray 1999).

As previously noted, the NYDEC has been successful in identifying Indiana bat maternity sites in the Hudson River valley through spring telemetry with aircraft. The animals that were found were within 50 km of the hibernacula. Pennsylvania's largest Indiana bat hibernaculum, in Blair County, has a maternity roost nearby at 2.4 km (Butchkoski and Hassinger 2002). An attempt to track migrating Indiana bats in 2003 (Butchkoski 2004) was unsuccessful and bats were lost beyond 50 km heading east. During the Blair County project, bats previously banded at the nearby maternity roost were not included in telemetry because the goal was to find additional roosts. Had the maternity site not been identified earlier, the spring migration study would probably have found it. It is likely that a well-prepared spring study at other Indiana bat hibernacula would prove successful in locating a nearby maternity roost. However, when considering a spring migration study, one should be prepared for failure. The maximum migration distance from hibernacula is estimated at ~520 km (Gardner and Cook 2002). Bat migrations approaching this distance are probably beyond the ability of available technology to keep up with them.

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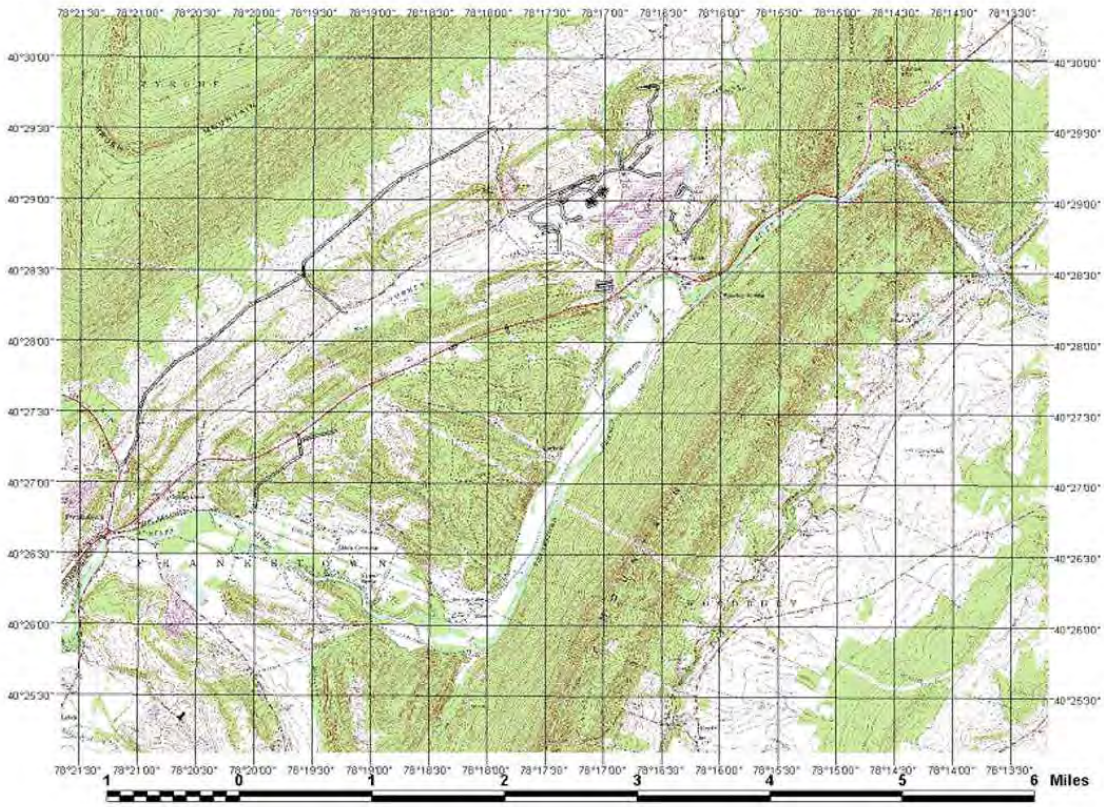
Cal Butchkoski has been working with bats since 1982 with the Pennsylvania Game Commission. Bat specialties include artificial roosts and cave/mine surveys/management. Since 1997, he's been studying Indiana bats using a building as a maternity roost and used telemetry to identify foraging habitats, travel corridors, and use of artificial roosts. He has initiated several attempts at tracking Indiana bats from hibernacula to summer habitats and worked closely with New York's Department of Environmental Conservation migration success. Plans are underway for another migration tracking attempt in spring of 2005. It's hoped that using the techniques learned through various trials and the success demonstrated by New York's Department of Environmental Conservation, that another summer maternity site could be found in Pennsylvania or adjacent States.

PGC Form:
WD-ACT1-05/02

PA Game Commission, Wildlife Diversity Section
Bat Activity Record - To be filled out each morning after a night of telemetry.



Activity Record For Bat No.__________ (Label Areas on above map and indicate locations by times below) Page 1 of ______

Start Date	1900	2000	2100	2200	2300	2400	TIME 0100	0200	0300	0400	0500	0600	0700

Figure 2. Example of bat activity schedule provided to field crew. At the end of each night's work, the crew summarizes the bat's activity by labeling locations on the map and making notes by time in the lower portion of the schedule. This is helpful for completing a more detailed schedule seen in Fig 4. The form illustrated above is provided in tabloid (11 X 17) format or larger to provide enough space for detailed note taking.

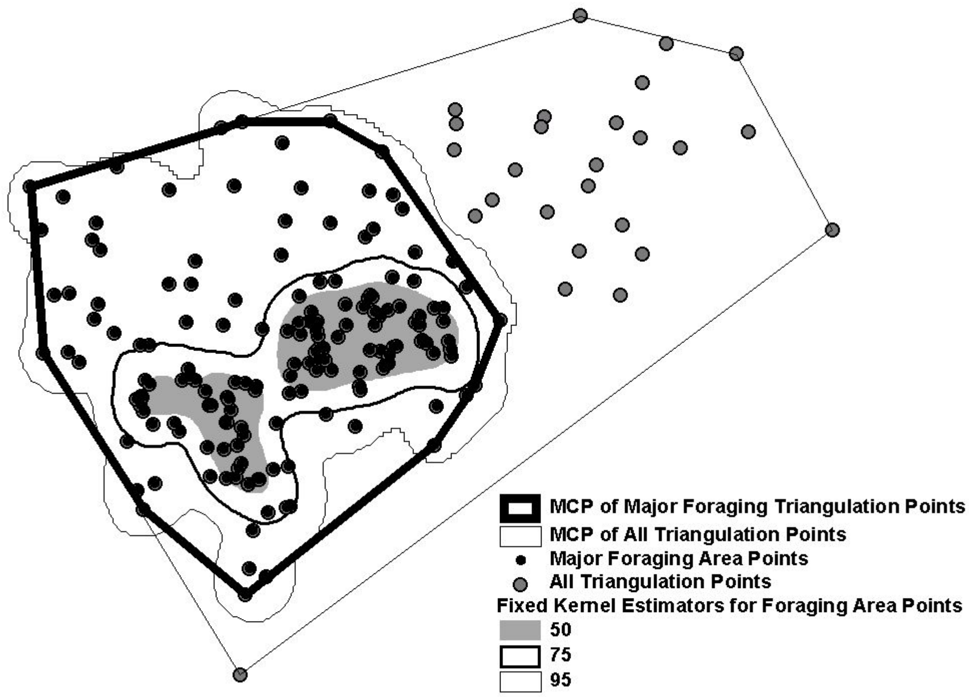
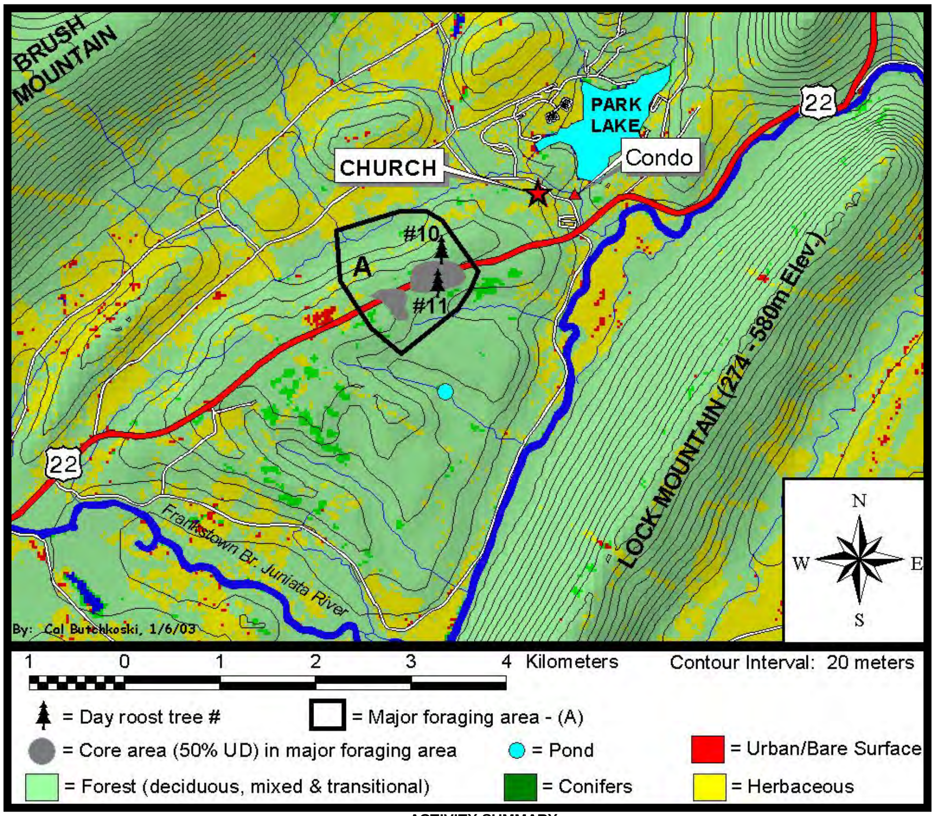
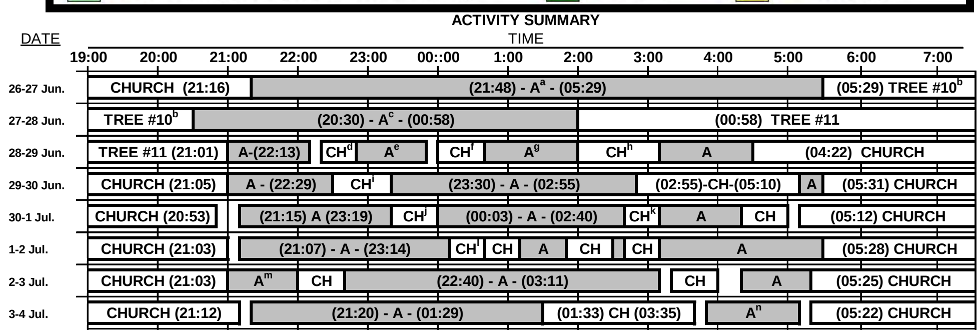


Figure 3. Example using triangulation data points to compute Minimum Convex Polygons (MCP), and Fixed Kernel Utilization Distribution (50%, 75% and 95%). In this example, data points are divided into two groups: Major foraging area and other points which are primarily traveling data points. Major foraging area points were identified when the bat stayed in an area greater than 1 hour.





[a]Detected night roosting: 21:48-22:06, 22:31-22:35, 23:15-23:21, 01:38-01:41, 03:38-03:43.
[b]Bat spooked out of roost tree during dusk approach, flew on south side of route 22 and roosted before emergence at 20:30.
[c]Detected night roosting: 21:59-22:09.
[d]Roosted in Church attic from 22:25 to 22:45.
[e]On area "A" from 22:51 to 23:51 and headed for church.
[f]Roosted in Church attic from 00:02 to 00:38.
[g]On area "A" from 00:38 to 02:04 when it entered the Church attic.
[h]In Church attic from 02:04 to 03:08. Returned to area "A" until returning to roost in church at 04:22.
[i]Bat roosted in Church attic from 22:29 to 23:20
[j]In Church attic from 23:19 to 00:03.
[k]In Church attic from 02:40 to 03:12; flew around church/Canoe Creek & area "A"; entered church again from 04:26 to 05:02; Bat then reentered Church attic at 05:12.
[l]Bat in Church from 00:07 to 00:39; in Church again from 00:43 to 01:05; flew to area "A" and back in Church from 01:46 to 02:31; exited and reentered Church from 02:40 to 03:14; foraged in area "A" then back to Church at 05:28.
[m]On area "A" from 21:13 to 21:56 when it entered Church; exited Church at 22:38; On area "A" from 22:40-03:11; Bat in Church from 03:25-04:04; On area "A" from 04:19 to 05:20 and finally roosting in Church at 05:25.
[n]Bat on area "A" from 03:50-05:10; Went to roost in Church at 05:22; Transmitter found on attic floor at 22:50.

Figure 4. Example of foraging and roosting activity patterns, locations of foraging areas, and day roosts for a pregnant female Indiana bat weighing 8.2 g. It's assumed parturition occurred on 28 June when nightly roost visits began. This data was compiled using information from field notes and triangulation data. The church attic and condo (large artificial bat roost) are both known Indiana bat day roosts. The bat was initially captured and radio-tagged in the church attic.

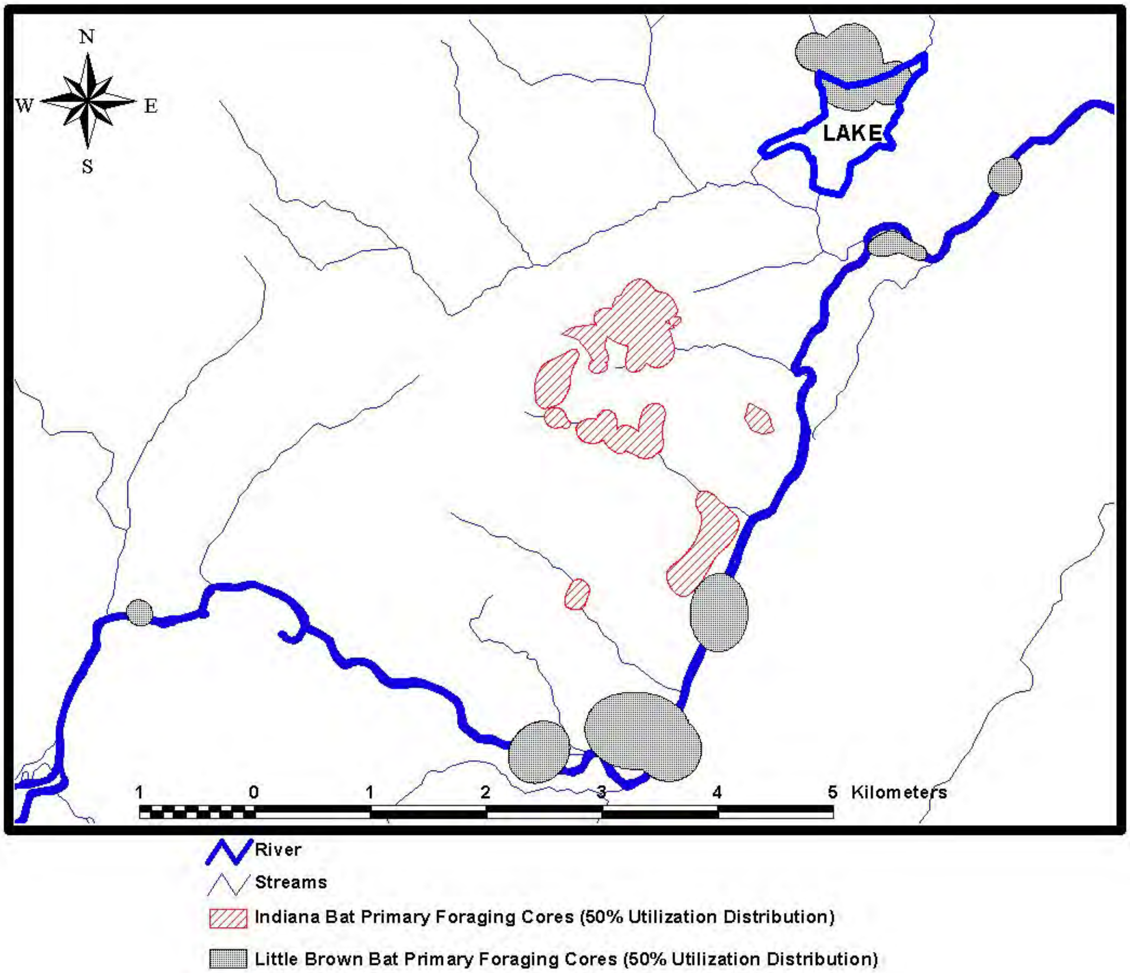


Figure 5. Primary foraging area cores (50% Utilization Distribution) for 12 Indiana bats and 8 little brown bats at Canoe Creek study site in Blair County, Pennsylvania. Primary foraging cores for little brown bats are on and adjacent to major bodies of water (river and lake) while Indiana bat cores are located on intermittent streams and dry forested hillsides. The above data was collected through 5 years summers of telemetry (2000 thru 2004).

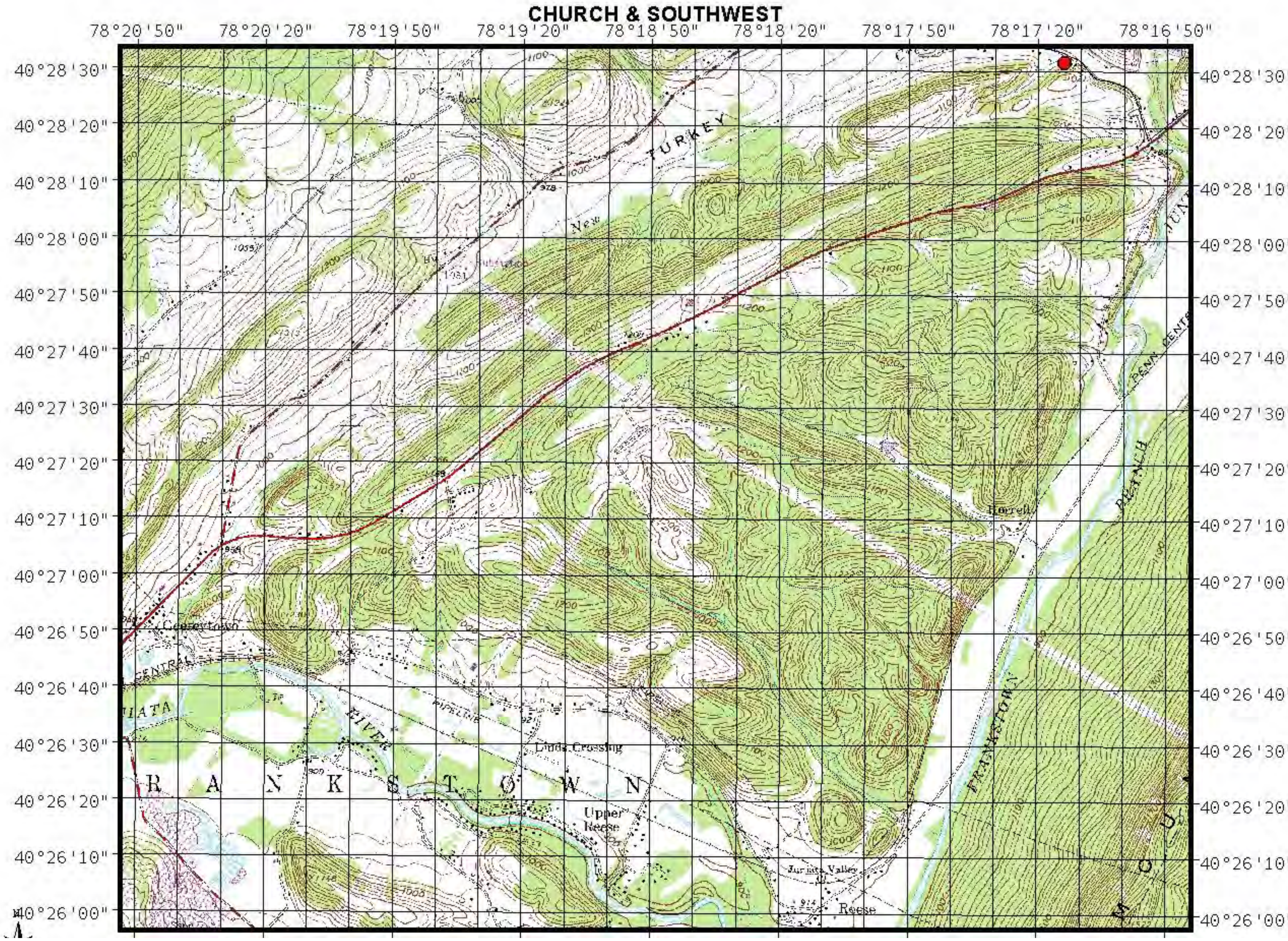


Figure 1. Example of field maps provided to telemetry crew. Map grids allow field personnel to plot their GPS locations and troubleshoot triangulation problems. Scale is small enough to provide topographic information. Several of these may be necessary to cover a research area.

SUMMER HABITAT ASSESSMENT

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Abstract

Assessing the quality of habitat for the Indiana bat is of great concern for many land managers. Understanding which habitats are important to Indiana bats is crucial to predicting which areas are likely to be impacted by future management actions. Additionally, with this understanding, mitigation or restoration efforts can better be focused to improve habitat for Indiana bats should that be a goal.

Habitat assessment can be done using either qualitative or quantitative methods. Qualitative methods of habitat evaluation are perhaps the easiest method of habitat assessment. However, it requires a solid background of working with Indiana bats and having a good understanding of the intricacy of Indiana bat behavior. This experience is not widely held by most land managers faced with evaluating potential habitats.

Quantitative methods of measuring Indiana bat habitat are more desirable because it removes user-bias associated with making judgments about potential habitat. However, it is perhaps the most difficult because of the great variation in the habitats within the range of the Indiana bat. Habitats that may be suitable in some areas may be sub-optimal in others.

Lastly definitions of suitable or optimal habitats are not well defined. This variation in definitions is due in part to differences between male Indiana bats and reproductively active females that form maternity colonies. Male Indiana bats have great breadth and width in their habitat requirements. Reproductively active females are rarely encountered alone. Most often they form maternity colonies and the requirements for a colony are considerably greater in extent than would be needed by single individual.

In this review, we examine the methods and data available for making both qualitative and quantitative habitat assessments.

Introduction

Assessing suitable habitat for the Indiana bat is of great concern from conservationists to developers. Any situation when potential habitat is affected by management decisions is subject to scrutiny under the Endangered Species Act. Accurate methods of habitat assessment are critical to determining what areas are potential Indiana bat habitat and may be subject to restrictions or limitations. This review examines existing data to evaluate current habitat assessment models and to synthesize available data to foster an understanding of suitable habitat for the Indiana bat. The idea of suitable habitat differs greatly between male and reproductively active female Indiana bats. The majority of research has focused on the needs of reproductively active females which form well defined maternity colonies. These maternity colonies require specific resources and environmental conditions that are more restrictive than those of male Indiana bats. While less work has been done on male Indiana bats, it would appear that the foraging requirements for males are similar to that of females. However, male Indiana bats have been found roosting in a wider range of habitats and structures. Except for requiring a sheltered roost, male Indiana bats border on being classified as opportunistic or generalist in their roosting requirements. Male Indiana bats are capable of using almost any habitat that provides some forested cover for foraging and structures for roosting (Menzel et al. 2001). Therefore, the definition of suitable habitat for male Indiana bats is met considerably easier than it is for maternity colonies. While under the Endangered Species Act there is no legal distinction between male and female Indiana bats, biologically speaking maternity colonies are considerably more important to the survival and recovery of the species. Therefore, it should be the goal of conservation, mitigation, or restoration efforts to provide suitable habitat for maternity colonies with the assumption that if habitat is suitable for a maternity colony it is also suitable for males.

Indiana bats have been documented using different areas for roosting and foraging. Therefore to be classified as suitable, habitat need only meet the minimum requirements for one life-requisite of the Indiana bat. That is, if a habitat is suitable for foraging but not roosting it is still considered suitable habitat and must be treated as such.

The habitat evaluations that biologists make are reflections of what we believe to be important to Indiana bats based from the relatively few studies that have been conducted. The suitability of a habitat is technically meaningless unless it is related back to reproductive success. Since no studies to date have related habitat-use back to reproductive output, we truly have no idea what makes a habitat suitable or not. If Indiana bats survive and reproduce as successfully in a "poor" habitat as they do in an "optimal" habitat then from a biological perspective, the habitats are of equal quality. Currently, all habitat evaluations are only based on the absence or presence of Indiana bats and not based on reproductive success. Many studies often document reproduction by catching juvenile bats or observing the increase in the population when young become volant. However, no studies have examined the survival of adults or recorded the level of recruitment of offspring. Given the dynamic of source-sink relationships documented in other animal groups (e.g. Fauth et al. 2000), many of the habitats that we would consider optimal based on the numbers of Indiana bats may, in fact, be sinks. However, there is no data to support or refute this idea. Regardless, with current technology we are limited to the assumption that areas that have more Indiana bats are of higher quality than those areas with no or few bats (cf Van Horne, 1983).

Qualitative Approaches

Qualitative methods of habitat evaluation are perhaps the easiest method of habitat assessment. However, it requires a working background with the Indiana bat and a good understanding of the intricacy of Indiana bat behavior. While a complete knowledge of the literature is always helpful, it is not a substitute for actual experience working with Indiana bats in the field. This experience is not widely held by most land managers faced with evaluating habitat in the field.

Much variation exists in the roosting requirements of the Indiana bat. Additionally, qualitative descriptions of suitable habitat vary greatly between male and reproductively active females. Male Indiana bats have been found using a variety of roost structures from exfoliating bark of dead trees to bat houses and other artificial structures, including, in one instance, a metal bracket on a utility pole (Harvey 2002). Additionally, greater than 5,000 male Indiana bats also have been documented using abandoned mines throughout the summer in southern Illinois. With regards to tree-based roosts, male Indiana bats have been documented in trees 8.4 cm DBH and greater (Hobson and Holland 1995; Kiser and Elliott 1996; MacGregor et al. 1999). Roosts of males have been found in areas with open to closed canopies and at heights of 3m and greater. The great variation in roosts suggests that male Indiana bats may be roost generalists.

The roosting requirements for maternity colonies are more restrictive than those of males. Most maternity roosts are found under the exfoliating bark of large diameter dead or dying trees (Menzel et al. 2001). A complete review of Indiana bat maternity roosting resources can be found elsewhere in the document (Kurta in press). Rarely does one tree provide all the resources a maternity colony needs. Most maternity colonies use multiple roost trees. The number of trees varies greatly and is probably a function of many factors including but not limited to the size of the colony, quality of the habitat, and the quality of the individual roosts (Menzel et al. 2001). Recommendations for densities of potential roost trees are complicated at best. To date, there is no consensus on the definition of a potential roost tree. Some studies have suggested densities ranging from 13.2 tree/ha to 64 tree/ha (Menzel et al. 2001). Potential roosts should be from an acceptable species however; this list continually grows with each additional study. Perhaps it is better to think of potential roosts in terms of the resources they produce like the amount of exfoliating bark present and not the tree species (Rommé et al. 1995). Some tree-species provide roosting resources while alive (e.g. shagbark hickory, *Carya ovata*), however, the exfoliating bark of these trees is usually relatively small and to date no large maternity colonies have been documented in a completely live tree. While many biologists discuss the ideas of primary and alternate roosts, the application of these ideas in the field is often unfeasible. The definition of these categories is based on numbers of roosting bats, which is often not applicable in many smaller colonies. Additionally, it is theorized that alternate roosts provide resources that primary trees do not (see Callahan et al. 1997), yet this has not been documented in the field (Menzel et al. 2001). Indiana bat roost-trees are an ephemeral resource by their very nature (standing dead trees). Many studies focus on the numbers and types of roosts used by a colony, but few discuss the need to provide future roosts to replace roost attrition. Conservation, mitigation, or restoration efforts must include plans for continual production of high quality roosting resources for maternity colonies.

Indiana bat foraging habitat has received even less research than roosting. To date, no studies have examined preference or avoidance of foraging habitat. All data available on the topic is observation in nature (Menzel et al. 2001). While few studies have documented Indiana bats foraging in habitats such as uplands, a common theme in most studies is the presence of riparian habitats (Menzel et al. 2001, Carter et al. 2002). A complete review of Indiana bat foraging habitat is presented elsewhere in this publication (Whitaker in press). At the landscape level, Carter et al. (2002) documented differences between areas that contained maternity colonies and areas that did not in Illinois. Areas that contained maternity colonies had fewer and smaller patches of urban area, more but smaller patches of agriculture, more patches of water, and more and larger patches of deciduous forest.

A topic seldom covered in discussions about Indiana bat habitat is the amount of area required to supply a colony all the resources needed. The distribution of roosts for a given colony has been calculated in many studies. Some smaller colonies such as the one in Northern Michigan have all roosts within a 5 ha wetland (Kurta et al. 1996). Where some larger colonies such as those studied in Missouri had all the roosts within a 200-700 ha area (Callahan et al. 1997). However, none of these studies were able to document the amount of area that the colonies used for foraging or the relationship between the two areas (Menzel et al. 2001). Unpublished data from southern Illinois suggests that there is a wide range in the relationship between the size of the foraging area compared to that used for roosting. For instance in one southern Illinois colony, the roosting area (100% MCP = 91.7 ha) was only 5.5% of the total area used by foraging bats of that colony. Whereas, in another colony only 35 km away, the roosting area (100% MCP = 963 ha) was 45.5% of the total area used by the bats. This illustrates the importance of including sufficient area to provide all the resources needed by maternity colonies. The foraging area used by these two colonies (1682 ha and 2118 ha) was similar despite the differences in estimated population size and roosting area size (see Carter 2003).

When assessing individual habitats, context within the landscape must also be considered. Proximity to other suitable habitats or to areas with known Indiana bat activity may play a role in the colonization and or the continued use of an area. Habitats with connectivity to other areas of suitable habitat will increase the chances of use by Indiana bats. Small isolated forest fragments are not as valuable as large continuous forest tracts or areas with large numbers of forest patches. Additionally, while Indiana bats have been documented migrating large distances (Kurta and Murry 2002), proximity of suitable habitat to known hibernacula can only increase the chances of future occupation.

The definition of optimal habitat will also likely differ depending on the region of the country. In the Midwest, optimal areas are often found in riparian or bottomland forests where large numbers of snags are present. Often these areas are fragmented with patches of agriculture or grasslands interspersed. In these areas Indiana bats often form large maternity colonies regularly over 100 individuals. In the eastern portions of the range, the Indiana bat often forms maternity colonies in more intact forests. The three colonies located by Britzke et al. (2003) and Harvey (2002) were in habitats that are described as dense, mature and often old growth habitat. The climate is described as cool and moist with annual precipitation in excess of 127 cm (Harvey 2002). These colonies are smaller in both size and extent than typical mid west colonies (Britzke et al. 2003). Lastly, these maternity colonies have even been documented at relatively high elevation (e.g. 1158 m; Harvey 2002). While, the landscapes where these colonies are found dramatically differ from the ones found in the Midwest, the characteristics of the individual roost trees were very similar to those found in other areas (Britzke et al. 2003).

Quantitative Approaches

Quantitative methods of measuring Indiana bat habitat are more desirable than qualitative methods because it removes user bias associated with making judgment calls about a habitat. However, it is perhaps the most difficult to accomplish, because of the great variation in the habitats within the range of the Indiana bat. What may be suitable habitat in some areas may be sub-optimal in others. Additionally, conservation advocates may insist that for male Indiana bats, suitable habitat is met with a single dead tree. Regardless, the predictive models proposed to date are valuable tools for evaluating habitat even if their use may be regional and do not account for all the resources needed by Indiana bats. Additionally most models have not been validated with data from other studies.

The Indiana bat HSI model of Rommé et al. (1995) is one such model that has not been validated to date. There is are a couple of underlying assumptions that Rommé et al. (1995) makes that are not clearly stated. Although not specifically a HSI model, similar assumptions are made by Miller (1996). Farmer et al. (2002) who reanalyzed the same data presented by Miller (1996) and Rommé et al. (1995) also makes these same assumptions. The first assumption relates to the data used to build the HSI models. The data was collected from locations were Indiana bats were captured with mistnets. All models assume that these bats are using capture sites for both roosting and foraging. Recent work (Carter unpublished data) calculated movements of greater than 4 km from roosting to foraging sites. Therefore the data collected within the 1km diameter circles around the capture sites may not represent both foraging and roosting habitat data. And in some cases may only represent habitats used for commuting between these areas. Secondly, almost all data for building these HSI models were from capture sites located on streams. All models use circular polygons to calculate the habitat around this clearly linear habitat features. They make the assumption that the habitats outside the linear stream corridor influence the use of the site. However, it is well known that bats, including the Indiana bat, use streams for travel corridors, which is why biologists so often setup mistnets in stream corridors when attempting to catch bats (Kunz and Kurta 1988). Since many of the habitats in the areas where data were collected are linear in nature, it is logical to conclude that habitats up to 1 km perpendicular to the stream may not have a bearing on bat use of the streams. The decision to use a 1 km diameter circle around each capture site for habitat analysis was based on estimated home range sizes of Indiana bats from Gardner et al. (1991). However, this failed to take into account the shape of these home ranges or their position relative to the capture location. Gardner et al. (1991) clear documents that most often the home range of the bats is not centered on the capture location (Gardner et al. 1991 pg 5). Additionally, unpublished home-range data from southern Illinois shows many Indiana bat home-ranges to be linear in shape.

Despite these possible invalid assumptions, these HSI models do attempt to quantify Indiana bat habitat into a predictive model, which is an attractive tool to land managers. Using the data collected in a study from southern Illinois (Carter 2003), I suggest the models needs to be refined. Although data collected by Carter (2003) were not gathered with the express purpose to validate these models, the necessary information can be interpreted or estimated from the existing data.

The model of Rommé et al. (1995) consists of nine variables, some of those having multiple parts. It examines both roosting and foraging habitat and two landscape variables. Using the data from southern Illinois, the Rommé et al. (1995) HSI model categorized the maternity colony area as moderate habitat (HSI = 0.4237). Given the numbers of bats captured and tracked, this habitat should be rated well above average, perhaps a value of 0.8-0.9. The attribute that the Rommé et al. (1995) model inadequately graded is Variable 2 – "mean diameter of overstory trees." This HSI model fails to take into account that not all older aged forests have a "J" shaped diameter distribution curve. Many forests, especially those regenerating after a large-scale disturbance, may have a large component of the forest in smaller diameter trees (Oliver and Larson 1990), such is the case in this maternity colony. These numerous small trees lower the average dbh of the stand. While sufficient quantities of large dbh trees are important, the way the current variable is calculated perhaps overly weights larger trees. The suitability line of the Variable two graph (Rommé et al. 1995) should be shifted to the left or the slope should be decreased (Figure 1). Another variable that may easily change the outcome of this model is variable seven "percent of total trees in the 5-12 cm dbh range." Similar to the problem associated with variable two, the weighting and calculation of variable seven may low the score for a forest with a high percentage of young and old trees. The current HSI model is geared toward an even distribution of all tree age-classes. However, many of the best Indiana bat habitats are older forests that have been severely disturbed (e.g. flooding), causing high tree-mortality and increasing the number of very young trees.

The model of Farmer et al. (2002) is a much simplified model consisting of three variables: the number of habitat types >10% of area, density of suitable roost trees, and percent of land in forest. The Farmer et al. (2002) model classifies the habitat in the Carter (2003) study area in southern Illinois as a 0.7 or 0.8 depending on the specific equation used. The Farmer et al. (2002) model succumbs to a similar problem faced by many HSI models. First, the habitats at different study sites rarely fall into the same categories as those used to build the HSI model. In the southern Illinois study area, the limiting variable was the percent of landscape in forest. The southern Illinois study area had approximately 75% in forest habitat, according to the HSI this is above optimum. However, a large portion of the study area (>25%) was in bottomland forest that was severely impacted by floods, which killed up to 80% of the trees in some areas. This habitat type while classified as a forest and is mostly open canopy. This would effectively drop the percent of forest in the landscape to a level that would be considered optimal by this HSI model. Therefore, despite the problems inherent to over simplification of the Farmer et al. (2002) model, the data of Carter (2003) supports it.

The model of Rittenhouse et al. (2004) was designed for the Hooser National Forest. This model is a Geographic Information Systems (GIS) based model. It uses moving window analysis of habitat coverages to calculate certain variables. As such, it cannot easily be validated within the scope of this manuscript. However, examination of the four variables can attempt to evaluate its predicted performance. The first variable uses stand age to calculate snag suitability. The optimal roost suitability (=1) is achieved for trees ≥110 years old. This variable was calculated based on two relationships. First that snag suitability is considered a logistic-curve relationship to snag DBH, where suitability begins at 17 cm DBH and is maximized at 50 cm DBH. The second relationship is snag density to stand age as found in Fan et al. (in prep – see Rittenhouse et al. 2004). The second model variable examines solar radiation by identifying canopy gaps within the forest. Areas with gaps that are ≤20 yrs get an optimal suitability. Areas with gaps >20 yrs in age are considered unsuitable (=0.0). The model does not explain the spatial component of this variable. It is assumed that the actual gap is not suitable based on its age, what is unclear is to what distance away from the gap does the variable rating extend. The third variable measures distance to water. It is unclear as to what is considered a suitable water source. The fourth variable is calculated using a moving window analysis in GIS. This analysis attempts to calculate the level of interspersion of the first two variables within the landscape. Overall this model appears to be is well conceived but requires a GIS and the habitat data to perform this analysis.

All three models appear to be designed to evaluate habitats that have not been subject to large-scale disturbance. The models are well suited for evaluating the long-term suitability of a habitat for Indiana bats. However, Indiana bats are often found in highly disturbed areas where flood, insects, or some other large-scale disturbance event has resulted in large numbers of snags. While these habitats may not support maternity colonies indefinitely, they are definitely high quality habitat for the immediate future.

Conclusions

Regardless of the method used to evaluate habitat, there is a great difference between suitable and optimal habitat. Male Indiana bats are capable of being found in almost any forested area where some roosting resources exist. However, optimal habitat for maternity colonies is far more restrictive. Furthermore, optimal habitat for maternity colonies differs between different parts of the specie's range. In the Midwest, optimal habitat is usually found in bottomland or riparian habitats that have large amounts of roosting resources, as well as a mixture of riparian and other habitats for foraging. In the eastern part of the range, maternity colonies can be found in more upland type habitats that are less fragmented but still have sufficient roosting resources. While legally, most forested habitats within the range of the Indiana bat can be considered suitable habitat, it should be the goal of conservation, mitigation and restoration efforts to produce optimal habitat for Indiana bat maternity colonies. Successful maternity colonies are key to the survival and recovery of the endangered Indiana bat.

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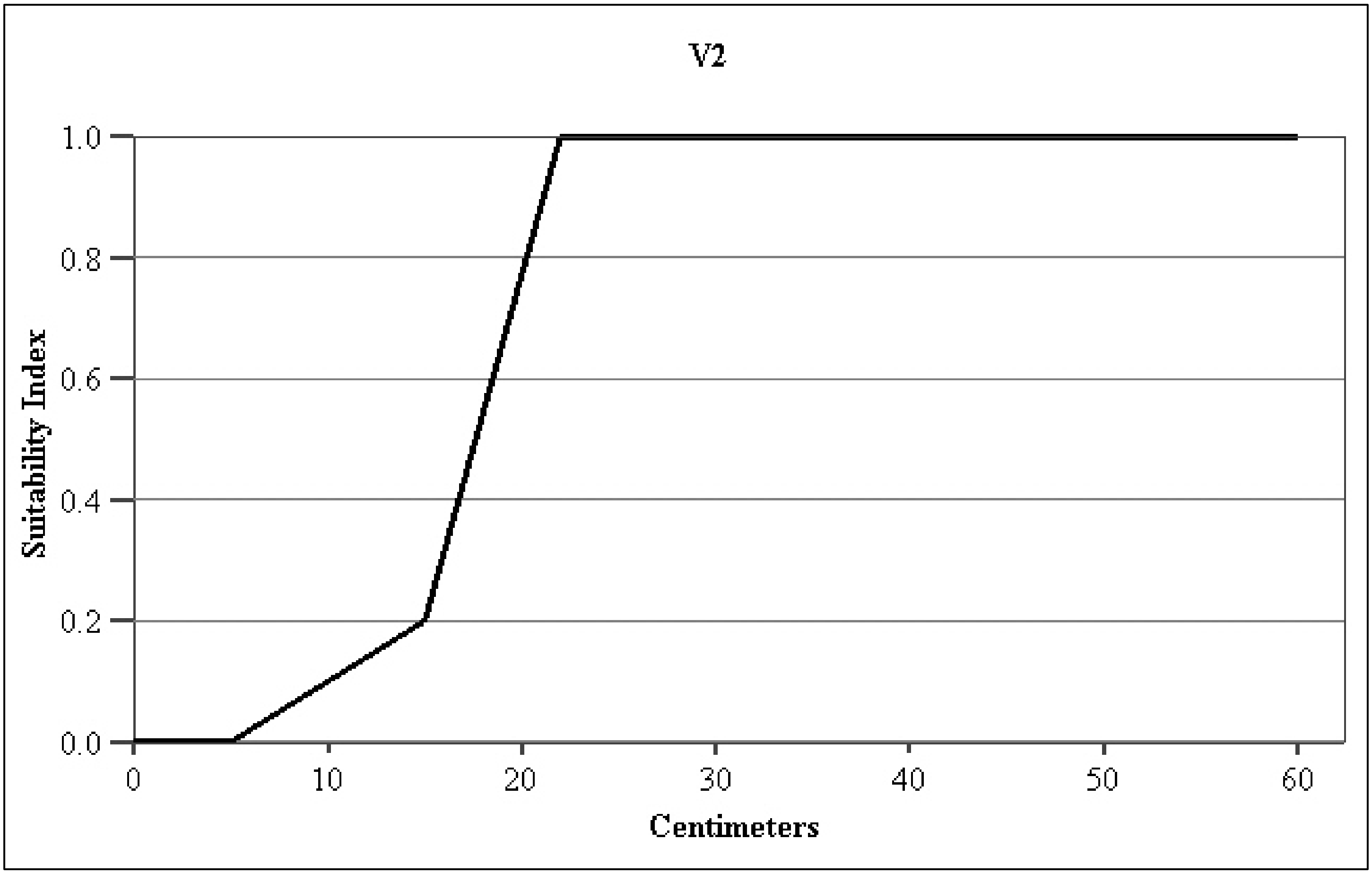

Figure 1. Replacement variable graph for Variable 2 (mean diameter of overstory trees) in the Rommé et al. (1995) Habitat Suitability Index model.

FIELD TECHNIQUES FOR BIOLOGICAL ASSESSMENT: ASSESSMENT OF POTENTIAL HIBERNACULA AND SWARMING/STAGING HABITAT

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Abstract

The Indiana bat (*Myotis sodalis*) is protected under the Endangered Species Act wherever it is found, including underground mines, which may be used as winter hibernacula. Because mines are unsafe to enter, use can be determined by sampling entrances during autumn swarming and spring staging. Assessing the potential for use begins with determining whether mines/portals are present. Maps or other documents may be available or a search of the property may be required. Next, it is important to learn about the mine. Bats are more likely to use large, complex systems than small, simple systems. Determine the number of entrances, their size, and their vertical relationship to one another. How much time has passed since closure? Inspect the entrance. Is there evidence of instability, flooding, airflow, use by bats, or lack of use? Would use make bats susceptible to predation? Is there suitable habitat and drinking water nearby? If the mine is potentially suitable for bats, sampling with a trap or mist net should be completed in autumn or spring. Sampling should be for two nights, from dusk and continuing for five hours, with temperatures above 10°C during the first two hours and above 0°C during the rest of sampling. Sampling may be supplemented with a bat detector. Interpretation of the data must not only include the presence/absence of endangered bats, but also whether the mine provides suitable wintering habitat. Very limited captures of Indiana bats and other species may not be indicative of a hibernaculum. Captures of large numbers of bats, regardless of whether Indiana bats are caught, is strong evidence that the mine provides suitable winter habitat.

Introduction

Listing of the Indiana bat (*Myotis sodalis*) under the Endangered Species Act entitles the species to protection wherever it is found. The range encompasses much of the eastern forests between the Appalachian Mountains and the prairies of the plains States. During summer, the Indiana bat forms maternity colonies in wooded areas, typically under the exfoliating bark of live, dead, or dying trees. In winter, the natural habitat for hibernation is in limestone caverns; however, some types of man-made structures, such as inactive underground mines, may provide sites suitable for hibernation. Hibernacula with large populations of bats are concentrated in Missouri, Indiana, and Kentucky, while hibernacula with smaller populations are found in many parts of the range.

Hibernating Indiana bats can often be found and counted in caves, either by measuring areas of bat cluster or by counting individual bats in the cave or from photographs. These techniques provide a direct indication of the importance of each hibernaculum for the species. Some mines, particularly limestone mines, can also be entered; however, entering many mines, including coal mines, is an unacceptable risk. Therefore, an alternate method of assessing use by hibernating Indiana bats is important when mines that may serve as hibernacula will be closed or destroyed.

Use of mines can be determined by sampling entrances in autumn when Indiana bats arrive for hibernation and in spring when they depart. Autumn swarming is a term used to describe a seasonal activity of microchiropterans at hibernacula in North America (Cope and Humphrey 1977) and Europe (Parsons et al. 2003). It is the use and visitation of hibernacula and nearby habitats in late summer and early autumn, and for many species it is associated with the opportunity for sexes to meet and mate. In autumn, Indiana bats swarm at caves used as hibernacula, although individuals probably come and go throughout the autumn season. Spring staging is often used to describe the departure of bats from hibernacula and can be thought of in general terms as the reverse of swarming. During this time, bats apparently remain near hibernacula for a few days before leaving for summer maternity areas. They may use this time to help prepare for migration.

Assessing Mine Portals for Use

Assessing mine portals for potential use by hibernating bats using through spring and autumn sampling involves a series of questions, which are addressed in the following sections.

Are Portals Present?

While intuitive, the question "*Are mines/portals present on the property?*" can be overlooked or presence/absence is assumed. Often, this information is available from maps of past mining activities from public and private sources. Often, this information has been incorporated into the decision-making process for many activities, but has not been applied to the question of whether bats may be present. Put simply, engineers and miners may not be aware that the information is important to concerns for natural resources and endangered species.

Sometimes, a site inspection may be necessary to determine whether portals are present or to verify information from other sources. Many portals to underground voids are associated with coal seams at specific elevations, which may help streamline efforts to locate portals. Auger holes are also associated with exposed seams. However, portals may be at other elevations if associated with entrances to move air mine that have collapsed. Field efforts can also be made more efficient by looking for old facilities, equipment, tailings, or other evidence of past activities. Once portals, or potential portals, are identified, it is important to determine their status. Are they open, and have they always been open? Were they closed but have slumped open, and if so, is there any indication of when this occurred?

What is Known About the Mine?

Mine entrances/portals do not exist in isolation - there is also a void. It is important to learn what you can about the mine. Was it large or small? Are/were there multiple entrances? Are there maps? What is the time since closure?

The morphology of a mine or cave strongly affects its suitability for hibernation (Humphrey 1978) by affecting airflow and thus corresponding hibernaculum temperatures. Large complex caves and mines offer more opportunities for the combination of characteristics needed to support airflow while remaining thermally stable. These systems typically allow airflow to cool the cave, but the volume and complexity of the hibernaculum buffers temperature changes so they do not occur too quickly. Multiple openings often contribute to airflow, especially if they are at different elevations, typically with cooler air entering at the lower elevation and warmer air exiting from the higher opening. Entrances that are side by side may do less to cool the mine than entrances on opposite sides of the mine. The size of the entrance, or entrances, can also affect airflow and suitability of the mine as a hibernaculum.

The time since last activity may provide a clue as to the potential for use by bats. Bats may be more likely to find and use suitable mines as time of inactivity increases. In Ohio, nearly 10,000 Indiana bats were found in a limestone mine about 15 years after mining operations ceased, although other types of activities had continued in the mine (Brack unpub. data).

Complete a Portal Examination

The entrance(s) to the mine may help provide information about use of the mine by bats. Are entrance passages horizontal, sloped, or vertical? (Use a spot light to see into the mine without entering it.) Vertical or sloped passages are often associated with airflow. Is there airflow into or out of the mine? Is the entrance stable? If the entrance is collapsed shut, it may obstruct airflow or may be impassable by bats, but a collapsed entrance may still allow airflow if bats can get into the mine via other portals. Is the entrance flooded or is there evidence of past flooding? Passages that flood may kill bats or be impassible to bats even if portions of the mine do not flood. What is the temperature inside the entrance relative to outside temperatures? (Use a point-and-shoot infrared thermometer to take a temperature without entering the mine.) A large difference in temperatures may be another indication of air movement.

Is there evidence the portal has been used by bats? The presence of guano or insect remains indicates probable use by bats. These may be very hard to find, requiring a careful, detailed search of flat surfaces such as stones, leaves (living or dead), or open, dry ground is required. Is there evidence that use by bats has not occurred? A profusion of intact spider webs or cobwebs indicates a lack of bat passage. Would use of the portal make bats susceptible to predation? Is there evidence of predation, such as tracks, scat, or the remains of bats that have been eaten? Does vegetation or a ledge at the entrance provide a site that predators could use to catch bats? Does vegetation obscure the entrance, making passage difficult or reducing airflow? Is habitat near the entrance suitable for bats, including roosting and foraging habitat (woodlands or other natural habitat) and is there a source of drinkable water nearby?

Direct Sampling

If the portal(s) and mine system are potentially suitable for bats, then direct sampling should be completed during suitable weather in autumn or spring. Watching the entrance at dusk may help determine whether bats are using the mine, but it will not identify species and bat activity cannot be determined after dusk. Bats entering and exiting the mine can be caught for identification using a bat trap or mist net at the entrance. Two nights of trapping, starting at dusk and continuing for five hours, is the typical level of sampling effort. If there is reason to suspect that many bats use the entrance, trapping is preferable to netting, as there is less potential for injuring bats. Portions of the entrance not covered by the trap or net should be closed off with bird exclusion netting.

The timing of sampling should be coordinated with the local field office of the U.S. Fish and Wildlife Service, as staging and swarming seasons may vary with latitude and elevation. In general, female Indiana bats leave hibernacula earlier in spring (beginning in mid-April) than do males (peak of departure in early May). Limited mating may occur in spring (Hall 1962). Spring sampling is typically completed late March through early May. During autumn swarming, the abundance of females increases and decreases with the season, but males are always more common (Cope and Humphrey 1977; LaVal and LaVal 1980). The number of swarming females peaks in September. By late September, many females are hibernating, while many males remain active until mid-October or later, apparently in an effort to breed late-arriving females. Early during autumn swarming, Indiana bats often visit hibernacula at night, but do not day roost there. As the autumn season progresses more bats roost in hibernacula.

Temperature and precipitation likely influence swarming chronology and the level of nightly activity; rain depresses swarming activity in Europe (Parsons et al. 2003). Large, wet cold-weather systems may be part of the seasonal cycle driving timing of swarming (Brack unpub. data). As a result, sampling should not be completed on nights of sustained precipitation, or when temperatures fall below 10°C during the first two hours of sampling or below 0°C during the rest of sampling. It is important to begin sampling promptly at dusk, or shortly before if bat activity begins earlier. As the autumn season progresses, nightly activity begins earlier in the evening (Brack unpub. data; Parsons et al. 2003).

Spring sampling is often more constrained than autumn sampling because the season is shorter and there are more days of unsuitable weather. Large weather systems can delay sampling for many days. In addition, latitude and elevation affect seasonal and daily temperatures.

A bat detector can be used to supplement data obtained from trapping and netting, but when it is too dangerous to approach the entrance, use of bat detectors may be the only suitable form of sampling. Typically, the detector is pointed at the entrance to see what is exiting and entering the mine. Nevertheless, it may detect bats that are not using the portal. A few bats can produce many, many calls. If a detector is used in conjunction with a trap or net and nothing is heard or caught, it may provide sufficient data to eliminate a second night of trapping.

Interpreting Field Data

While a survey will reveal whether or not endangered bats were caught, interpretation of capture data may not be as clear-cut. The question is not only whether endangered bats were caught, but whether the mine provides suitable wintering habitat and whether that habitat is occupied.

Little is known about bats during the spring and autumn migration/transient period. Indiana bats may visit mines during this period but not hibernate in them during winter. It is probable that bats use a variety of roosts, including trees, caves, mines, holes of various types, and possibly a variety of non-traditional roosts, during migration. Bats migrating from hibernacula in southeastern New York to summer maternity sites roosted in trees on a building in a gap between a cinderblock wall and a joist under an elevated deck (Sanders and Chenger, unpub. tech. report), as well as in the siding of a house and in trees of suburban yards (Hicks pers. comm.). In late summer, a juvenile Indiana bat was found in central Indiana on the side of a building that had a rough cement exterior (Brack unpub. data). In northern Ohio, several Indiana bats have been caught in autumn in sandstone crevices that likely serves as a migratory stop-over (Summit County Metro Parks unpub. tech. report). During migration, other species of bats have been found in a variety of unlikely locations, including ships at sea, log piles, and rodent holes in treeless areas (Brack and Carter 1985). In addition, bats undoubtedly "explore or sample" a variety of situations and habitats, including mines, that are not currently suitable for use.

Caves and mines that provide suitable hibernacula for the Indiana bat are often suitable for other species of bats (Brack et al. 2003; Stihler and Brack 1992). Therefore a large concentration of bats of mixed species indicates that the mine is probably suitable for hibernation and therefore more likely to harbor Indiana bats - now or in the future. In this case, failure to catch Indiana bats does not mean the mine is not suitable for the Indiana bat, and loss of suitable habitat can constitute harm or harassment.

Regulatory decisions will be made based on the presence/absence of the Indiana bat, the number of bats, and probably the number of species and species diversity. Consequently, interpretation of field data must be made with caution. Capture of a single Indiana bat when only a few bats are caught is probably not indicative of a hibernaculum – and instead is indicative of another type of use. The capture of many bats (especially of several species), but not an Indiana bat, is probably indicative of a suitable hibernaculum. When interpretation of the data may not be clear, it is wise to contact the U.S. Fish and Wildlife Service (and State resource agency as appropriate) to ascertain whether additional sampling while still in the field would be helpful. This may save time and money.

Acknowledgements

I thank Andrew King, U.S. Fish and Wildlife Service, and Ramona Briggeman, Indiana Department of Natural Resources, for assistance and patience with requirements of the forum and this paper. I thank Environmental Solutions & Innovations, Inc. (ESI) for support to complete and present the paper and Adam Mann (ESI) for technical and logistic assistance. Many people have contributed to the evolution of these field techniques. Dean Metter and Gary Finni provided inspiration.

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INTERPRETING INDIANA BAT SURVEY RESULTS: A U.S. FISH AND WILDLIFE PERSPECTIVE

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Abstract

The Office of Surface Mining (OSM) and State Regulatory Authorities (RA) request the U.S. Fish and Wildlife Service (Service) to review hundreds of surface mining permit applications each year to ensure their compliance with section 7(a) (2) of the Endangered Species Act of 1973, as amended, and the non-discretionary Terms and Conditions contained within the Service's 1996 national programmatic Biological Opinion (BO) and Incidental Take Statement (ITS). For proposed mining plans within the range of the Federally endangered Indiana bat, Service biologists review the provided information, identify and attempt to rectify data deficiencies, and consider multiple biological factors to determine whether Indiana bats may be affected by the proposed activities. In order for a mining activity to affect an Indiana bat, three criteria must be met: 1) one or more individuals must be present, 2) they must be directly or indirectly exposed to the action and 3) that exposure must elicit a physiological and/or behavioral response from the individuals. This paper focuses on the first criteria – establishing presence or probable absence.

Typically, the first step a Service biologist takes in evaluating whether Indiana bats may be present is to determine the suitability and distribution of any existing summer (i.e., forested roosting and foraging habitat) and winter habitat (i.e., underground mines/caves/potential hibernacula) within and surrounding a proposed permit area. If suitable habitat is present, but bat survey data are lacking, the Service typically requests the applicant to conduct field surveys to confirm presence or probable absence and to better define the demographics of any bat populations using the area (e.g., is there an Indiana bat maternity colony present or a few widely scattered males?). The applicant then decides whether or not they wish to conduct the bat surveys. If an applicant opts not to conduct surveys, then the Service must evaluate the proposed plans using available data and assuming some reasonable number of individual Indiana bats and/or colonies is likely present and may be affected. However, if bat surveys are completed, then presence or probable absence and local demographics can be more firmly established and the Service can then complete a more detailed effects analysis using fewer cautious assumptions. In general, permit areas where Indiana bat surveys are completed but none are captured will require no or far fewer species-specific conservation measures as compared to those where suitable habitat was present, but no surveys were conducted.

Although the capture of an Indiana bat(s) confirms its presence, failure to catch one does not absolutely confirm the species' absence. This is because currently available survey techniques cannot ensure 100% detection of Indiana bats, especially when they only occur in low numbers. Therefore, Service biologists exercise caution when interpreting negative survey results and consider additional factors before concluding the species is absent or only present in low numbers. In this paper, I present reasonable assumptions and rationales that Service biologists

commonly use to interpret the various possible outcomes of Indiana bat surveys and discuss potential environmental indicators, confounding factors, and regional differences that also need to be considered before drawing final conclusions.

Andy King began his professional career as an environmental consultant and is currently an endangered species biologist in the U.S. Fish and Wildlife Service's Bloomington Field Office in Indiana, where he primarily conducts Section 7 consultations and assists with Indiana bat recovery efforts. Over the past 15 years, he has conducted numerous Indiana bat surveys, telemetry studies, and habitat assessments across the species' range. The Bloomington, Indiana Field Office has the Service's national lead for coordinating Indiana bat recovery efforts across the species' range. He received a B.S. in Wildlife Science from Purdue University and a M.S. in Raptor Biology from Boise State University.

Session 3

Consultation Process

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THE CONSULTATION PROCESS: FEDERAL AND STATE REQUIREMENTS UNDER SMCRA AND ESA

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Abstract

This paper describes the requirements to protect threatened and endangered species under the Surface Mining Control and Reclamation Act (SMCRA) and Endangered Species Act (ESA). The 1996 Biological Opinion on Surface Coal Mining and Reclamation Operations is the main focus for compliance with SMCRA and ESA. In addition, the consultation process under the ESA is followed when a Corp of Engineers Permit is required. A discussion of the success of the States in implementing the 1996 Biological Opinion is also offered. Two factors affecting such success include how the States implement their SMCRA delegated program and how they have complied with the 1996 Biological Opinion. Successful implementation of the 1996 Biological Opinion can be furthered by using better information on endangered and threatened species; clarifying the roles of the States, the Service, and the Office of Surface Mining; and providing certainty to applicants concerning possible protective measures or surveying techniques.

Introduction

Endangered and threatened species are protected from the impacts of surface coal mining operations by State and Federal requirements as outlined in a 1996 Biological Opinion. Section 7 of the Endangered Species Act (ESA) is the genesis of these requirements. Section 7(a)(2) of the ESA directs all Federal agencies to insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. A Federal agency consults with either the Fish and Wildlife Service or the National Marine Fisheries Service (Services) when an action that is being "authorized, funded, or carried out" by that agency may affect endangered and threatened species or critical habitat (collectively listed resources). The consultation requirement applies only to Federal actions, such as when a Clean Water Act (CWA) 404 permit is needed for the approval of mining operations. In a similar manner, the State requirements were also a result of a section 7(a)(2) consultation because a Federal action was taken when the Office of Surface Mining (OSM) approved the different States surface coal mining regulatory programs. OSM's approval led to the State requirements being codified in the 1996 Biological Opinion on "Surface Coal Mining and Reclamation Operations under the Surface Mining Control and Reclamation Act." In a nutshell, ESA compliance is achieved by the regulatory authority, be it the State or OSM, fulfilling the responsibilities outlined in the 1996 Biological Opinion. If a CWA 404 permit is required and listed resources may be affected, the consultation duties can be achieved by integrating the requirements of the ESA, SMCRA, and section 404 of the CWA.

The 1996 Biological Opinion

The history of the 1996 Biological Opinion begins in the early 1980s. To fulfill the requirements of section 7(a)(2) of the ESA, OSM initiated consultation with the FWS on the various States that were seeking approval in the early 1980s to assume the programs that regulate surface coal mining and reclamation operations. Consultations were completed at that time. However, by the early1990s, it was recognized that the earlier consultations covered only those species that were listed at the time. Many additional species and critical habitat had been listed and designated in the ensuing years. In addition, a provision was added to the ESA in 1982 that required that incidental take of listed species be included in biological opinions.

Based on the limited number of species addressed by the earlier consultations and the need to include incidental take when approving mining operations, OSM requested formal consultation on March 21, 1995 regarding the continuation and approval of surface coal mining and reclamation operations under State and Federal regulatory programs. A biological opinion and conference report were completed on September 24, 1996. The Service concluded that the implementation of surface mining activities consistent with the regulations at 30 CFR Part 700 – End is not likely to jeopardize the continued existence of any threatened, endangered, or proposed species or result in adverse modification of designated or proposed critical habitats. This conclusion was predicated on implementation of the requirements described in the document and the terms and conditions set forth in the incidental statement.

The requirements described in the 1996 Biological Opinion are primarily based on the SMCRA implementing regulations, which pertain to the protection of endangered species, with the addition of the incidental take statement requirements of the ESA. The 1996 Biological Opinion is designed to be a streamlined process based on the protective requirements of SMRCA that reduces the potential for duplication of effort between State and Federal regulatory authorities, while maintaining a level of protection for listed species and their habitats equivalent to the ESA. The procedures described in the 1996 Biological Opinion are somewhat different than the "standard" consultation procedures followed when a Federal agency is directly responsible for a proposed action that may affect listed resources. This is important since many States have asserted primacy over SMCRA programs and have thereby severed the Federal nexus that triggers the ESA consultation responsibility. The procedures of the 1996 Biological Opinion ensure that the action will not cause jeopardy and also provide a mechanism whereby the Regulatory Authority (whether that is the State or OSM) and the mining applicant can receive an exemption from the ESA's prohibition on take of listed species. Absent these procedures, the applicant of surface mining activities that are likely to take listed wildlife would have to apply to the Service for an incidental take permit under section 10(a)(1)(B) of the ESA.

Consultation process for 404 permits

When a 404 permit is required and listed species may be affected or critical habitat may be modified, the section 7 consultation process follows the regulations described in 50 CR Part 402. Most surface coal mining operations require a 404 permit. The majority of permit coordination between the Corps and FWS entails informal consultation. While the Service follows the standard method of completing the biological opinion, it is important to note that the Corps of Engineers restricts its analysis to considerations regarding impacts to the aquatic environment. At the same time, the Clean Water Act and 404(b)(1) guidelines have different environmental standards than SMCRA regarding impacts to aquatic functions and values. This is an important consideration because the information required under SMCRA may not adequately address impacts to the aquatic environment in the context of section 404. Information collected under the SMCRA process may therefore need to be supplemented.

The Department of the Army has provided guidance that conditions permits to ensure compliance with the incidental take statement of a biological opinion. The guidance indicates that all elements of the incidental take statement must be included by reference in the Corps permit, that conditions be included that specify that the applicant must comply with the incidental take statement, and that the Services will enforce violations of the incidental take statement if necessary. The Corps includes language in the permit that describes the applicants responsibilities to comply with the incidental take statement and also forwards a copy of the biological opinion to the applicant.

A Description of the Two Processes:
The 1996 Biological Opinion and Section 7 Consultation

The Requirements of the 1996 Biological Opinion

The following is a summary of the requirements of the 1996 Biological Opinion on Surface Coal Mining and Reclamation Operations:

A. Gen eral Requirements

1. The review and issuance of permits must include the consideration of listed resources.

B. Pre-Ap plication

1. The Service Field offices will distribute and update a list of species and critical habitat and specific protection measures needed for these species and critical habitat to OSM and the Regulatory Authority.
2. The Regulatory Authority will determine whether a listed species or critical habitat is present in a proposed permit area or adjacent area based on the list provided by the Service.
3. When listed species or critical habitat are present in the permit area or adjacent area, the Regulatory Authority will coordinate with the Service and State Wildlife Agency to determine the scope and level of detail of resource information contained in a permit application.

4. The Regulatory Authority will provide to the applicant an explanation of the scope and level of detail necessary to complete the resource information in the permit application.

C. Perm it application package

1. The Applicant shall include the following resource information in permit applications for listed or proposed species or their critical habitat:
   a) Site-specific resource information.
   b) A protection and enhancement plan that describes how the operator will minimize disturbances and adverse impacts:
      i) Protective measures during the active mining phases of the operation.
      ii) Enhancem ent measures during the reclamation and post-mining phase of the operation.
2. The Service will review the resource information in the permit application. The Service requests the information from the Regulatory Authority which is to be provided within 10 days of the request.
3. OSM, State Regulatory Authorities, and the Service must develop additional species-specific or site-specific standards and procedures to protect listed resources.
4. The Regulatory Authority will quantify take of listed species resulting from mining operations. Quantification of take occurs on a permit-by-permit basis.
5. The Service will develop, in close coordination with OSM and the State regulatory Authority, any necessary site-specific measures to minimize potential take. The measures must be enforceable under the mining permit.
6. The Regulatory Authority will provide to the Service a written explanation whenever the authority decides not to implement species-specific measures recommended by the Service. The Service provides a concurrence letter to the Regulatory Authority if the Service concurs with the Regulatory Authority's action. If the Service does not concur with the Regulatory Agency's action an, elevation process will be used to reach agreement on the implementation of the species-specific measures.

D. Notification of Receipt of Complete Permit Application and Subsequent Permitting Actions

1. The Regulatory Authority will notify the Service of completed application, a significant revision to a permit, or a renewal of a permit.

E. Written Findings

1) As a precondition for approval of a permit application, the Regulatory authority will demonstrate, in writing, that the mining operation will not jeopardize listed species or result in adverse modification of critical habitat.
2) The Regulatory Authority will make a written finding that the exploration and reclamation activities will not jeopardize the continued existence of an endangered species or threatened species or result in destruction or adverse modification of critical habitat of those species.

F. No tification of Decision

1. The Regulatory Authority will notify the Service, in writing, concerning decision made on permit issued that the Service has offered comments.

G. Perform ance Standards

1. The Operator determines whether a listed species is present in the permit area or adjacent area during the pre-application phase of the operation or, if new information is presented at any time during the mining operation.
2. The Regulatory Authority consults with the State and the Service when the Operator determines that a listed species occurs in the permit area. The Regulatory Authority, in consultation with the Service, must identify whether, and under what conditions, the operator may proceed with the operation if listed species occur in the permit area.
3. The Operator shall use the best available technology to minimize disturbance of and adverse impacts to fish, wildlife, and related environmental values and shall achieve enhancement of these same resources where practicable.
4. The Operator will not jeopardize listed species or adversely modify critical habitat during mining operations.
5. The Regulatory Authority must notify the Service within one working day if a dead or impaired individual of a listed species is found in the permit area or in adjacent areas.

6. OSM and the Regulatory Authority must regulate the mining activity covered by the incidental take statement in the 1996 BO and in site-specific incidental take statements. The protective coverage for the operator against the unlawful take of listed species may lapse if the regulatory authority fails to require permittees to adhere to, or if OSM fails to monitor compliance with, the terms and conditions of the incidental take statement.
7. The Regulatory Authority must implement any species-specific protective measures to minimize anticipated incidental take. The Regulatory Authority must also require compliance by the operator with the species-specific protective measures.

H. C oal Exploration

1. The Applicant will include a description of any listed species within proposed exploration areas in exploration permits.
2. The Regulatory Authority shall only approve coal exploration permits if the Applicant has demonstrated that the action will not jeopardize listed species or adversely modify critical habitat.
3. The Operator will not disturb critical habitat during coal exploration as part of the performance standards.

I. Midterm Permit Review and Permit Renewals

1. The Regulatory Authority must require a reasonable revision of a permit at any time if the operation is not in compliance with the species protection provisions of the approved regulatory program.

J. C onservation Recommendations

1. The Service will recommend discretionary conservation recommendations to OSM in order to minimize or avoid adverse effects of the mining operation to listed species.

K. Rein itiation of Consultation

1) Reinitiation of consultation may be requested by OSM or the Service if
   a) new information indicates that the approval or conducting of mining operation and reclamation is affecting listed species or modifying critical habitat in a manner or extent not considered in the 1996 BO or
   b) the approval or conducting of mining operation and reclamation is modified in a manner not considered in the 1996 BO that causes an adverse effect to listed species or critical habitat.

L. Cu mulative Effects

1) The Applicant, in cooperation with the regulatory authority, must analyze cumulative impacts of mining operations at the site-specific level if listed resources are present in the action area.

Section 7 Consultation

All Federal agencies must consult with the Services when any activity authorized, funded, or carried out by that agency may affect a listed species or designated critical habitat. The Services conduct several types of consultations on federal agency activities, including formal, informal, early and emergency consultations for listed species or designated critical habitats, and informal and formal conferences for proposed species or proposed critical habitats.

Informal consultation is an optional process that includes all discussions and correspondence between the Services and a federal agency or designated non-federal representative, prior to formal consultation, to determine whether formal consultation is necessary. This process allows the federal agency to utilize the Service's expertise to evaluate the agency's assessment of potential effects or to suggest possible modifications to the proposed action which could avoid potentially adverse effects. If a proposed federal action may affect, and is likely to adversely affect listed resources, formal consultation is required.

Formal consultation is a process between the Services and a Federal agency, plus any applicant, that determines whether a proposed Federal action is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat. More specifically, jeopardy is defined as "…an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." Formal consultation begins with a Federal agency's written request and submittal of a complete initiation package and concludes with the issuance of a biological opinion and incidental take statement.

The initiation package that begins formal section 7 consultation includes the following information:

- A description of the action to be considered;
- A description of the specific area that may be affected by the action;
- A description of any listed species or critical habitat that may be affected by the action;
- A description of the manner in which the action may affect any listed species or critical habitat and an analysis of any cumulative effects;
- Relevant reports, including any environmental impact statement, environmental assessment, or biological assessment prepared; and
- Any other relevant available information on the action, the affected listed species, or critical habitat. (From 50 CFR 402.14(c))

In preparing a biological opinion during section 7 consultation the Services must:

- Review all relevant information that is provided by the action agency or is otherwise available;
- Evaluate the current status of the listed and proposed resources to be affected (this includes an evaluation of the threats facing these listed and proposed resources), and the environmental baseline within the action area;
- Evaluate the effects of the proposed action and cumulative effects on the listed and proposed resources;
- Use the above information to determine the effects of the proposed action on the conservation status of the listed species (i.e., evaluate the potential for the proposed action to result in jeopardy or adverse modification).
- Provide, as appropriate, a Reasonable and Prudent Alternatives to avoid jeopardy to listed species or adverse modification of critical habitat; Reasonable and Prudent Measures to minimize incidental take; and Conservation Recommendations.

A Brief Description of the Section 7 Consultation Process

The following is a summary of the generalized consultation process:

1) When a Federal action is proposed, the Federal agency considers whether listed or proposed species are present and whether designated or proposed critical habitat occurs in the action area.

2) If no listed or proposed species are present or designated or proposed critical habitat is in the action area then no further consultation is necessary.

3) If listed or proposed species are present and/or designated or proposed critical habitat is present then the federal agency may enter into informal consultation, which is an optional process, or initiate formal consultation if the action agency determines that the proposed action may affect listed species or critical habitat.

4) A biological assessment (BA) is prepared by the Federal agency if the action is a major construction activity. If the action is not a major construction activity, a biological evaluation (BE) is generally completed. Both the BA and BE are used to determine whether formal consultation is necessary. At this stage of the process, the Federal agency makes a determination about whether the action "is likely to adversely affect listed species" or "is not likely to adversely affect listed species". Likewise, a determination is made about whether critical habitat will be modified. If the Services concur with the Agency's "is not likely to adversely affect" determination, the consultation is completed. If the Federal agency or the Services believe that a "is likely to adversely affect" conclusion is appropriate, formal consultation is initiated.

5) The federal agency prepares an initiation package to start formal consultation. Assuming that the initiation package is complete, formal consultation is done in 135 days. The consultation portion is done in 90 days and the biological opinion is completed in 45 days. These timeframes can be shortened or lengthened based on certain stipulations set forth in the consultation regulations.

6) Formal consultation is designed to determine if the action is likely to jeopardize the continued existence of the listed species or destroy or modify designated critical habitat.

7) A biological opinion is prepared that will include Reasonable and Prudent Alternatives to the action designed to avoid jeopardy, Reasonable and Prudent Measures to minimize incidental take, the terms and conditions that implement the Reasonable and Prudent Measures, and Conservation Recommendations.

8) Once the biological opinion has been completed, the Federal agency determines whether and how to proceed with their action.

9) Reinitiation of consultation is required if the amount or extent of take is exceeded; new information reveals that the action may affect species or critical habitat in a manner or extent not previously considered; the action is modified in a way that causes an effect not previously considered; or new species are listed or critical habitat designated.

Examples of Reasonable and Prudent Measures Provided in Biological Opinions

Reasonable and Prudent Measures are an important means to protect listed species in the 1996 Biological Opinion and section 7 consultations. Such measures are required under the 1996 Biological Opinion, to minimize incidental take adverse effects and they are developed by the Service and the RA.

While Reasonable and Prudent Measures differ depending on the characteristics of the federal action, the Service has been fairly consistent regarding the Measures developed to minimize incidental take for the Indiana bat. Typical Reasonable and Prudent Measures for Indiana bats focus on the protection and management of bat habitat, timber harvesting, protection of bat hibernacula, and monitoring of bat activity. The following are examples of generalized Reasonable and Prudent Measures for the Indiana bat based on several biological opinions:

- Maintain adequate canopy cover in hardwood stands to provide Indiana bat foraging habitat. Provide a continuous supply of large roost trees for the bat by retaining a component of large, over-mature trees. Protect all known roost trees in the action area until they no longer serve as roost trees. Leave snag trees whenever possible unless they pose a threat to human safety. Include a diverse mixture of hardwood species that are considered to be of high value as Indiana bat roost trees. A list is provided of species that are considered of high value.

- Conduct timber harvest during times that will not coincide with the bats use of trees for maternity roosts or other uses. Limit road construction to times that the bat will not be present, generally between October 1 and April 30 of each year. Conduct prescribed burns at specific times, generally between January 1 and May 31.

- Protect all known Indiana bat hibernacula. Install bat-friendly gates to prevent unauthorized entry. Survey for potential bat presence during the fall swarming periods when a mine opening is scheduled to be backfilled.

- Establish buffer zones along perennial and non-perennial streams to protect riparian habitat used for foraging. Establish connectivity within post-mining forests.

- Monitor Indiana bat activity on selected treatment areas to determine the bat’s reaction/use before, during, and after the mining activity.

Protective Measures under Protection and Enhancement Plans

The Regulatory Authority, the Service, and OSM work together to develop protective measures for listed species. The main provision of the 1996 Biological Opinion process that relates to protective measures is the protection and enhancement plan prepared for a mine application. Protection and enhancement plans are included in each mining application prepared by the applicant to describe how the operator will minimize disturbances and adverse impacts to fish and wildlife and other environmental resources. Protective measures are used during the active mining phase of the operation and enhancement measures are used during the reclamation and postmining phase of the operation.

In addition to protection and enhancement measures, the Service and the RA may develop additional species-specific or site-specific standards and procedures to protect listed resources and site-specific measures to minimize take. Often these three distinct provisions may have similar or identical protective mechanisms based on what protective mechanisms are needed for the species. During the traditional section 7 consultation process, protective measures are developed as Alternatives to the action, Measures to minimize take, and Conservation Recommendations.

While the protective measures contained in Protection and Enhancement Plans may differ due to the specific spatial characteristics of where Indiana bats inhabit, there are common attributes of the measures that are supported by the Service. The following examples of protective measures are typical of ones contained in Protection and Enhancement Plans for the Indiana bat:

- Seasonal tree cutting restrictions
- Planting of trees that have a high-value as Indiana bat roost trees
- Protection of existing Indiana bat habitat
- Establishment of buffers around protected areas
- Enhancement of habitat (forest and aquatic)
- Monitoring of maternity roosts and hibernacula
- Public outreach programs
- Research

Another common approach that has been developed to determine the appropriate protective steps needed is to suggest two options in which the Indiana bat is either assumed to be present in the action area or mist net surveys are done. The first option to assume the presence of Indiana bats in the action area saves time and money that are associated with the need to perform mist net surveys. By assuming the presence of Indiana bat, the application would include protective measures deemed appropriate to avoid adverse effects to the bat. The second option to conduct surveys determines whether the bat is present, and therefore whether protective measures are necessary.

Several States, in coordination with FWS and OSM, have developed final or draft guidelines for preparing protection and enhancement plans. One example of a guideline has been developed for the State of Kentucky. The Kentucky Surface Mining Program within the Department for Natural Resources worked with the FWS and the Department of Fish and Wildlife Resources to develop "Guidelines for the Development of Protection and Enhancement Plans for the Indiana Bat (Myotis sodalis)." The draft Plan incorporates the use of either assuming presence (whether required when the bat is known to be present or by the choice of the applicant) or completing surveys. Three objectives form the core of the plan. The first objective is to minimize the potential to take an Indiana bat. An example of a measure to avoid take would be to only remove trees when the bat would not be present at the mine site. The second objective is the short-term replacement of the habitat that is lost during the mining operation. Girdling of trees along the perimeter of the mine site and locating bat houses near the site are examples of measures to replace habitat. The third objective of the plan is to restore and enhance habitat in areas where the habitat has been removed or degraded. Measures to restore and enhance habitat include creating watering areas, establishing ground cover, and planting a minimum of four different tree species that can be used by the bat. The plan also includes guidance on surveying techniques, portal assessment and survey requirements, sample plans, tree species lists, and information on bat house designs.

Other State offices have also been working on ways to implement the process outlined in the 1996 Biological Opinion. The FWS has used the Kentucky guidelines as a model, in coordination with the Regulatory Authority in Tennessee to develop protection and enhancement plans. While still to be finalized, the document will include measures that promote the preparation of protection and enhancement plans and measures that will fulfill the responsibility to minimize take.

In a similar fashion, the Ohio Department of Natural Resources, FWS, and OSM prepared a Policy Procedure Directive (PPD) that provides guidance to coal mining permit applicants in meeting requirements to protect the

Indiana bat. The PPD describes protection and enhancement plans that serve to protect the Indiana bat during mining operations and also minimize the potential for incidental take. Specific protective and enhancement measures are suggested, the option to either assume presence or survey for presence is offered, mist netting guidelines are described, a habitat suitability criteria is provided, and other information is offered.

Progress in Implementing the 1996 Biological Opinion

Based on discussions with Service field offices, there has been mixed success in implementing the 1996 Biological Opinion. In some States the RA and the FWS field offices are working well together. These States reported making progress while having only a small number of contentious issues on how to implement protective measures. In other States, the BO has not been adequately implemented.

Because a more comprehensive investigation of how well the implementation of the 1996 Biological Opinion has not yet been completed, the status of specific States compliance is not reported in this paper. Instead a more general discussion of the status of implementation is offered.

Several Service field offices have described the working relations between themselves and the RA as positive and successful. Guidelines on implementing protection and enhancement measures for the Indiana bat have been developed in at least two States, with a third State using one of the guidelines as a model for their own use. While the Service and RA in these States have interpreted the requirements of the 1996 Biological Opinion broadly, meaningful protection for the bats has been reported. One reason for this broad interpretation is that several of the requirements of the 1996 Biological Opinion, for example species-specific measures, protection and enhancement measures, and standards and procedures, may often be the same or similar. In addition, the State SMCRA programs are usually executed differently from State to State, which leads to differences in implementing the 1996 Biological Opinion. Common characteristics of those States where the RA and Service were working well together include the ability to interact on a professional basis, some experience in working out initial problems with the requirements that led to a more collegial engagement, and continued communication on issues regarding the Indiana bat and mining operations.

Most of the contentious issues reported by the Service involve the characteristics of mining in particular states or disagreements about specific protective measures. In some States, mining operations are large and in others they are small, but more numerous. This results in very different approaches to advancing protective measures for the Indiana bat. In addition, the effects of actions that occur in proximity to the mining operations under review are seldom factored into the analysis of impacts. These cumulative effects, for example the additive impacts of timber extraction or other mining operations, need to be considered when assessing whether listed species or critical habitat will be adversely affected by the proposed action. Examples of disagreements about implementing specific protective measures have included how and when to survey for bats, the inclusion of stream protection, how to consider protection of land adjacent to the mining operation as potential bat habitat, and conservation easements to protect habitat in the long-term.

In several States, the requirements of the 1996 Biological Opinion have not been followed and very little communication has occurred between the Service and the RA. These problems stem from long-term disagreements on how to regulate mining in each State and how to develop measures to protect listed species. Common characteristics of those States where the RA and Service were not working well together include a history of miscommunication, a misunderstanding about Service and RA responsibilities, a lack of a good relations between agencies, and an unwillingness to compromise. While these problems continue, efforts have begun to address these issues with at least one State agreeing to engage in discussions to improve the implementation of the 1996 Biological Opinion.

Integrating the Process and Making the Process Work

While the 1996 Biological Opinion has been in effect for a little over ten years, the implementation of the requirements has been slowed by the initial misunderstandings about responsibilities and lack of awareness of the document. In recent years, more emphasis has been given to explaining the requirements in multi-agency training and by working with individuals. The section 7 consultation process is better understood by Federal agencies and, notwithstanding the occasional problem, most consultations are completed within the timeframes of the SMCRA process. The following suggestions offered below address possible improvements to the consultation process:

- The Service can offer assistance with protection and enhancement plans earlier in the process during the application development. In addition, the Service can assist the RAs requirement to quantify the level of take under the 1996 Biological Opinion. In addition, any technical assistance offered by the Service would assist the RA with several different aspects of implementing the 1996 Biological Opinion.

- Better information on Indiana bats, including the use of summer habitat, maternity colonies, tolerance to disturbed habitat, and knowledge about bat presence.

- The preparation of guidance and protocols for the Indiana bat can ensure that protective measures will be developed for specific mining operations, which saves resources of all the parties. MOAs or other agreements on how the consultation process will be done can ensure proper communication and improved working relations. The clarification of roles of the States, the Service, and OSM in implementing the 1996 Biological Opinion would also improve the process.

- Integration of 1996 BO process and consultation process can save resources and improve the quality of the information collected. Since most of the work to develop SMCRA applications and meeting the requirements of the 1996 Biological Opinion is completed before the 404 permits are required, the information collected for the application and 1996 Biological Opinion could be used to satisfy the information needs of the 404 process. In addition, early involvement with the Corps during the preparation of applications could avoid the need to make changes in the mining operation at the time of issuing the 404 permit.

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ENDANGERED SPECIES CONSULTATION UNDER SMCRA: A STATE REGULATORY AUTHORITY PERSPECTIVE

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Abstract

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) includes a coal mine permitting process which requires that "consultation" take place between the regulatory authority (RA) and the U.S. Fish and Wildlife Service (USFWS) regarding Federally listed species. Several aspects of that consultation have been debated since passage of SMCRA (1977) including the detail and weight of consultation and specific legal requirements. Absence of case law has clouded these issues. In 1996, USFWS issued their Biological Opinion on the SMCRA program clarifying that consultation in the coal mine permitting process is not the same as ESA Section 7 consultation. Nevertheless, regulatory consultation should not only meet the legal requirements of the regulations, but should be conducted in an effective manner if the designed endangered species protections are to be realized. Effective consultation includes serious consideration of USFWS comments by the RA as well as an understanding by USFWS that their comments are interpreted by the RA's in the context of balancing endangered species protection with other environmental considerations and with economic factors as specified by SMCRA.

Introduction

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) includes a broad wildlife protection standard. Specifically, paragraph 24 of Section 515 requires the operation at a minimum "to the extent possible using the best technology currently available, minimize disturbances and adverse impacts of the operation on fish, wildlife, and related environmental values, and achieve enhancement of such resources where practicable." Regulations promulgated in furtherance of this performance standard require "consultation" with the U.S. Fish and Wildlife Service (USFWS) by the State regulatory authority (RA). Specifically, Title 30 of the Code of Federal Regulations (30 CFR) Sections 780.16(a)(1) and 784.21(a)(1), for surface and underground mining, respectively, require that the scope and level of detail for fish and wildlife resource information be determined by the regulatory authority "in consultation with" State and Federal agencies with responsibilities for fish and wildlife. The reference to Federal agencies is most often interpreted to mean the U.S. Fish and Wildlife Service. Additionally, 30 CFR Sections 816.97(b)&(c) and 817.97(b)&(c) require (for surface and underground mining, respectively) "consultation" by the regulatory authority with appropriate State and Federal fish and wildlife agencies in cases where the regulatory authority is notified by the operator of a listed species or bald or golden eagle nest in the permit area.

Consultation Requirements

The nature of these "consultation" requirements has been debated since passage of SMCRA. One school of thought holds that the term "consultation" in the 30 CFR regulations has the same meaning as that term in Section 7 of the Endangered Species Act (ESA). "Section 7 Consultation" is a process used frequently by the U.S. Fish and Wildlife Service in dealing with legislatively mandated consultation requirements of Federal agencies on endangered species issues. The process is governed by regulations found at 50 CFR Part 402 and by procedures outlined by the USFWS in their comprehensive document entitled "Endangered Species Consultation Handbook, Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act." Proponents of this school of thought have argued that the Federal funding nexus between the Office of Surface Mining Reclamation and Enforcement (OSM) and State regulatory agencies brings State permitting decisions within the context of "Federal agency actions" under Section 7 and that Section 7 consultation procedures therefore apply to the 30 CFR "consultation" requirements cited above. Another school of thought holds that Section 7 does not apply to State issued coal mining permits due to the nature of SMCRA State primacy and State sovereignty issues. This line of thought holds that State issued permits are State actions, not Federal actions, despite partial program funding by OSM.

Research has failed to show any case law on the applicability of Section 7 requirements to State issued mining permits. There does exist related legal history, however, regarding the designation of State issued SMCRA permits as "Federal actions" under the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA). Early in SMCRA history, it was established that State issued SMCRA permits are not subject to NEPA procedures, since they are State and not Federal actions. NHPA litigation in the 1990's resulted in an interpretation that primacy State issued SMCRA permits are Federal actions under that law; however, a recent appeal has reversed that opinion and the current interpretation is that they are not Federal actions. The question of State permits being Federal actions under ESA remains a clouded legal point, but as we shall see, has become a moot issue.

1996 Biological Opinion

In 1995, OSM requested Section 7 consultation with USFWS. The Federal action subject to consultation was OSM's continued implementation of SMCRA both as an oversight agency of primacy State programs and as direct regulator in non-primacy States, on Federal lands, and on Indian lands. The result was a Biological Opinion issued by USFWS dated September 24, 1996. The issue of "consultation" was again visited. Implementation of the 1996 Biological Opinion has resulted in an interpretation that "consultation" required under 30 CFR Parts 780, 784, 816, and 817 is not "Section 7 Consultation." People close to the issue often refer to Section 7 Consultation in this context as "Big C - Consultation" and non-Section 7 consultation as "Little c – consultation." In the context of the 30 CFR rules cited above, consultation is interpreted as "Little c - consultation" under the 1996 Biological Opinion."

Effective Consultation

We have determined what endangered species "consultation" in the 30 CRF rules is not, namely Section 7 consultation, but what is it then? 30 CFR defines many terms in Section 701.5, but "consultation" is not one of them. We therefore go to the dictionary definitions. The American Heritage Dictionary defines consultation as "A conference at which advice is given or views are exchanged," while the Webster's Revised Unabridged Dictionary defines it as "Deliberation of two or more persons on some matter, with a view to a decision." The key components appear to be advice, exchange of views, deliberation, and a decision. These components would suggest that the parties involved are communicating in an effective manner. For such effective communications to take place however, the parties must be speaking the same language, which is not always the case between the USFWS and the State RA. Ineffective communication is rooted in the differing mandates of the ESA and SMCRA. The Endangered Species Act is about protection and conservation of listed species. USFWS comments reflect this mandate. SMCRA, on the other hand, is about balancing the nation's coal production with environmental considerations. The RA's, who receive the USFWS comments will view those comments in the context of this balance. The consultation requirements in 30 CFR were clearly designed to provide a layer of protection for endangered species where conflicts with coal mining exist. In order for those protections to be fully realized, consultation must be done in an effective manner. To enhance the effectiveness of consultation, and hence the effectiveness of the designed endangered species protections envisioned in the consultation requirements, we suggest the following.

Serious Consideration of Advice

The advice given by the consulted party should be seriously considered by the party requesting the consultation. It is not simply enough to consult to meet the legal requirement to do so. The RA errs if he or she assumes the attitude that USFWS comments will be received and then disregarded without serious consideration. Such disregard may or may not meet the legal requirements to consult, but certainly is not effective consultation. It is important that the consulted party know that their comments are being seriously considered.

Advice Given its Due Weight

The advice received should be given its due weight. This does not mean that all advice given be followed, but an attempt to follow it should be made within the limits of balancing that advice with other considerations. In the case of USFWS advice on mining permits, the RA must balance that advice with other environmental considerations and with economic and legal considerations. For example, USFWS might recommend that a mining permit be denied because of a possible conflict with an endangered species. The RA must balance this concern with the economic concerns of ceasing the mining operation, including interruption of coal to the consumer. Also the RA may be concerned with a constitutional fifth amendment taking of the applicant's coal and rights to mine, and resulting litigation along those lines. Except for the rare cases where the operation would affect the continued existence of listed species or destroy or adversely modify critical habitats, or would result in an unpermitted "taking," the RA would most likely determine that the legal and economic considerations outweigh the endangered species considerations and issue the permit. The permit would most likely be issued with protection and enhancement measures (30 CFR 780.16(b), 784.21(b)) for the concerned species, which would "minimize" disturbances and adverse impacts "to the extent possible using the best technology currently available." In this example, the advice given was seriously considered by the RA, but the recommendation to deny the permit was rejected in light of the economic and legal considerations. To maintain the balance envisioned in SMCRA, the RA decided to issue the permit, but with reasonable protection and enhancement measures to balance the endangered species concerns with the economic and legal concerns.

The RA sometimes is faced with balancing one environmental consideration with another. For example, the most common method for avoiding mining conflicts with Indiana bat maternity roosting activity is to schedule tree clearing during the winter months, the time of year when Indiana bats are hibernating in caves. This may be an excellent method for avoiding a take of an Indiana bat, but is not a good practice for handling topsoil. Topsoil conservation is an important component of SMCRA's environmental protections (30 CFR 816.22). Winter tree clearing, during typically wet ground conditions, increases potential loss of topsoil through erosion and can result in unnecessary compaction. When balancing this environmental consideration however, most RA's have decided that the legal and environmental issues of endangered species conservation outweigh the topsoil considerations, and require the winter clearing to avoid a potential Indiana bat take.

Rejected Advice Should Be Justified

In those instances where advice is rejected for economic, legal, or environmental reasons, the RA should justify this. The rationale for the rejection should be documented and logically explained. Such explanation will let the consulted party (USFWS in this case) know that their advice, although rejected, was seriously considered. Such documentation also creates a record connecting the facts presented in the permitting process with the final permitting decisions, which is an important component in justifying the RA's findings.

In addition to the regulatory consultation requirements cited above, which use the words "consult" or "consultation," there are also consultation requirements that do not use these words per se. For example 30 CFR 780.16(c) and 784.21(c) require the RA to provide permit application information to USFWS for the purpose of providing USFWS an opportunity to comment on the application. Essentially, a "consultation" process is described although the word is not specifically used.

T&E Finding

One purpose of consultation with the USFWS is to provide the RA with the information necessary for the RA to determine whether or not the requisite threatened and endangered species finding (T&E finding) can be made. 30 CFR 773.15 prohibits the issuance of a coal mining permit unless the RA can make the following finding:

> "The operation would not affect the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.)."

The RA relies on the USFWS as a primary source of information necessary to make this finding. Other sources include the permit applicant, the State fish and wildlife agency, the public, and the RA's records. Litigation in Appalachia has raised an awareness by RA's that their findings are subject to intense legal scrutiny and can be voided by a court unless certain criteria are met. These criteria include:

1. The RA examined the relevant data.
2. The RA articulated a satisfactory explanation for its action.
3. The RA included in its explanation a rational connection between the facts found and the decisions made.

In the case of the T&E finding, OSM and the USFWS both recommend a jointly developed procedure for connecting the relevant T&E data with the required finding. The procedure parallels the USFWS Section 7 procedure used in making jeopardy/ no jeopardy decisions.

The procedure has four main elements: a review of the status of the species, a review of the environmental baseline (SMCRA rules use the term "site specific resource information" which captures the same idea), a prediction of direct and indirect effects of the permitting action, and a prediction of cumulative effects. Most RA's are already doing the first three of these to some extent. They continuously monitor the status of listed species in their coal fields. They review site specific resource information on listed species in individual permit areas. They predict direct and indirect effects of the permitting action on the species. What they have not typically done is an analysis of cumulative impacts as that term is used in ESA rules. 50 CFR 402.02 defines cumulative impacts as "those effects of future State or private activities, not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation." Examples of State activities could include expansion of a State park or construction of a new State highway. Private activities could include further development of adjacent coal reserves. The "reasonably certain to occur" criterion is stricter than a "may occur" criterion. To make this determination, the RA should have some concrete documentation that the action is reasonably certain to occur. The "action area" is equivalent to the combined SMCRA terms "permit area" and "adjacent area" as these terms are defined in 30 CFR 701.5. By adjusting procedures already used and adding a procedure for addressing cumulative effects, most RA's should be able to easily utilize this procedure recommended by both OSM and USFWS. In most cases, the RA's also need to better document this procedure so that the record will show the required connection between the facts found and the decisions made. It is thought that by following this procedure, the RA will be better enabled to defend their T&E finding in the judicial arena.

Incidental Take

Another new element of the 1996 Biological Opinion is the opportunity for the RA to include an incidental take provision in the coal mining permit. "Taking" a listed species without a permit to do so, is a violation of the Endangered Species Act. The taking of a listed species that results from, but is not the purpose of, an otherwise lawful activity, is called "incidental take." ESA allows for incidental take, however to be lawful, such incidental take must take place under the authority of a permit. The USFWS has authorized RA's to include an incidental take provision, as part of the mining permit, subject to three conditions which are:

1. The regulatory authority, acting in accordance with the applicable SMCRA regulatory program, must implement and require compliance with any species-specific protective measures developed by the Service field office and the regulatory authority (with the involvement, as appropriate, of the permittee and OSM).

2. Whenever possible, the regulatory authority must quantify the take resulting from activities carried out under this program. Whenever a dead or impaired individual of a listed species is found, the local Service office must be notified within one working day of the discovery.

3. Whenever the regulatory authority decides not to implement one or more of the species-specific measures recommended by the Service, it must provide a written explanation to the Service. If the Service does not concur, the issue must be elevated through the chain of command of the regulatory authority, the Service, and (to the extent appropriate) OSM for resolution.

Some States have proceeded with development of the species-specific measures mentioned in condition 1. In Ohio, a Memorandum of Understanding has been executed between the State of Ohio, USFWS, and OSM which stipulates species-specific measures for the Indiana bat, a process for the RA to report occurrences of listed species at the mines to USFWS, and a conflict resolution process pursuant to condition 3. Discussions have been initiated in Indiana. Illinois may develop similar measures in the future. To date in Illinois, no permits have been issued with an incidental take provision. Endangered species "take" in conjunction with coal mining has not been an issue in Illinois since passage of SMCRA and there is no reason currently to anticipate that this will change in the near future.

Post Permit Issuance Consultation

30 CFR Sections 816.97(b)&(c) and 817.97(b)&(c) require (for surface and underground mining, respectively) "consultation" by the regulatory authority with appropriate State and Federal fish and wildlife agencies in cases where the regulatory authority is notified by the operator of a listed species or bald or golden eagle nest in the permit area. In Illinois, this provision was invoked in 2002 when Freeman United Coal Mining Company discovered the presence of Indiana bats at their Industry Mine, located at Industry, Illinois, during a routine bat survey. Two Indiana bats were captured in a mist net by consultant William D. Hendricks of WDH Ecological Services. The bats were tracked to a maternity roost tree located in one of Freeman's permit areas. Freeman immediately notified the RA, who in turn, immediately notified USFWS. A buffer zone was established around the roost tree. USFWS reviewed with Freeman tree clearing plans in the vicinity and recommended adjustments to Freeman's plans. The suggested adjustments did not pose a significant threat to production plans and were easily accommodated by Freeman. USFWS, the RA, and Freeman were satisfied with the protection measures.

Other post permit issuance consultation opportunities include permit revisions, mid term reviews, permit renewals, and bond releases. The provisions for significant permit revisions are identical to those for new permits. Mid term reviews are generally conducted by the RA at 5 year intervals mid way between permit issuance and permit renewal, generally two and a half years after permit or renewal issuance. USFWS can request review of listed species issues as part of the mid term review for permits in which such issues arise after permit issuance. USFWS is notified of applications for permit renewals and may comment on these. Bond releases are announced in local newspapers. USFWS may comment on bond releases or may wish to review reclamation work in the field to assure compliance with any permanent protection and enhancement measures specified in the permit. USFWS is typically not notified of insignificant permit revisions, however, the RA should consider a notification for revisions involving listed species issues.

Summary

Regulations promulgated pursuant to SMCRA require State regulatory authorities to consult with the USFWS on Federally listed threatened and endangered species issues. Such consultation is provided in order to assure a layer of protection for listed species where conflicts with coal mining operations may exist. Although ESA Section 7 consultation procedures are not required for this SMCRA regulatory consultation, consultation should be conducted in an effective manner so that the envisioned endangered species protections can be realized. There is an opportunity for a new era in relations between State RA's and USFWS with implementation of the 1996 Biological Opinion. It is hoped that communications can be improved between these agencies by a better understanding by each of the other's legislative mandates. Coal mine reclamation can be a very creative process and opportunities for enhancement measures for the benefit of listed species do exist. It is hoped that improvements in the consultation process can lead to more realization of enhancement measures, including development of post mining habitats which are beneficial to wildlife, including listed species. USFWS and OSM have jointly developed a procedure for justifying the required T&E finding which both agencies recommend to State RA's. This procedure should enable the RA to defend the T&E finding in the judicial arena. Procedures resulting from implementation of the 1996 Biological Opinion should be relatively easy for the RA's to follow with only minor adjustments in most programs. Needed adjustments include cumulative effects analyses, incidental take provisions, and better documentation of the RA's logic in connecting permit application data with decisions made. It is hoped that the RA's and USFWS can work cooperatively through consultation to assure conservation and protection of listed species and to strike the balance between listed species management and the nation's need for coal as an energy source.

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PROTECTION OF INDIANA OF INDIANA BATS DURING COAL MINING: CONSULTATION AND COOPERATION OF OSM AND STATE REGULATORY PROGRAMS

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Abstract

The Indiana Bat (Myotis sodalis) is an endangered species as defined under the Endangered Species Act of 1973 (ESA). Indiana Bats may be found in many areas of the United States where coal is mined. Coal mining is regulated under the Federal Surface Mining Control and Reclamation Act of 1977 (SMCRA) and the Federal and State regulatory programs adopted pursuant to SMCRA and its implementing regulations. Federal and State regulations require that every permit application for surface coal mining include fish and wildlife resource information, as well as a plan for protection and enhancement of endangered species and their critical habitats. The regulations also require the regulatory agency to make a written finding that the proposed mining operation would not affect the continued existence of listed species or result in the destruction or adverse modification of their critical habitats. This combination of laws and regulations ensures that coal mining operations in the United States, if carried out in accordance with approved and properly implemented Federal and State regulatory programs under SMCRA, will not further endanger the continued existence of Indiana Bats. This paper reviews the progress of States and OSM in meeting the requirements of the 1996 Biological Opinion, specifically for the protection of the endangered Indiana Bat. The paper will discuss various approaches used by SMCRA regulatory authorities and how OSM is assuring implementation of the requirements in the Biological Opinion.

Background

The Indiana Bat (Myotis sodalis) is an endangered species as defined under ESA. Indiana Bats may be found in many areas of the United States where coal is mined. Coal mining is regulated under SMCRA and the Federal and State regulatory programs adopted pursuant to SMCRA and its implementing regulations. Federal and State regulations require that every permit application for surface coal mining include fish and wildlife resource information, as well as a plan for protection and enhancement of endangered species and their critical habitats. The regulations also require the regulatory agency to make a written finding that the proposed mining operation would not affect the continued existence of listed species or result in the destruction or adverse modification of their critical habitats. This combination of laws and regulations ensures that coal mining operations in the United States, if carried out in accordance with approved and properly implemented Federal and State regulatory programs under SMCRA, will not further endanger the continued existence of Indiana Bats.

The known range of the Indiana Bat overlaps all, or a portion, of active coal mining areas in the following States: Alabama, Arkansas, Maryland, Pennsylvania, Ohio, West Virginia, Virginia, Kentucky, Tennessee, Indiana, Illinois, Missouri, Iowa and Oklahoma. In all these States except Tennessee, coal mining is regulated by a State agency under laws and regulations determined by the Office of Surface Mining (OSM) to be no less effective than SMCRA and the Federal regulations. On an ongoing basis, OSM reviews and annually reports on State implementation of their regulatory programs to ensure that the responsible agencies are in compliance with their approved programs. Coal mining in Tennessee is regulated directly by OSM under a Federal regulatory program which ensures that the survival needs of Indiana Bats are met during coal mining processes.

OSM consulted with the U.S. Fish and Wildlife Service (FWS) under section 7 of the ESA with regard to the development of OSM's permanent regulations and also during the 1980s when it approved each State SMCRA regulatory program. However, in September 1994, OSM reinitiated consultation with FWS under section 7 to address two specific concerns:

- The initial section 7 "no jeopardy" opinions on State regulatory programs, issued by the FWS during the 1980s as part of OSM's approval of State programs, only addressed species listed at the time those opinions were issued.

- The concept of "incidental take" did not exist at the time of the initial "no jeopardy" opinions.

On September 24, 1996, the FWS completed its review of OSM's request for formal consultation and issued a Biological Opinion regarding the impact of current and future surface coal mining operations on listed species. In the Biological Opinion, FWS concluded that surface coal mining and reclamation operations, conducted in accordance with properly implemented Federal and State regulatory programs under SMCRA, are not likely to jeopardize the continued existence of listed or proposed species and designated or proposed critical habitats. The Biological Opinion also included an Incidental Take Statement that authorized the taking of a limited, but unquantifiable, number of listed individuals when the taking is incidental to, and not the intended purpose of, the surface coal mining and reclamation operations. In addition, the Biological Opinion identified specific Terms and Conditions that must be met by mining companies and SMCRA regulatory agencies, in order to minimize incidental take of listed species. Compliance with SMCRA requirements and the Biological Opinion ensures that mining companies and regulatory agencies will provide protection for the Indiana Bat during the coal mining process.

The Biological Opinion was based on and is consistent with the Federal SMCRA regulations. The Biological Opinion lays out responsibilities for all parties involved in the review and approval of mine permits and in the execution of mining activities. The following list includes each entity's major responsibilities:

State Regulatory Program

- Prior to approving any coal exploration permit, SMCRA permit or significant revision of a SMCRA permit, make a written finding that the exploration and reclamation activities or the proposed mining operation described in the permit application or revision will not jeopardize the continued existence of listed species or result in destruction or adverse modification of critical habitat of those species.
- Provide written notice to State and Federal fish and wildlife agencies whenever the agency receives an application for a new permit, significant revision of a permit or permit renewal.
- Upon request of FWS, provide resource information and the protection and enhancement plan to the FWS for review.
- Document consideration of all comments received in response to these notifications.
- Implement and require compliance with any species-specific protective measures developed by the FWS field office and the regulatory authority (with the involvement, as appropriate, of the permittee and OSM).
- Whenever possible, quantify the "take" of listed species resulting from activities carried out under the program. Whenever a dead or impaired individual of a listed species is found, contact the local FWS office within one working day of the discovery.
- Whenever the State Regulatory Authority decides not to implement one or more of the species-specific measures recommended by the FWS, it must provide a written explanation to the FWS. If the FWS does not concur, the issue must be elevated through the chain of command of the regulatory authority, the FWS and (to the extent appropriate) OSM for resolution.

Mining Company

- Provide fish and wildlife information at a scope and level of detail determined by the regulatory authority as necessary to develop a protection and enhancement plan that meets SMCRA requirements and complies with ESA.
- Develop an enhancement and protection plan that includes necessary measures that will be implemented during all phases of mining to minimize effects on listed species and other environmental resources,
- Comply with any species-specific protective measures included in the permit.

OSM

- Implement the requirements of SMCRA and the Biological Opinion in States where OSM is the regulatory authority (see responsibilities of State Regulatory Authority above).
- In primacy States, monitor compliance with the approved State program and the Biological Opinion's Incidental Take Statement's Terms and Conditions through program evaluation activities.
- When requested by the State Regulatory Authority or FWS, assist with resolution of disagreements regarding species-specific protective measures.

Implementation of the Biological Opinion by OSM and the States

State and OSM coal mining regulatory programs carry out their responsibilities under the Biological Opinion through the permitting and performance requirements of their approved programs. OSM performs additional functions that ensure primacy State implementation of the Biological Opinion through a combination of training, technical assistance, technology transfer, and program evaluation activities. The following are basic components of this course of action.

1. Development of Species-Specific Protective Measures and Conservation Guidelines

Species-specific protective measures are included in SMCRA permits when it is determined by the regulatory authority (State or Federal), after consultation with the FWS, that Indiana Bats may be present on a permit area at some point during the year.

In recent years, some States and the OSM Tennessee Federal Regulatory Program have been working with FWS to establish standard State-wide practices for protection of Indiana Bats on coal mines. At least one State also has entered into a Memorandum of Understanding regarding general coordination under the Biological Opinion. The following are some examples of regulatory authority-FWS coordination efforts:

- For several years, Kentucky has had a detailed policy document in place for use by coal mining companies and State program staff in developing and reviewing coal mine permit applications. The policy was developed in consultation with FWS, OSM and the coal mining industry and is in use today. However, a few aspects of the policy statement still require resolution by the FWS and Kentucky.
- In August, 2003, the State of Ohio, OSM, and FWS finalized and signed a June 2003 Memorandum of Understanding for agency coordination on protection and enhancement of endangered species. This document addresses how the agencies will cooperate on endangered species issues under the State SMCRA program. In February 2004, Ohio sent a policy/procedure directive on the subject, "Measures for Protecting the Endangered Indiana Bat," to all coal mining companies and mining consultants in the State. This document, developed in consultation with FWS, provides guidance to coal mining permit applicants for meeting the permitting and performance standards specific to the Indiana Bat.
- The OSM Knoxville Field Office (KFO) enforces SMCRA in Tennessee under a Federal regulatory program. KFO is working with FWS on a set of species-specific protective measures for Indiana Bats. FWS has, in cooperation with KFO, completed a draft of the measures which KFO is now reviewing. After its review, KFO will forward the draft measures to other agencies and to mining industry representatives for their comments. The protective measures will be issued in the form of a conservation guidance document for industry and OSM personnel to follow when preparing and reviewing permits involving Indiana Bat habitat.
- The State of Indiana is implementing a draft set of species-specific protective measures entitled, "Indiana Bat Conservation Measures for Surface Coal Mining in Indiana." which reflect extensive consultations between FWS, OSM and the State Regulatory Authority. A draft has been presented to the mining industry for their comments. Comments and other pertinent information will be reviewed and used by State and FWS management to finalize the guidance document.
- Illinois has had a draft Indiana Bat Policy in place for a number of years, which outlines general conditions and considerations for mine permit applicants to follow in developing Indiana bat protection and enhancement plans.

During 2004, several other States were discussing with their respective FWS field offices whether, and to what extent, programmatic Indiana Bat protective measures and conservation guidelines will be developed. In the absence of such agreements, States continue to conduct permit-specific consultations and to follow the requirements of the Biological Opinion, outlined above.

2. Trai ning

In January 2002, OSM began developing a training course for implementing the 1996 Biological Opinion in partnership with FWS and State regulatory program staff. The first course was taught August 6, 2002. By September 30, 2004, 128 people had received this training, including: 57 State, 33 OSM and 38 FWS personnel from 18 different States. The three-day course provides participants with a fuller understanding of the 1996

Biological Opinion, the underlying regulatory requirements and how the Biological Opinion is intended to operate. At the conclusion of this course, students should be able to:

- Describe the function of the Biological Opinion and how it relates to permitting actions under SMCRA;
- Explain when and how the SMCRA permitting authority must solicit and consider input from the State and Federal agencies with responsibility for fish and wildlife;
- Identify ESA-related resource materials pertinent to permit application preparation and analysis;
- Summarize ESA requirements and how they should be integrated into the SMCRA permitting process;
- Describe the responsibilities of both the regulatory authority, and the State and Federal fish and wildlife agencies under the Biological Opinion;
- Explain what the Biological Opinion means when it refers to species-specific protection measures, and, also, which agency is responsible for developing these measures;
- Explain the conflict resolution process that should be followed when the regulatory authority elects not to adopt a recommendation from the responsible fish and wildlife agency concerning species-specific protection measures;
- Explain what impact a disagreement concerning adoption of a species-specific protection measure would have on the regulatory authority's ability to proceed with a proposed permitting action, and
- Identify and explain the actions enumerated in the Terms and Conditions section (pp. 13-14) of the Biological Opinion, including an explanation of what measures the regulatory authority must take if it is possible to quantify the incidental take associated with each permitting action.

OSM also conducts other training courses that contribute to the effective implementation of the Biological Opinion. A course on the preparation of permit findings teaches participants to properly document the findings they must make in order to approve a surface coal mining permit, including the finding regarding impacts to listed species. Courses in analysis under the National Environmental Policy Act provide guidance and training in analyzing and documenting environmental reviews for projects and permits. These three courses contribute to the protection of Indiana Bats through the education of SMCRA program personnel.

3. OSM Evaluation of State Programs

OSM ensures compliance with the Terms and Conditions of the Biological Opinion through a combination of technical assistance, ongoing oversight and special studies. Ongoing oversight includes OSM inspector reviews of mining permits, vegetation plans and on-the-ground results during the mine-site inspections, as well as routine oversight coordination meetings. The oversight inspection process begins with the inspector review of State permit files prior to departing for field inspections. Mining operations are then inspected to ensure that permit conditions and overall mining plan requirements are met "on the ground." Thus, OSM inspectors ensure that Indiana Bats are protected during mining by reviewing the fish and wildlife protection and enhancement plan prior to performing the inspection, by looking for evidence of the required protection measures in the field and by participating in bond release inspections after the completion of reclamation.

An oversight review of permit findings was one of OSM's national priority program evaluation areas in 2000 and 2001. OSM efforts ranged from special studies to regional technology transfer events designed to improve State documentation of permit findings, including those related to fish and wildlife resources.

Special studies often are performed by OSM in partnership with State program staff to address specific topics identified during the evaluation year. During the evaluation years of 2000 to 2003, special studies were conducted in nine States where coal mining and Indiana Bats overlap. Studies covered a variety of topics associated with endangered species and implementation of the 1996 Biological Opinion. Where needed, OSM oversight personnel followed up on these evaluation findings with additional studies and assistance efforts to ensure that any program weaknesses were addressed promptly by State regulators. There also will be special studies to address compliance with the Biological Opinion in other States during 2005.

4. The Problem Elevation Process

The Biological Opinion requires each State Regulatory Program to work with the FWS to determine if species-specific protection measures are necessary and, if so, to develop these measures in consultation with the FWS. OSM is involved in the process to the extent necessary and appropriate. The Biological Opinion provides for the following action when the State Regulatory Program decides not to implement measures recommend by the FWS. It reads:

> "Whenever the regulatory authority decides not to implement one or more of the species-specific measures recommended by the Service, it must provide a written explanation to the Service. If the Service field office concurs with the regulatory authority's action, it will provide a concurrence letter as soon as possible. However, if the Service does not concur, the issue must be elevated through the chain of command of the regulatory authority, the Service, and (to the extent appropriate) OSM for resolution."

OSM may become aware of the need for agency involvement in this process in one of two ways: through its oversight examination of the findings made by the State Regulatory Authority or by receipt of a written request from either the State or FWS. FWS non-response concerning a State Regulatory Authority's decision does not, by itself, cause OSM to intervene in the negotiation process. OSM assists in the resolution of issues when requested by either the State or the FWS field office.

5. OSM Technology Transfer

OSM has sponsored three national interactive forums on bats and mines, including the latest one, "Indiana Bats and Coal Mining," to educate the regulatory community on the issues important to protection of the Indiana Bat. State Regulatory Authorities, along with State and Federal wildlife agencies and experts from the academic community, work together to develop and carry out these educational forums on bat protection issues.

6. Other OSM Technical Assistance to State Regulatory Authorities

OSM works with State Regulatory Authorities to facilitate the open exchange of ideas between Federal and State staff. For example, OSM has been working with FWS and the Indiana Division of Reclamation since 2001 to develop State-wide species-specific protection measures for Indiana Bats in that State. OSM staff encourages all States to maintain open and regular communication with FWS personnel on Indiana Bat issues to ensure the best protection possible for the Bats during coal mining operations.

Summary

In the 1996 Biological Opinion, FWS concludes that surface coal mining and reclamation operations, conducted in accordance with properly implemented Federal and State regulatory programs under SMCRA, are not likely to jeopardize the continued existence of listed or proposed species, and are not likely to result in the destruction or adverse modification of designated or proposed critical habitats. The Biological Opinion also includes an Incidental Take Statement which allows for the incidental take of a protected species, since the take is not the intended purpose of the surface coal mining operations. It also includes specific Reasonable and Prudent Measures and Terms and Conditions that must be met, in order to remain exempt from the prohibitions against take contained in section 9 of ESA. Additionally, the Biological Opinion contains specific provisions for resolution of disagreements between the State Regulatory Authority and FWS concerning implementation of species-specific protection measures recommended by FWS.

Thus, provided that the regulatory authority complies with its approved program and the Terms and Conditions of the 1996 Biological Opinion, OSM believes that, with respect to the Indiana Bat, the requirements of ESA are being adequately met and that the species is being protected during the approval and conduct of surface coal mining and reclamation operations.

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U.S. ARMY CORPS OF ENGINEERS CONSULTATION PROCESS

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Abstract

Section 301(a) of the Clean Water Act (CWA) generally prohibits a “discharge of a pollutant” unless you have obtained, and comply with, a permit issued under the CWA. Surface coal mining related activities conducted in streams and wetlands typically will result in addition of dredged or fill material. For example, placement of excess spoil in valley fills, construction of slurry impoundments, mine face-ups, dams for sediment ponds, road crossings, and in-stream mining that requires discharges of fill material into waters of the United States, require the need to get a permit under CWA § 404. Section 404 of the CWA, authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue permits for such materials. The scope of analysis of the U.S. Army Corps of Engineers (Corps) evaluation of surface mining projects pursuit to the National Environmental Protection Act (NEPA) is focused on the “direct and indirect, and cumulative effects of fills in waters of the U.S.” In other words, the Corps analysis is restricted to considerations regarding impacts to the aquatic environment. The Clean Water Act and the 404(b)(1) guidelines have different environmental standards than does SMCRA regarding impacts to aquatic functions and values. Therefore, requirements under SMCRA may not adequately address impacts to the aquatic environment in the context of § 404. The CWA § 404 permitting decisions by the Corps require compliance with other Federal laws, such as the ESA. Under NEPA, an activity that requires a Federal action (i.e. permit authorization) creates a nexus requiring coordination between Federal agencies. It is this requirement that obligates the Corps to coordinate with the USFWS regarding potential impacts to endangered species. The majority of permit coordination between U.S. Army Corps of Engineers (USACE) with U.S. Fish and Wildlife Service (USFWS) involves informal ESA Section 7 consultation. The Corps recognizes USFWS as the subject matter experts and seeks appropriate comments and recommendations to ensure the Corps determination of no jeopardy to a Federally listed species or no degradation or adverse modification of critical habitat.

Introduction

The Department of the Army (DA) regulatory program is one of the oldest in the Federal Government. Initially it served a fairly simple, straightforward purpose: to protect and maintain the navigable capacity of the nation's waters. Time, changing public needs, evolving policy, case law, and new statutory mandates have changed the complexion of the program, adding to its breadth, complexity, and authority.

Statutory Authorities

The goals and objectives of the Clean Water Act (CWA) are to maintain and improve the physical, chemical, and biological integrity of our nation’s waters. In order to fulfill these goals, Section 301(a) of the CWA generally prohibits a “discharge of a pollutant” unless you have obtained, and comply with, a permit issued under the CWA. You are generally subject to the requirement to obtain a CWA permit if the activity occurs in a regulated “water of the United States” (33 CFR 328.3), for example navigable waters plus their tributaries and adjacent wetlands. Secondly, the activity must result in the addition of a pollutant. The U. S. Army Corps of Engineers (Corps) regulates the “discharge of dredged or fill material” under § 404. The Environmental Protection Agency (EPA) or State delegated authority regulate “all other pollutants” such as effluent standards under § 402.

Types of Authorizations

Mining related activities conducted in streams or wetlands typically will result in the addition of dredged or fill material and thus need a § 404 permit authorization from the Corps. Examples include the placement of excess spoil in valley fills, construction of slurry impoundments, mine face-ups, dams for sediment ponds, road crossings, and in-stream mining. There are two types of permits available under § 404: individual permits and general permits.

Individual permits involve a project-specific review, public notice, and must comply with the 404(b)(1) Guidelines. Part of the individual permit decision-making includes the Corps public interest balancing process. The public benefits and detriments of all factors relevant to each case are carefully evaluated and balanced. Relevant factors may include conservation, economics, aesthetics, wetlands, cultural values, navigation, fish and wildlife values, water supply, water quality, and any other factors judged important to the needs and welfare of the people. The following general criteria are considered in evaluating all applications: 1) the relevant extent of public and private needs; 2) where unresolved conflicts of resource use exist, the practicability of using reasonable alternative locations and methods to accomplish project purposes; and 3) the extent and permanence of the beneficial and/or detrimental effects the proposed project may have on public and private uses to which the area is suited. No permit is granted if the proposal is found to be contrary to the public interest.

General permits are available for categories of activities that are similar in nature and will cause only minimal adverse individual or cumulative effects. General permits may be issued on a nationwide, regional, or Statewide basis and provide an expedited means for permitting the covered categories of activities. Nationwide permits are issued by the Chief of Engineers through the Federal Register rulemaking process. On January 15, 2002, the Corps issued Nationwide Permit (NWP) 21. NWP 21 authorizes the discharge of dredged or fill material into waters of the United States associated with surface coal mining and reclamation activities provided the activities are authorized by DOI, OSM, or States with approved programs under Title V of the Surface Mining Control and Reclamation Act of 1977 provided the permittee notifies the District Engineer in accordance with the "notification" general condition. In addition, to be authorized by this nationwide permit, the District Engineer must determine the adverse environmental effects associated with the activities are minimal both individually and cumulatively and must notify the project sponsor in writing. NWP 21, like other general permits, expires every five years and is set to expire on March 19, 2007.

Preapplication Consultation

The Corps strongly encourages a pre-application consultation with applicants at the earliest practical stage to inform them of preconstruction notification requirements and to coordinate with the SMCRA permitting agency. Early coordination avoids potential conflicts with other permitting agencies requirements and avoids unnecessary delays and minimizes data collection. The Corps will often conduct a site visit to the affected aquatic environment and discuss potential mitigation options during the preapplication consultation. The Corps asks applicants if Endangered Species Act (ESA) issues were coordinated with United State Fish and Wildlife Service (USFWS) and SMCRA permitting authority through the 1996 Programmatic Biological Opinion or regional species-specific guidelines.

USFWS Consultation

Permitting actions approved by the State SMCRA regulatory authority are not considered as Federal actions and do not normally require adherence to the National Environmental Protection Act (NEPA). In most cases, the Corps will be the only Federal agency involved in permitting a proposed mining-related activity and as such, will be responsible for compliance with NEPA. Under NEPA, an activity that requires a Federal action (i.e. permit authorization) creates a nexus requiring coordination between Federal agencies to ensure compliance with other statutes such as ESA. The Corps recognizes USFWS as the subject matter experts and seeks appropriate comments and recommendations to ensure the Corps determination of no jeopardy to a Federally listed species or no degradation or adverse modification of critical habitat.

The Corps initiates informal consultation with the USFWS when the PCN or public notice of the proposed action is sent for agency coordination. Under Section 7 of the ESA, Federal agencies must consult with USFWS when any action the agency carries out, funds, or authorizes (i.e. 404 permit) may affect a listed endangered or threatened species or may adversely modify or degrade designated critical habitat. The majority of all Section 7 consultations between the Corps and USFWS are informal consultations, with the proposed action resulting in a not likely to adversely affect determination. If it is determined that the proposed action is likely to adversely affect a threatened or endangered species, then formal consultation procedures would be requested by the Corps. Formal consultation may last up to 90-150 days, resulting in a Biological Opinion on whether the action will result in jeopardy. When USFWS makes a jeopardy determination, they also provide reasonable and prudent alternative actions. In the cases where USFWS makes a determination that the action may adversely affect a species, but not jeopardize its continued existence, USFWS prepares an incidental take statement provision.

The Clean Water Act 404(q) Memorandum of Agreement Between the Department of the Army and Department of the Interior, which was signed in 1992, establishes policies and procedures to "minimize, to the maximum extent practicable, duplication, needless paperwork, and delays in issuance of permits." The Memorandum also establishes coordination procedures; mechanisms for elevation of policy issues and individual permit decisions for review.

The Corps will fully consider the Department of the Interior (DOI) comments when determining compliance with the National Environmental Policy Act, the 404(b)(1) Guidelines, and other relevant statutes, regulations, and policies. The Corps will also fully consider the DOI's views when determining whether to issue the permit, to issue the permit with conditions and/or mitigation, or to deny the permit. Lastly, the U.S. Army Corps of Engineers is solely responsible for making final permit decisions pursuant to Section 404(a), compliance with Corps permit regulations, Section 404(b)(1) Guidelines, and Section 7(a)(2) of the Endangered Species Act.

Todd Hagman grew up in the coalfields of Western Kentucky along the Green and Ohio Rivers. He has been on staff at the Eastern Kentucky Regulatory Office of the U.S. Army Corps of Engineers, Louisville District since 2002. Since that time, he has helped develop the Eastern Kentucky Stream Assessment Protocol and serves as Regulatory Specialist on CWA § 404 permits in the Eastern Kentucky Coalfields. Prior to starting work with the Corps of Engineers, he was employed as an ecological consultant conducting aquatic biological assessments and endangered species surveys and monitoring. He received his Bachelor of Science in Wildlife Management and Master of Science in Biology degrees from Eastern Kentucky University specializing in aquatic ecology.

THE CONSULTATION PROCESS: STATE FISH AND WILDLIFE AGENCIES

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Abstract

The Surface Mining Control and Reclamation Act (SMCRA) requires that the regulatory agency notify State and Federal fish and wildlife agencies whenever the regulatory authority receives an application for a new permit, significant revisions to a permit, or a permit renewal [30 CFR 773.13, 774.13, 774.1]. The regulatory authority (RA) must also document consideration of all comments in response to these notifications. The Biological Opinion signed in 1996 clarified to some extent on how the regulatory authority would meet requirements of the Endangered Species Act (ESA). The consultation process for State fish and wildlife agencies varies greatly across the coal region in implementation. However, there are many things in common. Each State RA notifies the appropriate State and Federal fish and wildlife agencies when they receive new applications, significant revisions or a permit renewal. Each State RA must make a finding that the operation will not affect the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitat [30 CFR 773.15 (j) or 1996 BO pg 9]. Each State requires that the operator minimize disturbances and adverse impacts on fish wildlife and related environmental values, including compliance with the Endangered Species Act. Applications must also include a plan for enhancement of these resources where practicable. Where the consultation process varies is in participation of each State's Fish and wildlife agency. The level of participation varies from very high. For example, one State has a State Fish and Wildlife employee dedicated to SMCRA issues actually based in the RA office. Others have very low participation from their State Fish and wildlife agency. Contact is limited to the notification letters. Fish and wildlife issues are handled by the RA's staff biologist usually in close consultation with the U.S. Fish and Wildlife Service (USFWS). In implementing the Biological Opinion to comply with the ESA, some States have begun the formal process of establishing species specific protective measures for the Indiana Bat. The most common restriction at this time is set tree clearing dates to avoid summer roosting habitat and maternity sites. Ohio has adopted a comprehensive species specific plan for the Indiana Bat. Indiana and Kentucky are going through the process of developing a plan in consultation with USFWS, State fish and wildlife agencies and the State RA. Other States will soon be developing plans of their own.

SMCRA and the Endangered Species Act

Signed into law August 3 1977, the Surface Mining Control and Reclamation Act (SMCRA) was the first Federal statute specifically directed toward the regulation of the environmental impacts associated with surface coal mining. States could achieve primacy (or become the primary regulatory authority) by developing there own laws that were at least as stringent as SMCRA and obtain approval from the Office of Surface Mining OSM. SMCRA requires coordination with the requirements for other Laws such as the Endangered Species Act (ESA), The Migratory Bird Treaty Act, Fish and Wildlife Coordination Act and the Bald Eagle Protection Act. The Act also requires site specific information when the permit or adjacent area is likely to include listed or proposed endangered or threatened species. The scope and level of detail must be determined by the regulatory authority (RA) in consultation with State and federal agencies with fish and wildlife responsibilities. SMCRA requires that the RA find in writing that mining activities will not jeopardize the continued existence of an endangered or threatened species as a result in the destruction or adverse modification of critical habitat of those species. Each permit application will include a description of how the operator will minimize disturbance and adverse impacts on fish and wildlife and related environmental values. The application must also include a plan for enhancement of these values where practicable. It prohibits the taking of an endangered or threatened species in violation of the ESA and prohibits mining activity, which is likely to jeopardize the continued existence of endangered or threatened species.

Biological Opinion

The Biological Opinion signed in 1996 clarified to some extent on how the regulatory authority would meet requirements of the ESA. The Biological Opinion has three terms and conditions to comply with the ESA:

- The RA must implement and require compliance with any species-specific protective measures developed by the service field office and the RA (with involvement, as appropriate of the permittee and OSM)
- Whenever possible the RA must quantify the take resulting from activities carried out under this program. Whenever a dead or impaired individual of a listed species is found, the local Service office must be notified within 1 working day of discovery.
- Whenever the regulatory authority decides not to implement one or more of the species specific measures recommended by the service it must provide written explanation to the Service. If the service field office concurs with the RA's action it will provide a concurrence letter as soon as possible. However, if the Service does not concur, the issue may be elevated through the chain of command of the regulatory authority, the Service and possibly OSM for resolution.

In implementing the biological opinion to comply with the ESA some states have begun the formal process of establishing species-specific conservation measures for the Indiana Bat. The most common at this time is the seasonal tree clearing to avoid the summer roosting habitat and maternity sites. Ohio has adopted a plan for the Indiana Bat. Indiana and Kentucky are going through the consultation process of developing their own plans in consultation with USFWS, State wildlife agencies and the State RA.

The Consultation Process

So SMCRA, ESA and the Biological Opinion set the stage for the consultation process. The Consultation process for State fish and wildlife agencies varies greatly across the coal region in implementation, however there are many things in common. The notification process is the same across the region:

- Each RA notifies the State fish and wildlife agency on new applications, significant revisions and permit renewals.
- Each state is required to make the finding that mining activities will not jeopardize the continued existence of an endangered or threatened species or result in the adverse modification of their critical habitats as determined under the ESA.
- Each state requires the operator to minimize disturbance of and adverse impacts on fish, wildlife and related environmental values.
- Each state requires that the operator enhance where practicable and restore habitats of unusually high value for fish and wildlife.

Where the state programs differ is on the level at which the state fish and wildlife agency participates in the process. Some states have the minimum amount of participation. For example: Arkansas Game and Fish commission redirect reviews of threatened and endangered species to the Service for comment. Mississippi Department of Wildlife, Fisheries, and Parks comment by listing state and federal listed species within several miles of the permit area. Generally the states with the minimum amount of State input do not have a large coal program in the state.

Most states fall into the Average participation category. The State wildlife agencies in Illinois, Kentucky and Virginia all make substantive comments on the permit application with the State RA's staff biologist coordinating these comments. In the case of KY and VA, the wildlife agencies also make pre-mining site visits with the state RA. The state agency is very involved.

Indiana is an example of a state wildlife agency with the maximum participation. The State Fish and Wildlife agency has a biologist located at the state RA's office. This person is also the RA's staff biologist completing the wildlife reviews on each permit application that is submitted. The comments are included in the modifications letter. Site visits are made pre-mining, when schedules allow in coordination with the USFWS service. Reviews of new permits, renewals, significant revisions, land use changes, incidental boundary revisions, and applicable non-significant revisions are routed through the biologist. The State RA is also involved at the time of revegetation and final bond release. The biologist field checks almost every bond release dealing with wildlife or forest to evaluate its success and verify vegetation surveys. When reviewing a plan for its impacts to T & E species there are important issues that should be addressed.

Minimizing Habitat Loss for Non-Extraction Activities

Endangered species issue for surface coal mines. There are ways to minimize impact to habitat and still recover the coal. When developing the operations plan minimize habitat loss for non-extraction activities**:**

- Design stream and flood plain crossings for haul roads and equipment access where the habitat is narrowest. Construct sediment ponds in drainageways where substantial tree clearing is not necessary. Locate soil stockpiles, diversion ditches and processing areas where tree clearing would be minimal.
- Try to avoid edge habitat by Auger mining where practicable. Where an operation plan indicates tree clearing may not be necessary (no coal seam underlying portions of forest) follow FWS timber management guidelines for Indiana bats and keep disturbance minimal.
- Conduct seasonal tree clearing during the non-occupancy season.
- Try to maintain the existing forest until the last nonoccupancy season before mining, instead of clear-cutting years ahead of the mining process. Or have a qualified biologist approved by the FWS mark potential roost trees, and remove these trees during the nonoccupancy season thus still maintaining the foraging habitat but minimizing the potential take of the species.

Reclamation Planning

There are also some important considerations when developing the reclamation plan:

- The tree species planting mix should contain a mixture of known potential roost tree species for example Oak, Elm, Maple Hickory. The list should also include some faster growing species to provide a foraging matrix and travel lanes as quickly as possible.
- Restoration of riparian habitat should be equal to or greater than what existed pre-mining.
- The plan should provide connectivity to adjacent stands of undisturbed forest and all reclaimed habitat by establishing travel lanes such as fencerows along agricultural fields.
- Try to minimize compaction of the root zone to promote tree growth.

These are all strategies that can be used to have a more bat friendly mining operation.

Mitigation

One last thing that can be included here is mitigation: Mitigation could be accomplished in a variety of ways:

- To compensate for temporal habitat loss, habitat replacement could be required to be greater than 1:1 established on a site-by-site basis based on the quality of the affected habitat.
- Long-term easements could be established for forest replacement.
- Nearby unaffected habitat could be protected while reclaimed habitat matures.
- These mitigation strategies would work best if landowner incentives could be found for them to place their private property into these types of restrictive covenants.

Successes for Indiana.

Rick Clawson's presentation indicated that the species is on the rise in Indiana. Seasonal tree clearing is standard in almost all permits with any forest habitat. Tree species selection has improved over the last 5 years with more desirable trees being planted, sometimes with the emphasis on the more bat friendly species. It has been my observation that tree survival has also increased I believe due to better planting methods with strip killing ground cover prior to planting and experienced tree planters. Our coal operators are working to actually get approval to plant trees on prime farmland. This is a big step for highly agricultural Indiana.

Our biggest challenge is trying to develop species-specific measures for the bat. We've been working at least 2 years in conjunction with OSM and the FWS on the project and have come to a stand still. The plan that OSM, FWS and Indiana Division of Reclamation have developed is now out to the Indiana coal mining industry for review and comment. Hopefully we will have a signed functioning plan sometime in 2005.

Ramona Briggeman is the Reclamation Biologist for the Indiana Division of Fish and Wildlife. Prior to becoming the Reclamation Biologist for the Division of Fish and Wildlife, she was a Reclamation Specialist (mine inspector) for Indiana Division of Reclamation for 9 years. She received her Bachelor of Science degree in Life Sciences from Indiana State University.

AN ENGINEERING VIEW OF THE POTENTIAL IMPACTS BY THE COAL MINING INDUSTRY ON THE INDIANA BAT

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Abstract

The coal mining industry is a much maligned industry and has been stereotyped by both the media and environmental groups as unfriendly to citizens, environment, and most anything else. Sadly, past mining practices did little to offer support in defense of these claims. However, since the enactment of the Surface Mining Control and Reclamation Act of 1977 (SMCRA), coal mining has been moved to a highly engineered level of design and operation that has allowed for mining companies to extract coal from the earth in ways that are environmentally friendly and safe for local citizens. This report details the history and planning that has evolved in the protection of the Indiana Bat (Myotis sodalis) and gives an engineering view as to past and current successes and failures and possible future research efforts.

Introduction

I am honored to have been selected by our Session Chair, Dr. Richard Wahrer, to speak to this Conference today to present the Coal Industry's perspective with regards to the Indiana Bat. My name is Timothy C. Howard and I am President of Howard Engineering and Geology, Inc. in Harlan, Kentucky. Howard Engineering and Geology, Inc. has specialized in regulatory permitting with regards to coal mining issues in the Appalachian Coal Basin for over fifteen years.

I have been asked to represent the Coal Industry during this forum, however, my appearance today is not on behalf of any Coal Organization and my discussion today will be based on my company's views as to the relationship between coal mining activities and the protection of the Indiana Bat. I will focus on the impact that coal mining has on the Indiana Bat, the impact that the Indiana Bat has on coal mining, discussion of the Regulatory Agency's policies and guidelines, and of changes in policy that need exploring. My discussion will have a Kentucky flair, as most of the work performed by our firm deals with Indiana Bat issues in Eastern Kentucky.

The Impact on the Indiana Bat from Coal Mining

The territory of the Federally protected Indiana Bat is known to cover the vast majority of the Midwest with roost caves existing from Missouri to Ohio. My discussion will center on known populations that have been identified in underground cave networks located in the limestone formations that outcrop on the north slope of Pine Mountain in Harlan and Letcher Counties, Kentucky and underground cave networks located on the Brush Mountain in Bell County, Kentucky. It is these populations that have been impacted by coal mining activities in Eastern Kentucky. It is known that the Indiana Bat leaves its winter hibernacula for the summer. It is known that the Indiana Bat will roost and bear young in select loose bark or hollow trees. It is also known that the Indiana Bat will use abandoned mine adits as temporary summer shelter. It is the Bat's use of tree roost and the use of abandoned mine adits that has come under close scrutiny by the regulatory agencies.

Regulatory agencies have rushed to the rescue of the Indiana Bat in fear that coal mining activities are devastating the summer tree roost habitat. These agencies have formulated policies and guidelines that bat enhancement plans be incorporated into the Kentucky coal mine permits that would restrict the timing of the tree clearing for planned coal mining activities and force the mining companies to restock the mined areas with suitable loose bark tree species. In addition, these plans call for the installation of "bat houses" and the "girdling" or ringing of trees adjacent to the planned mining in an effort to increase the roost tree numbers. Everyone has expressed concern about the loss of the roost trees, however, to our knowledge, no agency has performed a study to determine if this loss, as a result of coal mining, has been dramatic. In work performed for our clients, it has been estimated that the frequency of "potential roost trees" is in excess of twenty (20) trees per acre of woodlands. This is based on biologist field examinations and markings for tree clearing in advance of planned coal mining. This is a tremendous number. Given this estimation, my firm has calculated that in excess of 3.5 million potential roost trees exist in Harlan County, Kentucky alone! Easily, it can be seen that coal mining will not have a dramatic effect upon the loss of potential roost trees. In addition, the loss of potential roost trees is only temporary in mined areas. Planned reclamation by the mining companies provide for the restocking of tree species that will only increase the frequency of potential roost trees.

Regulatory Agencies have also voiced concern over the loss of abandoned mine adits within planned coal mining that could support populations of the Indiana Bat. However, these agencies have developed what the coal industry feels are detailed portal closure plans that provide for safe closure of these adits to minimize any potential Indiana Bat taking. These plans are very straightforward but are seasonally restrictive.

The Impact on Coal Mining from the Indiana Bat

The restrictions that have been placed upon the coal industry as a result of the presence of the Indiana Bat are dramatic and far reaching. Regulatory agencies have come together in Kentucky to formulate guidelines for coal mining companies that fall within a specified radius of a known winter hibernacula of the Indiana Bat. Once a mining project has been deemed within this specified radius, the company has the option of mist netting specified areas of the planned mining to determine if any Indiana Bats are present or the company can "assume presence" of the Indiana Bat within the planned mining area and formulate plans to provide a "Protection and Enhancement Plan."

Mist netting offers the operator a definite determination as to whether the Indiana Bat is present within the project area. Pre-selected areas can be netted and, if no Indiana Bats are identified, the mining company can proceed with the project without restriction, except for the implementation of the reclamation enhancement provisions. This has been the advised option to our clients, provided the project planning allows for the restrictive netting dates. Mist netting can also add substantial costs to the project budget.

If the mining company is restricted by planning and mist netting is not feasible, the regulatory agencies have developed an "Assumed Presence" plan that allows for the mining company to forgo any field collection and assume that the Indiana Bat is present in the project area. By assuming presence, the mining company is obligated to incorporate a "Bat Protection and Enhancement" plan into the reclamation permit application. This Protection and Enhancement plan outlines many guidelines. Among them are; restrictive dates for the clearing of trees within the mining project area; incorporation of selective shag bark tree species into the re-forestation plan of the mining permit; girdling of select trees adjacent to the mining project area; and the implementation of stream buffer zones on intermittent and perennial streams.

The clearing of trees under an Assumed Presence determination is restricted to a time frame from November 15th through March 31st and the mining company can choose to retain biologists to mark only "Potential Roost Trees" within the project area or the mining company can choose to clear cut the entire area of planned mining for the next calendar year. Most mining companies initially retained biologists to mark roost trees within the project area, but experience has shown that the frequency of roost trees is such that clear cutting of the entire area was a more viable option. This has resulted in wholesale clear cutting of entire mountain sides, hollow fills, and mountain tops in advance of the planned mining. Our finding has been that this restriction creates a greater overall environmental harm than the protection it provides to the Indiana Bat.

The Enhancement and Protection Plan also restricts disturbance of the buffer zone near all intermittent and perennial streams within the planned mining area. Regulatory agency thinking is that these areas contain a higher probability of summer roosting due to their close proximity to water. However, surveys conducted for our clients have shown that most mining projects in Eastern Kentucky are located in the headwaters of intermittent or perennial streams and the stream gradients in these areas result in a fairly rapid stream velocity rate. These rapid velocity rates reduce the probability of shallow pool areas in the stream flow, areas in which a bat would find insects to feed. Surveys conducted for our clients have also shown shallow depression areas such as roadway rut depressions, pre-law strip mine pits and other areas in which water can collect and stand in a still state are prime habitat for bats to congregate and feed. One such area in which a netting of a young male Indiana Bat occurred was a well ventilated mine portal with a large pool of water immediately in front of the mine portal. This area has become a five star accommodation to any bat in the vicinity.

Discussion of Regulatory Agencies Policies and Guidelines

Currently, coal mining activities in Kentucky deemed within areas populated by the Indiana Bat fall under jurisdictional guidance of the United States Department of Interior, Fish and Wildlife Service and the Kentucky Department for Natural Resources, with input from the Kentucky Division of Fish and Wildlife Services. These three agencies have come together to develop the "Guidelines for the Development of Protection and Enhancement Plans for the Indiana Bat" that were published November 1, 2000. As noted earlier, these guidelines offer a straightforward policy on dealing with planned mining within areas populated by the Indiana Bat. However, it is our opinion that policy changes in the determination of whether a mining operation falls within these populated areas have not been straightforward. Initially, when the guidelines were issued, it was the consensus of the regulating authorities that only mining areas within a three (3) mile radius of known Indiana Bat hibernacula would fall under the Protection and Enhancement Guidelines. Currently, this radius has been extended to ten (10) miles. And now USFWS comments are recommending that all mining within the "natural range" of the bat adhere to these guidelines. To our knowledge, these increases are not substantiated with adequate and soundly proven research and studies. Clearly, it is the intent of USFWS to force all coal mining operations in Southeast Kentucky to adhere to the Protection and Enhancement Guidelines and to limit disturbances within intermittent and perennial streams through this guideline.

Discussion of Changes in Policy that Need Exploring

While the Kentucky "Guidelines for the Development of Protection and Enhancement Plans for the Indiana Bat" is a good starting point with regards to minimizing the potential taking of this protected species, in working with these guidelines, it has become apparent that some changes should be considered. Among them are:

- A review of the stream buffer zone restriction. Our experience shows that bats prefer to use still water bodies for water for feeding. These still water bodies offer a greater insect population over flowing intermittent or perennial streams. Consideration should be given to promote more shallow water depressions in the mining reclamation plans within areas populated by the Indiana Bat. This will only increase the feeding areas for the bats. Implementation of this buffer zone does little to promote the protection of the Indiana Bat, however, this buffer zone can cripple the feasibility of many mining projects.
- Clear cutting of timber in advance of planned mining. The guidelines as they are written offer no flexibility in the tree clearing dates in advance of planned mining. In order to avoid any interruption, most mining companies will clear much more timber than would be required, resulting in many areas being exposed to the natural elements with little or no vegetation. It is our opinion, this situation is much more environmentally damaging than the possibility of a protected species taking. It has already been discussed that the frequency of potential roost trees is high in the areas where a vast majority of coal mining takes place. Regulatory agencies need to reach a consensus on standard methods of tree sounding in order to allow for clearing of trees during summer roost periods. Many biologists feel that the sounding of trees in advance of cutting provides adequate warning and would result in ending the clear cutting of timber in advance of mining.
- Both the Mining Industry and the Regulatory Agencies need to lobby for research dollars for the study of the Indiana Bat. Identification of winter hibernacula, feeding habits, summer roost selection habits, flight habits and overall threat are all areas that need further study. Currently, limited research dollars exist for these studies and, unfortunately for the coal industry, a lack of study dollars has forced much of the research to be funded by the coal industry. Exact population counts are needed. The exact radius of known travel and the exact effect of the loss of summer roost trees both need to be studied. Support from both the environmental groups and the coal industry is needed to raise research dollars, no matter what the research reveals.

Conclusion

In closing, I want to stress that the coal industry is only one of many industries impacting the known areas populated by the Indiana Bat. Logging, residential development, commercial development, agriculture, and highway construction all pose a threat to the survival of the Indiana Bat. While coal mining and logging may result in a short term loss of summer roost habitat, this loss is only temporary and will be increased as a result of the planned enhancement guidelines. However, residential development, commercial development and highway construction are permanent in roost habitat loss. Agriculture poses, arguably, the greatest impact on the Indiana Bat due to the use of chemicals and pesticides in the growing processes. Unfortunately, these industries have largely received a pass by the environmental and regulatory community with regards to the protection of the Indiana Bat. The coal industry has been saddled as the culprit in the war to protect the Indiana Bat, when in fact, the coal industry may be aiding the increase in populations through the knowledge gained in enhancement plans involving the Indiana Bat.

Far too often, the coal industry is depicted as an exploiter; an exploiter of the workers, an exploiter of the community, and an exploiter of the environment. As with most other issues, the media focuses on the negatives that coal portrays. We see the workers that die from roof fall accidents, we see the devastation of a slurry impoundment collapse, we see moonscape pictures of mountaintop mining, and we see the articles of how “King Coal” has stripped the mountains of Eastern Kentucky of its’ wealth. But what you do not see is the explosion in the population of deer and turkey in Kentucky that is largely a result of the planned reclamation of mined lands. You do not see the coal industry’s support of the re-stocking efforts to bring Elk back to Eastern Kentucky; Elk that live and graze on reclaimed mine lands. You do not see the tax dollars that are pumped into State and local economies as a result of coal mining. You do not see citizens of the Commonwealth of Kentucky being able to buy groceries tax free; tax free because of the coal severance tax. You do not see the municipal water systems delivering drinking water to the citizens of Eastern Kentucky; water systems being constructed as a result of grants from fees collected by the Office of Surface Mining on mined coal. You do not see a bright young student receive the opportunity to attend college as a result of the numerous scholarships provided by the coal industry. And you do not see a worker, who was born and raised in Eastern Kentucky, make a good salary to support his family without having to leave his home and region. The coal industry you see today is not the coal industry of yesteryear. Today’s coal industry strives to be a good steward of the environment and corporate friend to the community.

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Session 4

Case Studies

Session Chairperson:
Bill O'Leary
Illinois Office of Mines and Minerals
Benton, Illinois

Notable Roosts for the Indiana Bat (Myotis sodalis)
*William D. Hendricks, **Rebecca Ijames**, M. Muller, L. Alverson, J. Timpone, and N. Nelson, Ecological Specialties, LLC., Symsonia, Kentucky*

Indiana Bats in West Virginia: A Review
Joel Beverly and Mark W. Gumbert, Ermine, Kentucky

Portal Exclusion Protocols
Dr. Richard Sherwin, Department of Biology, University of New Mexico, Albuquerque, New Mexico

The Use of In-Lieu-Fees to Mitigate Bat Habitat Loss at the Bull Run Surface Mine, Virginia: A Case Study
Lance Debord and Heather McDonald-Taylor, D.R. Allen & Associates, Abingdon, Virginia

Indiana Bat Habitat Management & Mine Planning: An Industry Perspective
Bernie Rottman, Black Beauty Coal Co., Evansville, Indiana

NOTABLE ROOSTS FOR THE INDIANA BAT (*MYOTIS SODALIS*)

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John Timpone, Mike Muller, Nate Nelson, and John Smelser
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Abstract

During the field season of 2001, Ecological Specialties, LLC performed an investigation to determine the status of the Federally listed endangered Indiana bat (*Myotis sodalis*) on a project for a proposed concrete facility in Ste. Genevieve County, Missouri. During the period of 26 June through 15 August of 2001, 28 sites were mist netted. A total of 94 bats were captured representing six bat species. During the survey, 18 Indiana bats were captured, representing 19% of the total bat captures (Hendricks et al. 2001). During the summer of 2002, Ecological Specialties, LLC conducted a survey for a coal mine in McDonough County, Illinois. During the second and third weeks in June of 2002, two sites were mist netted. A total of 13 bats were captured, two of which were Indiana bats. The Indiana bat captures represented approximately 15% of the total capture for the survey (Hendricks 2002). During the summer of 2004, an Indiana bat survey was conducted as part of the proposed I-69 Section 6 corridor in Indiana. During the period of the second and third weeks in July of 2004, a total of 254 bats were captured, ten of which were Indiana bats (Hendricks et al. 2004).

Missouri Roosts

During the summer of 2001, Ecological Specialties, LLC conducted an endangered species survey for the proposed concrete facility for Holcim Inc. The majority of the study area was located in Ste. Genevieve County, slightly south of Saint Louis. The study area was approximately 3,900 acres in size. A total of 28 sites were mist netted during the period of 26 June through 15 August of 2001 (Hendricks et al. 2001).

A total of 94 bats were captured from the 28 sites during the survey. The six species captured consisted of big brown bats (*Eptesicus fuscus*, n=2), eastern red bats (*Lasiurus borealis*, n=12), northern long-eared bats (*Myotis* septentrionalis, n=48), Indiana bats (*Myotis sodalis*, n=18), evening bats (*Nycticeius humeralis*, n=10), and eastern pipistrelle bats (*Pipistrellus subflavus*, n=4). Eighteen Indiana bats were captured, 12 female and 6 male, yielding approximately 19% of the total captures (Hendricks et al. 2001).

The first roost found during the study was a large maternity roost found across the Mississippi River. The radio-tagged lactating females were tracked, going from the Beagle Island roost in Illinois, flying across the Mississippi River, to forage in the uplands of the Holcim site in Missouri. The roost was located in a dead Cottonwood (*Populus deltoides*) snag (Figure 1). On 2 July of 2001, 138 bats were counted emerging from the roost tree. The second emergence count taken on 15 July of 2001, 230 bats were counted emerging from the roost tree. The difference in numbers may be attributed to newly volant young. The final count taken in August of 2001 yielded no bats (Hendricks et al. 2001).

The second maternity roost found during this survey, was found in a wooden telephone/power pole (Figure 2&3). The top of the pole was split open where the large bolt was used to attach the upper insulator. The bats were seen emerging out of the roost from this split. In July of 2001, 17 bats were counted emerging from this roost on the first night. The second count, conducted in the middle of July, 2001, yielded 15 bats. A final count, taken in October of 2001, yielded 5 bats emerging from the roost. This roost is believed to be the first documented record of a maternity roost in a power pole (Hendricks et al., 2001).

A single male Indiana bat was tracked to the third roost found during this survey. This roost tree was located approximately thirty yards from an active railroad track (Figure 4). Three bats were counted emerging from this roost tree on this first night of emergence counts. The following night, the radio-tagged male moved to a second roost on the second night. A total of 21 bats were counted emerging from this second roost. Twelve additional bats were counted emerging from a tree adjacent to the second male roost found as well (Hendricks et al. 2001).

Illinois Roosts

During the summer of 2002, Ecological Specialties, LLC conducted an endangered species survey for the Freeman United Coal Company, located near the small town of Industry, Illinois. The survey area was located in portions of both McDonough and Schuyler counties in northwestern Illinois. During the first sampling effort, two sites were mist netted between 13 June and 15 June of 2002. The second area sampled also consisted of two mist net sites that ran along the Grindstone Creek. The second sites were mist-netted later, due to prior heavy rainfall, between 20 and 22 June of 2002 (Hendricks 2002).

A total of thirteen bats were captured during the survey. Eastern red bats (*Lasiurus borealis*, n=8), northern-long-eared bats (*Myotis septentrionalis*, n=2), Indiana bats (*Myotis sodalis*, n=2), and eastern pipistrelle bats (*Pipistrellus subflavus*, n=1) were the four species captured. Two gravid female Indiana bats were captured, radio-tagged, and tracked, making approximately 15% of the total captures (Hendricks 2002).

One maternity roost was located during this survey; both females were tracked to the same maternity roost along the edge of a bottomland clearing adjacent to Grindstone Creek. The roost was located in a dead American Elm (*Ulmus americana*) (Figure 5). The tree exited along a property boundary and was most likely deadened by a bulldozer upon clearing the property line. Forty-six bats were counted emerging from the roost. This was the first maternity roost found on an active mine in Illinois (Hendricks 2002).

Indiana Roosts

During the summer of 2004, Ecological Specialties, LLC conducted an endangered survey for the proposed I-69 section 6 corridor between Indianapolis and Martinsville, Indiana. The survey area was located in portions of Morgan, Johnson, and Marion counties. The length of the project was approximately 25 miles running along the existing Highway 37. A total of 29 sites were chosen to be mist netted, between 14 July and throughout the survey area (Hendricks et al. 2004).

A total of 254 bats were captured from the 29 net sites. The 254 individuals represented seven species consisting of big brown bats (*Eptesicus fuscus*, n=66), eastern red bats (*Lasiurus borealis*, n=25), northern long-eared bats (*Myotis septentrionalis*, n=21), Indiana bats (*Myotis sodalis*, n=10), little brown bats (*Myotis lucifugus*, n=72), evening bats (*Nycticeius humeralis*, n=29), and eastern pipistrelle bats (*Pipistrellus subflavus*, n=31). Ten Indiana bats were captured, six were female and four were males. Of the six females captured, five bats were radio-tagged and tracked. No males were tagged or tracked per guidelines of the study (Hendricks et al. 2004).

The first maternity roost found during our survey was located approximately 150 yards from the centerline of the existing Highway 37 (Figure 6). The roost was located in what appeared to be a Cottonwood (*Populus deltoides*) snag. The first night the roost was observed, a total 64 bats were counted emerging (Hendricks et al., 2004).

The second maternity roost found was located a large power pole (Figure 7). A total of 110 bats were counted emerging from this roost on the first night. The majority of the bats emerged from the lowest section of the left pole. The poles were wrapped in a form of black plastic sheeting, which was used to protect the poles from woodpecker damage. The bats were roosting underneath between the pole and the plastic sheeting. The following day, the radio-tagged female relocated to an alternate roost about 300 yards north-northeast of the pole. Twenty-nine bats were counted emerging from the second/alternate roost the following night. The alternate roost was located in a live Hickory (*Carya sp.*) tree. Upon emerging from the roost the bats seemed to head toward the power line corridor uphill (Hendricks et al. 2004).

The final roost located during this study was found in a dead Elm (*Ulmus sp.*), along the floodplain of the White River (Figure 8). The location of the roost was surrounded by agricultural land. A total of 15 bats were counted emerging from this roost (Hendricks et al. 2004).

Summary and Conclusion

The roosts information compiled both what is thought to be typical and non-typical roosts. The endangered species survey conducted in 2001, for the proposed Holnam (Holcim) Inc. concrete facility in Missouri, provided new and unusual insights about Indiana bat maternity roosts. Radio-tagged female Indiana bats were found roosting in Illinois, crossing the Mississippi River nightly, and foraging in Missouri. Ecological Specialties, LLC documented what is thought to be the first maternity roost found in a telephone/power pole. The same roost was the first maternity roost found south of the Missouri River in Missouri as well. The male roost, from the Holcim Inc. survey, was found within approximately thirty yards of an active railroad track (Hendricks et. al. 2001).The survey conducted for the Freeman United Coal Company during the summer of 2002, revealed the first Indiana bat maternity roost found on an active mine in Illinois (Hendricks and Alverson 2002). The survey conducted during the summer of 2004, as part of the I-69 expansion project uncovered a maternity roost located in a power pole in Indiana. Another roost found during the I-69 survey was located approximately 150 yards from the centerline of the existing highway 37, the proposed route for I-69 (Hendricks et al. 2004).

More and more, much attention is provided when dealing with the normal/typical maternity roost of the Indiana bat in dealing with concern for the survival and impact of them. But what about abnormal/non-typical maternity roosts? It would be interesting to know the number of man-made structures suitable for bat roosts, the number of telephone/power poles suitable for bat roosts; and, even more specifically, how many man-made structures (i.e. telephone/power poles, etc.) are suitable for and being used for Indiana bat roosts.

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Figures

Figure 1. Indiana bat maternity roost on island in Mississippi River.

Figure 2. Indiana bat maternity colony in A telephone pole in Missouri.

Figure 3. Close-up of Missouri Indiana bat maternity colony roost.

Figure 4. Male roost adjacent to railroad tracks in Missouri.


Figure 5. Indiana bat maternity roost at the Freeman Mine in Illinois.


Figure 6. Indiana bat maternity roost in Southern Indiana.


Figure 7. Maternity roost of the Indiana bat underneath plastic on power pole.


Figure 8. Maternity roost of the Indiana bat in a Fencerow adjacent to agricultural fields.

INDIANA BATS IN WEST VIRGINIA, A REVIEW

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Abstract

We reviewed peer-reviewed and non-peer-reviewed literature, and communicated with individuals working with the Indiana bat (*Myotis sodalis*) in West Virginia. Hibernating Indiana bats have been observed in as many as 32 West Virginia caves. The winter population is estimated at 10,770; an increase of 5,009 over the last 14 years. Three maternity colonies, representing nine roost trees, have been located in Boone and Tucker counties. Exit counts conducted at these trees ranged from 1 to 25 bats. Twenty-six roosts have been located for male Indiana bats, with exit counts ranging from 1 to 23.

Key words: Indiana bat, West Virginia, hibernacula, maternity colony, summer range, *Myotis sodalis*

Introduction

The range of a species is often influenced by climatic conditions, topography, geology, availability of food, and accessibility of suitable habitat. These variables can differ with season and geographic region. Species may respond to climatic changes, reduction of food, and changes in habitat condition in many ways. Some possibilities include adapting to the harsh condition of winter, hibernating, making regular seasonal migrations to separate summer and winter ranges, or migrating to specific areas to hibernate. Most species of North American bats seasonally move between summer breeding colonies and winter hibernating roosts, **(**Barbour and Davis 1969**)** leaving large portions of their range unoccupied during various seasons of the year. Among the variety of bat species in North America that exhibit such behavior is the federally endangered Indiana bat (*Myotis sodalis*).

The range of the Indiana bat extends throughout the eastern United States, mainly in association with major cave regions and areas north of the cave regions (Harvey et al. 1999). The species can be found from Vermont and northern New York southward through the Appalachian Mountains into northwestern Florida, expanding westward into the Ozark Plateau of Oklahoma, Arkansas, and Missouri (Harvey et al. 1999). During winter, the Indiana bat hibernates in cool caves and abandoned mines that are located primarily in karst areas of the east-central United States (USFWS 1999). Here, more than 85% of the range-wide population occupies relatively few caves, most in Kentucky, Missouri, and Indiana (USFWS 1999).

It is believed that upon emergence from hibernation, female Indiana bats and some males migrate to core summer ranges, in Illinois, Indiana, Michigan, and Missouri (Humphrey et al. 1977, Gardner et al. 1991, Kurta et al. 1993a, 1993b, 1996, 2002, Callahan et al. 1997). Although there is evidence that movement may occur in other directions, most migration activity is oriented in a north-south direction (Barbour and Davis 1969), e.g., Kurta and Murray (2002) documented four individuals from a maternity colony in Michigan migrating south an average distance of 460 $\pm$ 28 km to four different hibernacula in Kentucky. For this reason, summer maternity habitat in the eastern and southern portion of the Indiana bats range has not been well investigated.

Study Area

West Virginia is the largest coal-producing State in the eastern United States, and the second largest nationally (Bostic pers. comm. 2005). Geologically, two-thirds of West Virginia contains relatively flat lying rock (Appalachian Plateau Province), while about one-third is comprised of folded and faulted rock (Valley and Ridge Province) (Lessing 1996, Fenneman 1938; Figure 1). The Allegheny Mountains are considered part of the Appalachian Plateau Province. Nearly all mining in West Virginia occurs within the Appalachian Plateau Province. The sandstone and limestone ridges in the Valley and Ridge Province provide the habitat for most known Indiana bat hibernacula in West Virginia (Stihler personal communication 2003).

West Virginia is also divided into two forest regions, the Mixed Mesophytic and Oak-Chestnut (Braun 1950). These forest regions closely mimic the geologic provinces, with the Mixed Mesophytic Region occurring almost entirely within the Appalachian Plateau Province and the Oak-Chestnut Region occurring within the Vallay and Ridge Province.

Historically, in the Mixed Mesophytic Forest, the upper slopes and ridgetops were dominated by oak (*Quercus spp.*) and American chestnut (*Castanea dentata*) (Braun 1950). However, the American chestnut component of the forest was decimated by a blight during the early to mid-1900's (Braun 1950). In addition to white oak (*Quercus alba*), pine species may also be prevalent on some ridges. Especially ubiquitous are Virginia pine (*Pinus virginiana*) and shortleaf pine (*P. echinata*). Ravines in this area are typically dominated by eastern hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*), with an understory of rhododendron (*Rhododendron spp*.). The lower slopes are typically dominated by tulip tree (*Liriodendron tulipifera*).

Forested habitat within the Oak-Chestnut Region can vary greatly according to elevation and aspect (Braun 1950). As indicated by its name, dominants in this region are oaks and formerly the American chestnut. Again, however, the American chestnut component of the forest was decimated during the early to mid-1900's. In much of this region, oak and tulip trees have replaced the American chestnut component of the forest. Other common species include eastern hemlock (in the coves) and beech (*Fagus grandifolia*) (ravines), with upper elevations having red spruce (*Picea rubens*) and balsam fir (*Abies balsamea*) (Ricketts et al. 1999). Mixed-Mesophytic woods, if present, are limited to coves and lower ravine slopes.

Methods

The discovery of Indiana bat maternity colonies throughout the Appalachian Mountains has expanded the distribution of potential summer maternity habitat for the species (Butchkoski and Hassinger 2002, Britzke et al. 2003, Beverly and Gumbert 2003). With such discoveries we felt that it was important to systematically organize the data for the State of West Virginia so that proper consideration could be given to the potential of this region as summer habitat for Indiana bats. This review is based on information obtained from peer-reviewed and nonpeer-reviewed literature, and personal communications from individuals working with the species in West Virginia and throughout the Appalachian Mountains.

Results

Winter – Trends seen in Indiana bat hibernacula surveys since 1990, indicate that West Virginia's winter population is slightly increasing (USFWS 1999; Table 1). Currently, the winter population is estimated at 10,770 (Stihler and Wallace 2004), an increase of 5,009 bats over the last 14 years. Winter surveys conducted in 1990, 1995, 2000, and 2004 have shown increased counts of 5,761, 8,001, 10,747, and 10,770, respectively (Stihler 1991, Stihler 1996, Stihler et al. 2001, and Stihler and Wallace 2004). The increase in population could be attributed to the reduced disturbance of most known hibernacula in West Virginia initiated by education and bat-friendly cave gates or fences. Most of the increase seen in West Virginia has been from more bats being found at historic hibernation sites, although documentation of new caves within the State has also played a small role (less than five percent of the total).

Hibernating Indiana bats have been observed in as many as 32 West Virginia caves (Stihler pers. comm. 2004). The number of bats using these caves is generally small and six historically used caves are no longer inhabited by Indiana bats. Of the 26 actively used Indiana bat caves in West Virginia none are "Priority One," one is a "Priority Two," and seven are "Priority Three" hibernacula (USFWS 1999 and Stihler pers. comm. 2004). Populations of hibernating Indiana bats in West Virginia caves range from a single individual to a population of nearly 8,600 in Hellhole, the "Priority Two" hibernacula (designated as critical habitat) in Pendleton County (Stihler pers. comm.. 2004). Other counties in West Virginia with winter records include Greenbrier, Hardy, Mercer, Monongalia, Monroe, Pocahontas, Preston, Randolph, and Tucker (USFWS 1999) (Figure 2). Most, but not all, of these hibernaculum are located outside of the coalfields region. For example, Preston County's only hibernaculum (there are other caves in the area that have not yet been surveyed) is in the middle of a coal mining district.

There is no record of Indiana bats using abandoned coal mine portals in West Virginia as hibernacula. However, an Indiana bat was captured at the entrance of an abandoned mine portal. On 10 September 2002, Johnson et al. (2002) captured an Indiana bat during mine portal surveys in the New River Gorge, Fayette County. However, because of safety issues the mine could not be surveyed in the winter, and it has not been confirmed that Indiana bats are using the site as a hibernaculum.

Summer – Historically, there was little evidence of reproduction in West Virginia by Indiana bats. An adult female Indiana bat was captured on 16 August 1995, in Tucker County very near to a hibernaculum (Stihler, In Press). Due to the bat being captured outside the maternity season, it is difficult to say whether the animal had been using the area as its summer habitat or if it had just returned to the area from its summer range. A juvenile male Indiana bat was captured in Nicholas County while, night roosting under a concrete bridge (Kiser et al. 1999). Initially, this capture was treated as representing a maternity colony. However, after additional effort did not result in the capture of another bat, there was doubt that this bat did actually represent a maternity colony (Stihler pers. comm. 2005 and Kiser et al. 1999). Because this bat was captured late in the maternity season (5 August 1999), and found in an unusual habitat, it has been considered a vagrant (most likely migrating to a nearby hibernaculum, rather than evidence of a local maternity colony) (Stihler pers. comm. 2005). Owen et al. (2001) reported the capture of a post-lactating Indiana bat in Randolph County in east-central West Virginia in July of 1999. However, the identification of this bat has been questioned based on the presented body measurements and available photographs of the animal (Stihler, pers. comm. 2005).

The recent discovery of three maternity colonies in West Virginia provides conclusive evidence that suitable habitat and temperatures are present within the Appalachian Mountains to support reproductive Indiana bats (Figure 2). During the summer of 2003, two reproductive Indiana bats were captured in Boone County and subsequently tracked to two separate roost tree areas (Beverly and Gumbert 2003, Beverly et al. 2003). As such, we are treating these two areas as two separate maternity colonies. However, based upon proximity of roost areas (approximately one mile from each other), size of colonies (exit counts ranging from one to four bats), and disturbances in the area that may have disrupted the original colony (logging), it is possible that these two roost areas actually represent only one maternity colony. In 2004, two more reproductive females were captured and tracked. One bat was captured in Boone County and used the same roost tree area as bats captured in 2003 (Beverly 2004). The other bat was captured in Tucker County (Sanders Environmental Inc. 2004).

Based upon telemetry work conducted on the three colonies of Indiana bats discovered in 2003 and 2004, there have been nine different maternity roost trees located in West Virginia (Table 1). Of these, 8 have been dead trees and 1 roost tree was a live-damaged tree (a live tree with a crevice, cavity or a dead limb). Six of the roosts were located under exfoliating bark, while 3 roosts were in crevices. The Tucker County colony and one of the Boone County colonies roosted in mature second growth forest; however, these sites had been selectively cut within the last 1-3 years. Splintered topped trees were created during the logging activity and provided crevice roosts for the bats. At least four tree species were used as roosts, including basswood (*Tilia americana*), sugar maple (*Acer saccharum*), northern red oak (*Q. rubra*), and scarlet oak (*Q. coccinea*) (Beverly 2004, Beverly and Gumbert 2003, Beverly et al. 2003, Sanders Environmental Inc. 2004). Two other maternity trees were listed simply as oak and maple (Sanders Environmental Inc. 2004) and were located in an area that had a number of snags created by a fairly recent fire. Roost trees ranged in size from 13.6 to 33.0 cm dbh (Table 1). Exit counts conducted at eight trees ranged from 1 to 25 bats. Of special note, is the roost tree (maple) located in Tucker County that had 25 bats exiting. This tree was located at 915 m in elevation, making it the highest elevation maternity roost tree ever reported for the species (Sanders Environmental Inc. 2004).

Unlike reproductively active females, there have been a number of adult male Indiana bats captured in West Virginia (Ford et al. 2002, Stihler et al. 1998, Sanders Environmental Inc. 2004, Sanders pers. comm. 2004, Stihler In Press, Sargent pers. comm. 2005; Figure 2). Based upon bats that have been radio-tagged and tracked, 26 roosts have been located for males. These roosts have been located in both summer and fall. Of these roosts, the data for 6 trees was not available to us, seven have been snags, eight have been live, and five have been live-damaged trees (Table 2). One of these bats was tracked to a playhouse that had been constructed of rough lumber (Stihler et al. 1998), and the condition of one tree was not identified. Another bat was tracked to a dead shagbark hickory from which 23 bats were seen exiting at dusk (Sanders Environmental Inc. 2004). Eleven tree species were used as roost trees, i.e., shagbark hickory, sugar maple, American beech (*Fagus grandifolia*), white oak (*Q. alba*), tulip tree, black cherry (*Prunus serotina*), red maple, northern red oak, chestnut oak (*Quercus montana*), white ash (*Fraxinus americana*), and red elm (*Ulmus rubra*; BHE Environmental Inc. pers. comm.. 2004, Ford et al. 2002, Johnson et al. 2002, C. Sanders pers. comm.. 2005, Sanders Environmental Inc. 2004, Stihler et al. 1998). Trees ranged in size from 12.7 to 69.1 cm dbh (Table 2).

Discussion

The disturbance to winter hibernacula is believed to be one of the major reasons for past declines of the Indiana bat (USFWS 1999). Thus, protection of these habitats has become a top priority for Federal and State wildlife and land management agencies (USFWS 1999). The known significant hibernacula in West Virginia (Priority Two and Priority Three caves) have been effectively protected. In addition, most known hibernacula in West Virginia are located outside of the coalfields region**.** With few coal seams in the vicinity, the coal industry as it operates today should pose little threat to the long-term protection of these natural limestone features.

It is difficult to ascertain the impact that current mining will have on potential Indiana bat winter habitat in the coalfields of West Virginia. Across the Indiana bat's range, there are many mines used as hibernacula (USFWS 1999), however, most of these have been iron, silica, limestone, or graphite mines, few have been coal mines. However, Indiana bats have been captured at abandoned coal mine entrances throughout the Appalachian Mountains, including one capture at a mine portal in West Virginia. Therefore, it is possible that Indiana bats utilize coal mines as hibernacula. Only a small portion of West Virginia's existing abandoned coal mines have been surveyed and, because of safety issues, few of these mines have actually been, or should be, entered in an attempt to locate hibernating Indiana bats. As more surveys are conducted, it is possible that Indiana bat winter use of coal mines will be confirmed.

Most male Indiana bats remain near the hibernacula and roost in trees within the surrounding forests during the summer (Kiser and Elliott 1996, Gumbert et al. 2002, Ford et al. 2002, Stihler In Press). Based upon the number of hibernating Indiana bats in West Virginia (and surrounding states), it is reasonable to expect adult male Indiana bats could occur in various locations throughout the State.

Researchers had previously thought that the Appalachian Mountains within the Eastern United States were not utilized as Indiana bat maternity habitat. Brack et al. (2002) showed that portions of the Indiana bat's range in the east are slightly cooler in summer than the core summer areas to the north. The cooler temperatures were thought to deter maternity colony formation in this region. Despite these dynamics, reproductive records for Indiana bats in the Appalachian Mountains continue to accumulate.

West Virginia, which is located outside of the core summer area of the Indiana bat, sits near the center of the Appalachian Mountains. Indiana bat maternity colonies have been located within the Appalachian region, including New Jersey, New York, Pennsylvania, Ohio, Kentucky, Virginia, North Carolina, and Tennessee (USFWS 1999). One of the first records was the capture of a juvenile male in late July (1992) along a riparian area in southwest Virginia (Hobson 1998). In southeastern Kentucky, three juvenile males were captured during the summer of 1995 (Bryan and Gumbert 1995, KSNPC 2000) and a lactating female was captured in 1999 (KSNPC 2000). Britzke et al. (2003) recently located maternity roost trees in Nantahala National Forest in western North Carolina and Great Smoky Mountains National Park in eastern Tennessee. These bats were found in very different habitat types compared to the core maternity range (Callahan et al. 1997, Kurta et al. 1996, Gardner et al. 1991, Humphrey et al. 1977). The area was categorized as dense mature temperate rain forest (>99% forested) dominated by pines, hemlock, and birch (Britzke et al. 2003, Harvey 2002, Libby et al. 2000). In the northern portion of the Appalachian Mountains, Butchkoski and Hassinger (2002) discovered a maternity colony of Indiana bats roosting in an abandoned church in Pennsylvania. The habitat within the vicinity of the church included oak and hickories, as well as northern hardwoods (birch; maple, *Acer* spp.; and beech, *Fagus* spp.).

The Indiana bat maternity colony in Tucker County and the two in Boone County, West Virginia, are among the few colonies known for the Appalachian Mountains. In addition, they represent the first Indiana bat maternity colonies in West Virginia for which roost trees were identified. These colonies exhibited a number of differences in roosting ecology compared to colonies located in the Indiana bat's core maternity range (Humphrey et al. 1977, Gardner et al. 1991, Callahan et al. 1997, Kurta et al. 1996a) and others found within the Appalachian Mountains (Butchkoski and Hassinger 2002, Britzke et al. 2003).

Acknowledgements

Unpublished reports and data were obtained with support from West Virginia Department of Natural Resources, United States Fish & Wildlife Service, and Monongahela National Forest. B. Sargent, C. Stihler, M. Ford, C.

Sanders, R. Romme, R. Slack, and B. Hendricks provided unpublished data and information about bats and roost trees they had collected in the field. J. O'Keefe developed the maps. Technical commits and reviews were provided by C. Stihler, J. MacGregor, C. Elliott, E. Britzke, and J. Kiser.

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Table 1. Characteristics of female Indiana bat roosts in West Virginia according to tree condition (alive, live-damaged, or dead) and roost type (bark, crevice, or cavity). Continuous variables are presented as *X ± SE (range).*

Species[a]	n	dbh (cm)	Tree Condition			Roost Type			Largest exit count	References[b]
			Alive trees	Live-damaged	Dead trees	Bark	Crevice	Cavity		
A	1	30.0	0	0	1	1	0	0	25	4
AS	2	21.6+8.6 (15.5-27.7)	0	1	1	1	1	0	1	1
TA	3	24.0+4.8 (18.5-26.8)	0	0	3	0	3	0	4	1, 2
Q	1	33.0	0	0	1	1	0	0	n/a	4
QC	2	14.5+1.4 (13.5-15.5)	0	0	2	2	0	0	1	3
QR	1	13.6	0	0	1	1	0	0	1	3
Total	10	22.1+7.5 (13.5-33.0)	0	1	9	6	4	0		

[a]A=*Acer* sp., AS=*Acer saccharum*, TA=*Tilia americana*, Q=*Quercus* spp., QC=*Quercus coccinea*, QR=*Quercus rubra*

[b]1, Beverly 2004, 2, Beverly and Gumbert 2003; 3, Beverly et al. 2003; 4, Sanders Environmental Inc. 2004;

Table 2. Characteristics of male Indiana bat roosts in West Virginia according to tree condition (alive, live-damaged, or dead) and roost type (bark, crevice, or cavity). Continuous variables are presented as *X ± SE (range).*

Species[a]	n	dbh (cm)	Tree Condition			Roost Type			Largest exit count	References[b]
			Alive trees	Live-damaged	Dead trees	Bark	Crevice	Cavity		
A	1	30	0	0	1	1	0	0	n/a	5
AR	2	17.8 + 7.2 (12.7-22.9)	0	1	1	1	1	0	n/a	5, 6
AS	1	69.1	1	0	0	1	0	0	n/a	2
CO	5	50.6 + 15.1 (27.9-68.0)	5	0	0	5	0	0	23	2, 5, 6
FG	1	52.6	0	0	1	1	0	0	n/a	4
FA	1	36.1	0	1	0	0	1	0	n/a	6
LT	2	24.3 + 3.5 (21.8-26.7)	0	0	2	2	0	0	n/a	6
PS	1	27.2	0	1	0	1	0	0	n/a	6
Q	2	33.0 + UD	1	0	1	2	0	0	n/a	5
QA	1	UD	1	0	0	1	0	0	n/a	4
QR	1	47	0	1	0	1	0	0	n/a	5, 6
QM	1	18.3	0	1	0	1	0	0	n/a	5
UR	1	47.5	0	0	1	1	0	0	n/a	6
UD	6	UD	UD	UD	UD	UD	UD	UD	n/a	UD
Total	20	41.1 + 16.9 (12.7-69.1)	8	5	7	18	2	0		

[a]A=*Acer* sp., AR=*Acer rubrum*, AS=*Acer saccharum*, CO=*Carya ovata*, FG=*Fagus grandifolia*, FA=*Fraxinus americana*, LT=*Liriodendron tulipifera*, PS=*Prunus serotina*, Q=*Quercus* spp., QR=*Quercus rubra*, QM=*Quercus montana*, UR=*Ulmus rubra,* UD=Unavailable Data

[b]1, BHE Environmental Inc. pers. Comm.. 2004; 2 Ford et al. 2002; 3, Johnson et al. 2002; 4, C. Sanders pers. Comm.. 2004; 5, Sanders Environmental Inc. 2004; 6, Stihler et al. 1998.

Table 3. Date of capture, site type, county, band number, number of roost trees used, and reproductive condition for Indiana bats captured in West Virginia.

Date of capture	Site Type	County	Band type	Band number	Number of roost trees used	Repro. condition of bat	References
16-Aug-95	Forested Road Corridor	Tucker	n/a	n/a	n/a	Post-lactating *	7
11-Jul-99 For	est Ephemeral Pool	Randolph	n/a	n/a	n/a	Post-lactating *	5
5-Aug-99 Br	idge	Nicholas	n/a	n/a	n/a	Juvenile Male *	4
23-Jul-03	Wooded Road Corridor	Boone	Light blue	3351 2		Post-lactating	2
29-Jul-03	Wooded Road Corridor	Boone	Light blue	3352 3		Post-lactating	3
11-Jul-04	Wooded Road Corridor	Boone	KY F&W	A09083	3 L	actating	1
12-Jul-04 For	est/Non-portal	Tucker	WV DNR	A02585	2 L	actating	6

* Questionable records of reproductive activity of Indiana bats in West Virginia, (see text).

[a]1, Beverly 2004, 2, Beverly and Gumbert 2003; 3, Beverly et al. 2003; 4, Kiser et al. 1999; 5, Owen et al. 2001; 6, Sanders Environmental Inc. 2004; 7, C. Stihler pers. comm. 2004

Table 4. Date of capture, site type, county, band number, and number of roost tree used for adult male bats captured in West Virginia.

Date of capture	Site Type	County	Band Type	Band No.	Number of roost trees used	References[a]
Summer 1995*	Forest (1) and Cave (7)	Tucker n/a		n/a	n/a	8
8-Sep-97	Big Springs Cave	Tucker	n/a	n/a	5	7
8-Sep-97	Big Springs Cave	Tucker	n/a	n/a	3	7
8-Sep-97	Big Springs Cave	Tucker	n/a	n/a	2	7
8-Sep-97	Big Springs Cave	Tucker	n/a	n/a	n/a	7
2-Aug-99 Fo	rest/Non-portal	Clay	White	1471	n/a	6
14-Jul-00 For	est/Non-portal	Randolph	WV DNR	A01260 n	/a	4
16-Jun-00	Forest/Non-portal	Tucker	n/a	n/a	3	2
20-June-01	Forest/Non-portal	Randolph	WV DNR	A00790	n/a 4	
10-Sep-02	Mine Portal	Fayette	n/a	n/a	n/a	3
5-Aug-03 Fo	rest/Non-portal	Raleigh	WV DNR	A01784	n/a 1	
10-July-03	Forest/Non-portal	Randolph	WV DNR	A01260	2 4	
28-Jun-04 For	est/Non-portal	Pocahontas	WV DNR	A02594 2		5
30-Jun-04 Fo	rest/Non-portal	Pendleton	WV DNR	A01095	n/a 5	
30-Jun-04 Fo	rest/Non-portal	Pendleton	WV DNR	A01096	3 5	
11-Aug-04 Fo	rest/Non-portal	Pendleton	WV DNR	A02587	5 5	
summer 2004	Forest/Non-portal	Nicholas	n/a	n/a	n/a	6

* = Eight bats were captured at Fernow Experimental Forest, seven at a hibernacula entrance (Big Springs Cave) and one nearby the entrance.

10 July 2003 record was a recapture of bat from 14 July 2000

[a]1, BHE Environmental Inc. pers. Comm.. 2004; 2, Ford et al. 2002; 3, Johnson et al. 2002; 4, C. Sanders pers. Comm.. 2004; 5, Sanders Environmental Inc. 2004; 6, B. Sargent pers. Comm.. 2005; 7, Stihler et al. 1998, 8, Stihler In Press.

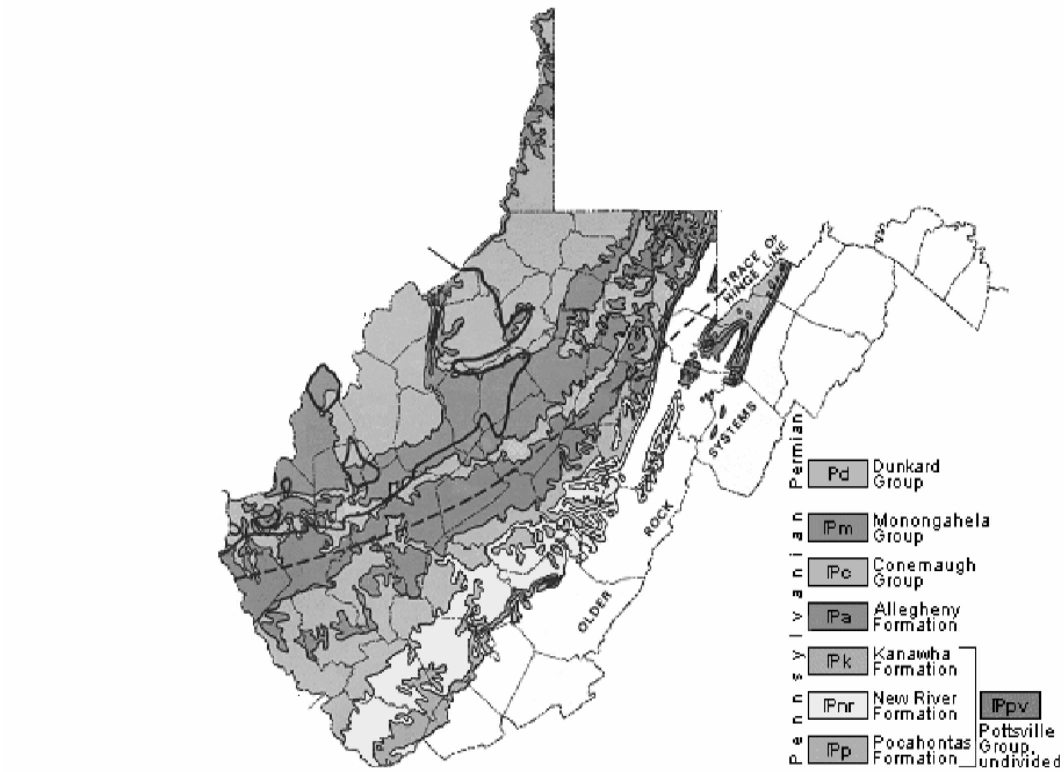

Figure 1. Generalized geologic map of the coal fields of West Virginia (West Virginia Geological and Economic Survey). Shaded areas indicate Appalachian Plateau Province while non-shaded areas indicate Valley and Ridge Province.

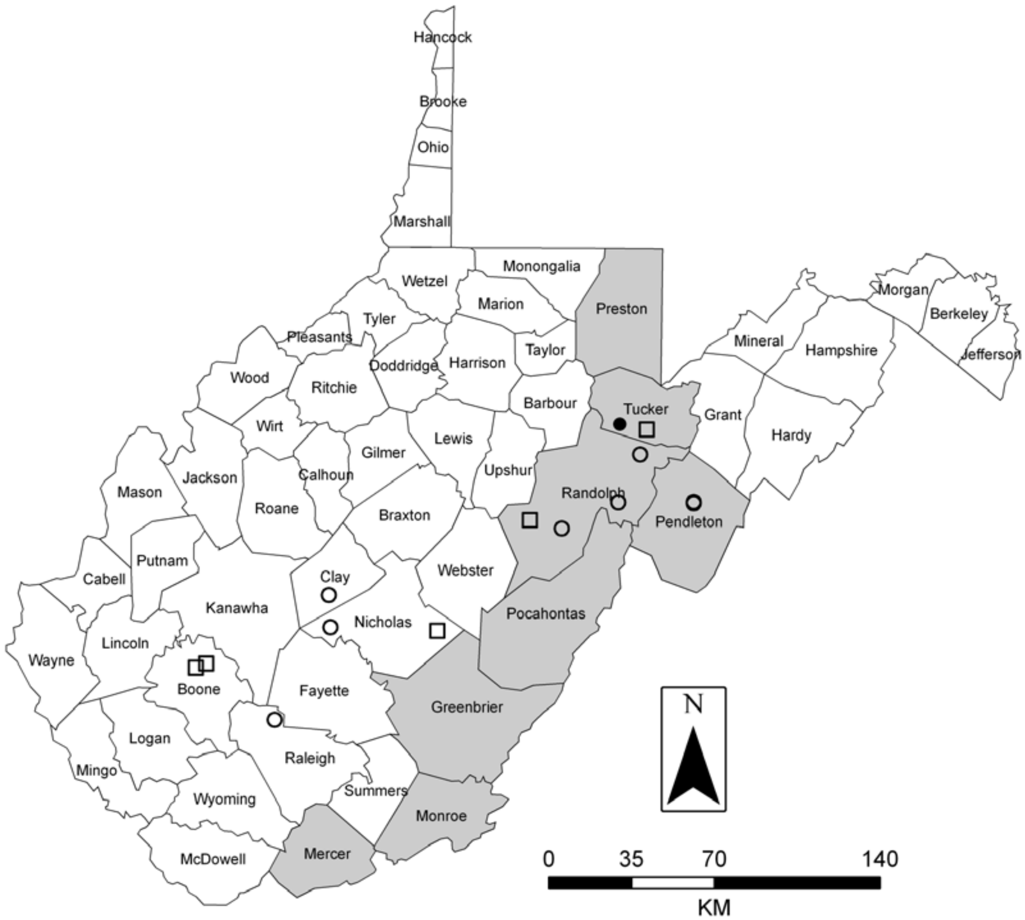

Figure 2. Distribution of summer reproductive and non-reproductive Indiana bat records (reproductive records are shown as squares and non-reproductive records are shown as circles). The solid circle indicates Fernow Experimental Forest, where nine male Indiana bats have been captured at or near an hibernacula (Big Springs Cave). Shading indicates counties with Indiana bat hibernacula.

PORTAL EXCLUSION PROTOCOLS FOR THE ENDANGERED INDIANA BAT (*MYOTIS SODALIS*)

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Abstract

While there is abundant and strong evidence that underground mines provide critical habitat for the Indiana bat (*Myotis sodalis*), it is not always possible to maintain access to these workings. Portal and internal instability, concerns for potential liability, and budgetary constraints may necessitate the permanent closure of mine portals, despite the biological importance of the resource in question. When portal maintenance is not an option, it is critical that adequate steps be taken to best ensure that roosting bats are excluded from subterranean features prior to portal closure. The gregarious nature of this species allows large, demographically non-random assemblages to be formed during particular times of year. This suggests that failure to adequately remove roosting bats prior to closure, could entomb large numbers of individuals resulting in local and even regional extirpation. There has been no systematic research investigating the effectiveness of various portal treatments for excluding *M. sodalis* from subterranean roosts. Therefore, we are forced to play the role of biological detectives. Through application of our basic understanding of the natural history of this species, and by drawing on research regarding exclusions of other species, we can infer the best approach for excluding *M. sodalis* from roosts. It is only through an *a priori* understanding of the biological importance of a mine that responsible exclusion activities can be conducted. The type and timing of use necessarily dictates the intensity and timing of exclusion treatments, and degree of mitigation that may be required (i.e. protection of replacement roosts). In this talk, we will discuss the various philosophies and approaches to exclusions, including materials and timing of exclusion and closure activities.

Key words: *Myotis sodalis*, abandoned mine, coal, roost, exclusion.

Introduction

Bats are commonly known to associate with mines in most parts of the country, with an estimated 30 to 70 percent of those in the western portion of the country occupied by bats for at least part of the year (Sherwin et al. 2000). In the upper Midwest, within the range of the Indiana bat, up to 70% of the open subsurface mines are in use by one or more species (Tuttle and Taylor 1994). Of course, these figures are representative of the proportions of orphaned mines that have been surveyed and may change as more sites are inventoried. Mines are used throughout the year with seasonal occupancy reflecting local variables. They are used during the cold season for hibernation by approximately half of the 43 species of bats in the U.S. while an equal number of species has been observed roosting in abandoned mines during the warm and migratory seasons.

The relationship of the Indiana bat and underground mines is a complex one. Historically, winter colonies were likely constrained to caves; however, underground mining has modified the roosting landscape to such a degree that large colonies now occupy these novel resources. For example, the magazine mine in Alexander County Illinois, which ceased operation in 1980, has become home to a hibernating colony of over 14,000 individuals. They are most commonly observed in subterranean workings during winter hibernation, and, less commonly, during spring and fall migratory periods (Whitaker and Rissler 1992). During winter, most (85%) of the known individuals are located in seven hibernation roosts, with roughly half of those constrained to two of these sites (Drobney and Clawson, no date). During warmer parts of the year, colonies and individuals roost in trees and anthropogenic surface features (i.e., buildings and bridges). This seasonal variation in distribution and density implies that constraints are likely more pronounced during cold seasons as opposed to warm. Therefore, wintering colonies will be more sensitive to density-independent events, such that during this period individuals and colonies are at highest risk. Hibernating colonies are composed of large aggregations of mixed-sexed groups with colony numbers often exceeding tens of thousands of individuals (Thomson 1982).

Like many other species of bats, the roosting and habitat requirements of *M. sodalis* vary by sex, and throughout the year. In summer, male *M. sodalis* roost under loose bark in trees, in caves and mines, and in man-made structures such as buildings and under bridges (Whitaker and Brack 2002; Kiser et al. 2002). Males do not generally undertake long-distance seasonal migrations and summer roosts are often near winter roosts. In fact, summer bachelor roosts are often located adjacent to, or even in, the same caves/mines that individuals hibernated in during the previous cold season (Kurta et al. 2002). The majority of male *M. sodalis*, however appear to roost outside of the actual hibernacula (Whitaker and Brack 2002; Richter et al 1993).

Summer roosting habits of the female *M. sodalis* were not understood until the 1970s when a maternity colony was discovered in a felled tree (Humphrey et al. 1977). In recent years, researchers have located maternity colonies under the loose bark of trees and, in one case, inside a building (Butchkoski and Hesinger 2002). Female *M. sodalis* tend to migrate longer distances between summer and winter ranges than do males. In fact, migration distances of 200 miles have been noted (Richter et al. 1993). Both males and females exhibit high-site fidelity to hibernation roosts with up to 80% of those studied returning to the hibernacula that was used the previous winter (Cope and Humphrey 1977; Humphrey et al. 1977).

As summer ends, the bats begin returning to hibernation roosts, with migration extending between late summer and mid fall. During the migratory period, individuals tend to roost in the shallow portions of the hibernation roost where temperatures are warmer than at depth. As numbers increase at winter roosts, nightly swarming begins and peaks in intensity by late fall (Cope and Humphrey 1977). Nightly foraging continues throughout the fall as individuals attempt to supplement fat reserves necessary to survive the upcoming winter (Thomson 1982; Cope and Humphrey 1977). Nightly foraging bouts can be intense with individuals harvesting as many as 600 insects per night during this fattening period. As the weather gets cooler, swarming and foraging activities begin to diminish and bats move into deeper, cooler portions of the hibernation roost. In general, *M. sodalis* requires cooler roosting temperatures than conspecifics (Raesley and Gates 1987). There is some natural arousal throughout the winter, as individuals move within and between hibernation sites to seek the optimal thermal conditions (Whitaker and Rissler 1992). However, *Myotis sodalis* enters deep hibernation and is less active during the winter than species roosting in more benign winter ranges where occasional foraging is possible (Whitaker and Rissler 1992; Sherwin et al. 2003). Therefore, this species must be able to survive an extended period dependent upon energy stored during late summer feeding alone. By selecting roosting locations where cooler ambient temperatures prevail, they can more effectively reduce basal body temperature, minimizing catabolization of fat, and increasing probability of survival. Roost temperatures become too cold however, or individuals will be required to burn fat to raise body temperature above ambient which burns reserves too quickly, such that they may not have enough fat to survive (Tuttle and Kennedy, 2002). While this balancing act allows the bats to survive the winter, it places them in a precarious position where deviation from the narrow range of tolerance may be lethal. Variation in temperature is often a direct function of airflow through the roost, which is often necessary to produce the range of thermal conditions needed for survival (Tuttle and Kennedy 2002). Additionally, internal roost features such as chimneys, raises, and stopes (voids located above the main level of the roost) often produce microclimates that are often warmer, more humid, and more thermally stable than those throughout the rest of roost. Conversely, winzes, stopes, and declines (voids located below the main level of the roost) provide protected microclimates cool air it trapped such that they remain cooler than background roost temperatures. *Myotis sodalis* are most strongly associated with hibernacula with large entrances, high passage heights, and high inner chambers (Raesley and Gates 1987). The combination of large openings and internal dimensions tends to promote cooler winter temperatures than observed in more confined locations. When combined with multiple entrances, subterranean habitats will be more likely to include cold temperatures necessary for hibernation by *M. sodalis*. In order to further mediate the temperatures, bats also form dense, tightly-packed clusters which often include between 300 and 500 bats per square foot, and may include thousands of individuals.

In addition to the requirement of appropriate thermal conditions, bats need locations where disturbance is kept to a minimum. Arousing the bats from hibernation increases their metabolic rate through fat catabolization, which can deplete fat reserves tremendously (Johnson et al. 1998 Currie 2002). As the bats near the end of the hibernation period, fat reserves are largely depleted and risk of winter mortality is highest. Therefore, any perturbations (human disturbance, abrupt temperature changes, etc.) nearing the end of hibernation can have a much more profound effect on survival than at any other time of year (Raesley and Gates 1987).

In addition to the narrow thermal conditions and required protection from disturbance, *M. sodalis* also appear to select roosts based on landscape level features. They are more strongly associated with mines and caves located in landscapes that include intact stands of deciduous forest, low levels of cultivated land, and some standing water within 1 km of the entrance (Raesley and Gates 1987).

Defining the Problem

Human settlement and resource exploitation across the United States have had a tremendous impact on virtually every species that occurs in this country. Perhaps one of the greatest impacts on bat communities has been the dramatic alteration of roosting landscapes (Sherwin et al. 2003). Historically, *M. sodalis* was constrained to extremely limited winter roosting habitat, such that much of the natural history of the species likely reflects this seasonal bottleneck. Underground mining has created new subterranean habitat on an unprecedented scale, and many species have responded by quickly taking advantage of this novel habitat such that seasonal, and even specific distributions now reflect the distribution of abandoned mines (Sherwin et al. 2000a, b; Sherwin et al. 2002; Sherwin et al. 2001, Altenbach and Sherwin 2002; Sherwin and Altenbach 2002). Like many other species of bats, *M. sodalis* has also taken advantage of abandoned mines to satisfy winter roosting requirements.

While this may regard abandoned mines as refuge habitat to which bats have fled as historic caves have become increasingly impacted by humans (Sherwin and Altenbach 2002), there are occasions when access to abandoned mines must be precluded and mine openings closed. In many cases, portal integrity is so rapidly and entirely degrading that costs prohibit stabilization and mine openings simply fail. In other cases, underground conditions are such that lethal internal environments are occasionally created (i.e., toxic gases, combustion, internal collapse, radon daughters), wherein individual sites actually become population sinks and should not be maintained. Many mines are located on private lands and property owners are reluctant to expose themselves to liability associated with open mines on their property. In fact, some active mining operations may have reclamation plans that do not allow for maintenance of open mines following cessation of mining activities. Additionally, owners may not wish to deal with an endangered species on their property and choose to simplify their lives by expelling bats from roosts.

When one is faced with the challenge of closing potential roosting habitat the most important issue is to adequately ensure that colonies are not extirpated as a direct result of closure activities. No research has been conducted on the effectiveness of various strategies for excluding *M. sodalis* from roosts, nor is any long term data available that suggests what the long term impacts of roost closure are on populations of this species. However, data have been collected on the impacts of various closure methods, and long term effects of roost closures on cavernicolous species in the western U.S. The general recommendation for exclusion of bats from roosts involves the installation of 1" chicken wire or similar material over mine openings during periods when bats are active with the idea that bats can navigate the material to exit the site, but will be so inconvenienced that they will be reluctant to travel through the material to reenter the site and will move to a new location. While this approach is effective in some situations, it is extremely simplistic and assumes that all bats in all roosts across all landscapes are identical in both roosting requirements and behavioral response. Unfortunately, there are a suite of factors that impact the sensitivity of individuals and colonies to exclusion activities. As a general rule, smaller colonies in areas where roosts are abundant are more likely to quickly abandon roosts at which exclusion materials have been installed. Larger colonies and those roosting in landscapes where suitable alternative roosts are limited can be extremely resilient to exclusion efforts. For example, exclusion materials left in place for 3-5 nights are most often sufficient to cause abandonment of roosts by small colonies of Townsend's big-eared bat roosting in small mines in Nevada. However, larger colonies, roosting in larger mines often require the maintenance of exclusion materials for 3-5 weeks. Additionally, total abandonment is rarely achieved without manual removal of stragglers (may be as high as 20% of total colony), and the firing of smoke bombs. Once excluded, individuals will return nightly to search for possible access with visitation continuing for months and even years following the permanent closure of all openings.

In general, *M. sodalis* are using abandoned mines during the cold season, migratory period and in some cases, as summer bachelor roosts. Therefore, it would appear that the simplest solution to this problem is to close portals during the summer months when roosts are least likely to be used, or are inhabited by small numbers of bachelor males. However, we recommend a highly modified approach to these exclusions that departs from techniques recommended for other species of bats. Because of the known propensity to ignore acoustic information when emerging from roosts, the installation of exclusion materials could result in the collision of many individuals into material causing stress, injury and possibly death if left unattended. Therefore, exclusion materials should be monitored nightly throughout the period of exclusion.

The initial step in conducting an exclusion project is to develop baseline data regarding the type and timing of roost use. Additionally, exit behaviors and patterns should be determined. Expected dates of occupancy should be understood and colony size should be established. Survey techniques are discussed elsewhere in this volume and need not be further elucidated. We recommend installation of exclusion materials during the warm season and that they be left in place until the site is vacated by all bats of all species. When multiple openings access the same underground workings (connections must be confirmed through internal surveys), it is most effective to first simplify exit opportunities by closing all but one of the openings. The remaining opening should be the one that is most accessible, most easily covered, and safest to work around. If possible, we recommend closing the preferred opening and forcing bats to use a less favored opening. This will often be the largest opening and hence the most difficult to cover with exclusion materials. Furthermore, eliminating the preferred opening will translate directly to site abandonment for some individuals as it will disrupt established flight patterns. Exclusion materials should be placed over the remaining opening. Some individuals will be reluctant to exit through exclusion materials; therefore confirmation of site vacancy is necessary. We recommend conducting both internal and external surveys to establish vacancy. It will likely be necessary to physically remove any lingering individuals. These should be carefully removed from the substrate, placed in soft-sided bags, taken from the mine and released some distance away. Upon final confirmation of vacancy we recommend the firing of non toxic smoke bombs throughout the mine during the evening. Of course, the internal atmosphere must be checked for particulates, volatile and/or explosive gases prior to firing bombs. On the morning following bombing a final internal survey should be conducted, immediately after which the opening should be permanently sealed. Excluded bats have been documented to repeatedly investigate opening locations for years following closure, and breaches of closure materials (i.e., through subsidence, or human vandalism) have led to re-colonization of the roosts. Therefore, closures should be monitored annually to investigate integrity of seals.

Despite the seemingly obvious choice of timing, this approach should be treated with a great deal of caution. If roosts are closed during the summer months, individuals will be unaware of the loss of roosting habitat until arrival in late summer/fall. As such, many will make landscape level migrations from summer ranges to winter roosts only to find them closed. These migrations are energetically costly, and individuals are dependent on winter roosts for seasonal activities preparatory to hibernation. As such, individuals will spend energy seeking alternate fall/winter roosts expending calories that would otherwise be converted to fat reserves necessary for hibernation. Regardless of whether replacement mitigation habitat is available, it is critical to remember that we have no empirical data regarding impacts of roost loss on individuals, colonies, and populations of *M. sodalis*. Therefore, it is critical that initial exclusion activities be conducted within the framework of robust scientific inquiry. Only through intense research will we be able to understand the effectiveness of recommended exclusion protocols for the long-term maintenance of *M. sodalis.*

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Dr. Richard E. Sherwin is an assistant professor of biology and the resident mammalogist in the Department of Biology at Christopher Newport University. As an applied ecologist, he is interested in translating the most current research techniques to the conservation and management of wildlife species. His research interests are in understanding how biological processes translate across spatial and temporal scales. He is fascinated by how scale-sensitive properties (i.e., habitat use) of ecological systems affect the science of conservation biology. His research program is broad and includes a multi-disciplinary approach, with investigations ranging from molecular to landscape ecology. Much of his current research addresses the response of cavernicolous species of bats to intensified human settlement of western North America during the 19th and 20th centuries. In particular, he is investigating the applicability of landscape genetics for elucidating patterns of genetic isolation and expansion following the dramatic alteration of the roosting landscape resultant from underground mining. This research involves a collaborative team that includes mining companies, State and Federal agencies, and academics from a range of disciplines including geology, hydrology, and history. His research into the use of abandoned mines by bats has led him to over 4,500 abandoned mines throughout the United States, Canada, Mexico and Central America. He received a B.S. in Botany and Range Science (1995), and M.S. in Zoology (1998) from Brigham Young University and a PhD in Biology from the University of New Mexico (2003).

THE USE OF IN-LIEU-FEES TO MITIGATE BAT HABITAT LOSS AT THE BULL RUN SURFACE MINE, VIRGINIA: A CASE STUDY

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Abstract

The payment of an In-Lieu-Fee was used to mitigate for bat habitat loss at the Bull Run Surface Mine. Bull Run is a contour and area surface mine located in the southeastern part of Wise County Virginia. D.R. Allen & Associates P.C. was contracted by Paramont Coal Company Virginia, LLC, formerly Coastal Coal Company, LLC, to design the mine operations plan and to provide environmental and permitting services for the project. Historic mining within the project area had created numerous abandoned mine portals. The mining had taken place before the Surface Mining and Reclamation Act of 1977 (SMCRA); therefore, no reclamation of the portals had occurred. One portal had been previously gated by the Virginia Division of Mined Land Reclamation (DMLR), Abandoned Mine Lands Unit (AML). The operations plan proposed re-mining in historic areas, impacting the abandoned portals and the bats that could potentially be using them. The gated portal was found to be providing habitat for the eastern small-footed bat (*Myotis leibii*) and was considered a high value wildlife resource; therefore, mitigation of the impact was required. Mitigation was originally proposed *in situ*; however, due to stability and cost concerns the original design was abandoned. The payment of an in-lieu-fee was proposed and approved by the DMLR as an appropriate alternative to the original mitigation proposal. The in-lieu-fee payment will be used to protect a cave in Lee County, Virginia. The cave provides habitat to a significant number of gray bats (*Myotis grisescens*). The protection of this cave will be significant to the conservation of the gray bat in Virginia.

Introduction

The Bull Run Surface Mine is located in the southeastern portion of Wise County, Virginia. The area is located along the eastern edge of the Appalachian Plateau physiographic province near the Ridge and Valley physiographic province of Virginia. The Appalachian Plateau is characterized by steep, intricately dissected drainages where level surfaces are rare. Approximately 71% of southwest Virginia is forested. The Appalachian Plateau is commonly referred to as the “coal fields” of southwest Virginia.

Prior to SMCRA, numerous underground mine portals were abandoned. Abandoned underground coal mines serve as key habitat for many different species of bats in the coal fields of southwest Virginia.

Three Federal and State listed threatened and endangered (T&E) bat species are known from southwest Virginia. These are the Indiana bat (*Myotis sodalis*), gray bat (*Myotis grisescens*), and Virginia big-eared bat (*Corynorhinus townsendii virginianus*). The Indiana bat is known from both the Appalachian Plateau and Ridge and Valley of southwest Virginia; the gray bat and Virginia big-eared bat are known from the Ridge and Valley. No gray or big-eared bats have been documented in abandoned coal mines in southwest Virginia (Reynolds 2004).

Environmental Assessments

The original permit application for Bull Run Surface Mine was prepared in 2000. During the environmental assessment phase, 9 abandoned mine portals were located within the permit boundary. The mining, that created these portals, had taken place prior to SMCRA; therefore, no reclamation of the portals had occurred. Historic deep mine mapping was used to determine that the portals were connected. One of the portals, Portal No. 2, was surveyed in 1987 by the Virginia Abandoned Mined Land Unit (AML) (MacGregor and Bryan, 1987). During that survey, 2 eastern pipistrelles (*Pipistrellus subflavus*) and 1 big brown bat (*Eptesicus fuscus*) were captured. Following the survey, AML installed a bat-friendly gate at the portal opening (Figure 1).

Figure 1. Portal No. 2 prior to impacts.

All 9 portals were observed at dusk in the fall of 2000 during suitable weather conditions to determine if any were being utilized by bats. Bat activity was observed only at Portal No. 2. Additional surveys were conducted at Portal No. 2 to determine if any threatened or endangered bat species (T&E) were using the portal (Brack 2001).

No Federal or State T&E species were captured during surveys at Portal No. 2. In two nights of trapping, 44 eastern small-footed bats (*Myotis leibii*), 4 long-eared bats (*Myotis septentrionalis*), 1 little brown bat (*Myotis lucifugus*), and 6 big brown bats (*Eptesicus fuscus*) were captured. Brack 2000 documented that the large complex mine works with multiple entrances with topographic variation increased the likelihood of air flow through the system, increasing the probability of suitable bat habitat. Due to the results of the surveys, Portal No. 2 was considered a high value wildlife habitat by the DMLR.

Eastern Small-footed Bat

The range of the eastern small-footed bat is large; however, concentrations of individuals in the Appalachian Mountains are rare (Best and Jennings 1997). The largest and most frequently reported concentrations have been from New York where three mines have been reported to contain over 100 individuals (Brack 2000). In the southern portion of the range, including Virginia, West Virginia, and Tennessee, concentrations of more than a few individuals are uncommon (Brack 2000).

The eastern small-footed bat is not listed as threatened or endangered by either the U.S. Fish and Wildlife Service (USFWS) or the Virginia Department of Game and Inland Fisheries (VDGIF). The USFWS classifies the species as a species of concern, which carries no legal status. The VDGIF considered classifying the species as endangered in 1978 and 1989; however, they have not designated a legal status to the bat (Terwilliger 1991).

Impacts

The mine operation plan proposed contour and area mining of the coal seam at Portal No. 2. This type of mining produces a wide, open pit along the contour of the coal seam. In this case, the width of the pit or contour cut was approximately 350 linear feet. As the operation progresses following the outcrop of the coal seam, the overburden, removed to gain access to the mineral commodity, is immediately placed in the previously mined area, such that reclamation is carried out contemporaneously with extraction (EPA 2002).

Impacts to Portal No. 2 from the proposed mine plan were substantial. The contour and area mining would remove overburden from the outcrop of the coal seam approximately 350 horizontal feet intersecting the abandoned underground mine works. The proposed mining at Portal No. 2 would create a highwall of approximately 170 vertical feet (See Figure 2). The proposed impacts to the portal would result in permanent closure once the reclamation occurred, thus eliminating the use of the portal by bats.

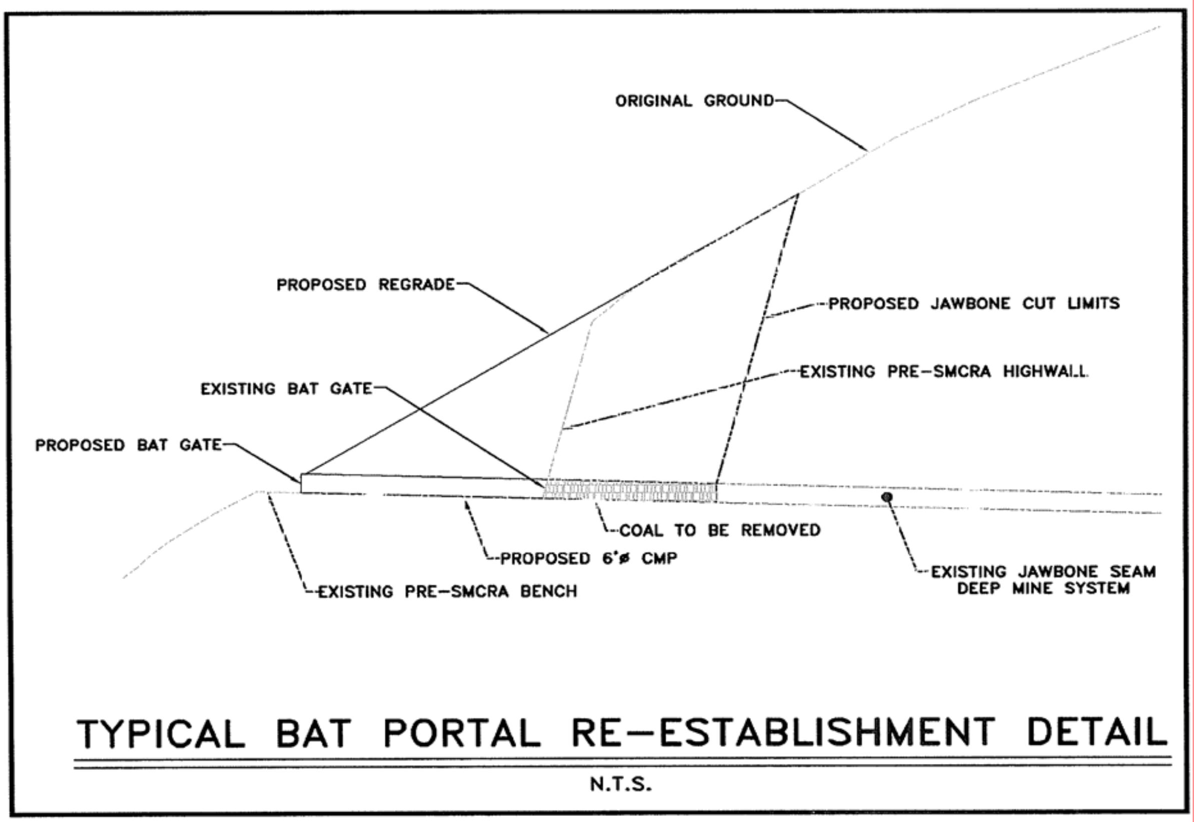

Figure 2: A detail of the proposed on-site mitigation plan proposed in the original permit application**.**

Mitigation

DMLR's regulations require that "The permittee shall, to the extent possible using the best technology currently available, minimize disturbances and adverse impacts on fish, wildlife, and related environmental values and shall achieve enhancement of such resources where practicable" (4VAC 25-130-816.97(a)). They also require surface mining activities to "….avoid disturbances to, enhance where practicable, or restore, habitats of unusually high value for fish and wildlife" (4VAC 25-130-816.97 (f)). Since Portal No. 2 was considered a high value wildlife resource, DMLR required mitigation for the impact.

On-site mitigation was proposed to mitigate for the impacts to the portal. The original mitigation plan proposed to bury a 72" diameter corrugated metal pipe along the contour cut from the mine portal to daylight for a distance of 350 linear feet. During reclamation, backfill material would be placed over the pipe with heights of cover starting at 8 ft. extending back and upward to the mine opening some 170 linear feet deep (Figure 2). Once the pipe and backfill material was in place, a bat friendly gate would be placed over the entrance of the pipe (Figure 3). This was to occur at 2 portal locations in order to allow air flow inside the abandoned underground mine works. The proposed mine project and associated mitigation was approved by VDMLR.

Mining on the site began in 2001. Reclamation of the highwall near one of the mine portals to be restored commenced in 2003. At that time, D.R. Allen and Associates, P.C. was contracted by the mine operator to examine the feasibility of the proposed design. Geo/Environmental Associates, Inc. of Knoxville, Tennessee was sub-contracted by D.R. Allen and Associates to conduct geotechnical analyses of the proposed design. This included an examination of the long-term structural capacity, corrosion resistance, and cost of the pipe. Geotechnical analyses concluded that to provide for long term structural stability a 14.75 inch-thick reinforced concrete pipe (RCP) or 0.75 inch-thick steel pipe should be used. The RCP would provide the greatest corrosion resistance and therefore last the longest. The cost of the RCP was estimated at $550.00 per linear foot while the steel pipe was estimated at $394.00. The mitigation plan required 700 linear feet of pipe to be installed, 350 feet at each portal site. The materials for the project would cost between $275,000 and $385,000. This cost estimate included materials and delivery, but not installation.

Another issue concerning the mitigation plan was changes in the deep mine works brought on by the surface mining operation. It was unclear if the two restored portals would actually re-establish the air flow in the deep mine works and provide suitable bat habitat.

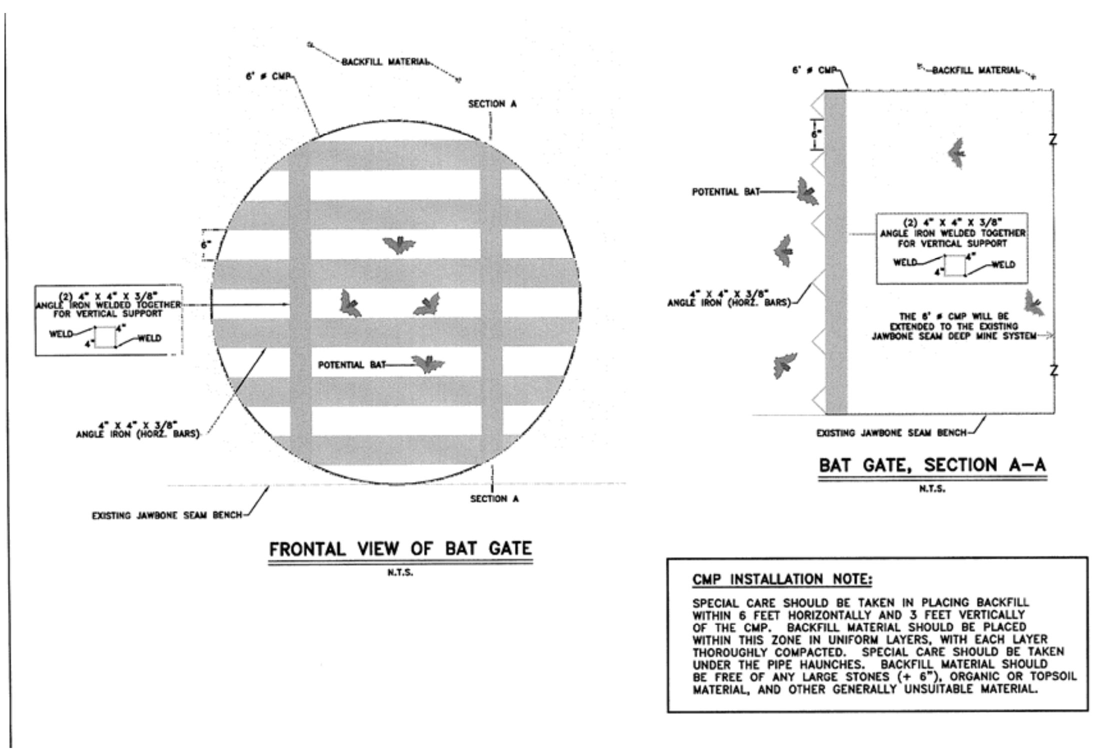

Figure 3: Bat Gate Detail as proposed in original mitigation.

Coupled with the estimated costs of the mitigation plan and the uncertainty of its success the on-site mitigation was not considered a feasible alternative. In order to satisfy DMLR requirements an alternative mitigation plan had to be devised.

Alternative Mitigation

Due to the level of impacts to Portal No. 2, additional on site mitigation was not available. This left off-site mitigation or the payment of in-lieu-fees as the only practicable alternatives. In order to locate potential mitigation sites, several natural resource agencies in Virginia were contacted. Among these were the Virginia Department of Game and Inland Fisheries, Virginia Department of Conservation and Recreation, U.S. Forest Service, and The Nature Conservancy. Potential mitigation sites needed to be as close to the permit area as possible and have ecological value equivalent to or greater than Portal No. 2. Emphasis was placed on finding a site that provided habitat for either the eastern small-footed bat or a T & E species.

The Virginia Department of Conservation and Recreation (VDCR) discovered (summer 2003) a cave in Lee County, VA. The cave potentially provides winter roosting habitat to a significant number of gray bats (Orndorff 2003). To date, insufficient biological data has been collected on the cave to determine how the bats use the cave (Reynolds 2004). However, speculation is that gray bats use this cave during spring and fall migration and possibly as a winter roosting habitat. Currently there are no known winter roosts for gray bats in Virginia (Reynolds 2004). The protection of this cave would be significant to the conservation of the gray bat in Virginia.

The cave needs protection due to a high potential for human disturbance because it is easily accessible, and minimal technical expertise is required to navigate it. It is also a potentially significant site for gray bats. Since it was in an adjacent county within the upper Tennessee River watershed and of significance to bat conservation in Virginia, protection of the cave would provide mitigation for impacts to Portal No. 2.

D.R. Allen and Associates proposed to DMLR that the operator pay an in-lieu-fee. VDCR would then work with DMLR to protect the cave.

In-lieu-fees are becoming increasingly used by industry and regulatory agencies to offset impacts to natural resources. The U.S. Army Corps of Engineers has even developed models and protocol for in-lieu-fee payments for impacts to aquatic resources. The use of in-lieu-fees to mitigate terrestrial impacts was a new concept for DMLR. Difficulty arose in placing a monetary value on the ecological value of Portal No. 2. In order to determine the required in-lieu-fee amount VDMLR based the amount on the average cost of gating an abandoned mine portal. The average cost AML spends on a portal gate was estimated at $7,000, since the original mitigation plan proposed to restore and protect two portals the in-lieu-fee amount was set at $14,000. DMLR also required the operator to perform a bat exclusion at Portal No. 2 prior to disturbing the portal.

Gray Bat

The gray bat (*Myotis grisescens*) is extremely rare in Virginia. The known populations in Virginia are large; however, they are concentrated in a few caves. (Terwilliger 1991). In summer, an estimated 4,000 to 8,000 bachelors and transients roost in four caves in Virginia (Terwilliger 1991). No known winter roosting sites exist in Virginia (Reynolds 2004). The gray bat is on the periphery of its range in Virginia. The protection of the Lee county cave would be significant for the conservation of gray bats in Virginia (Orndorff 2003).

Discussion

Due to site considerations that reclaimed surface mines present, original mitigation plans must often be altered or abandoned in order to provide a successful, ecologically sound mitigation project. Because of stability concerns with the original design, and subsequent cost concerns with an upgraded design, the original mitigation plan was abandoned. The cost associated with upgrading the original design did not appear to be commensurate with the level of impacts created by the proposed operation. Therefore, an alternate mitigation plan was developed which provided an in-lieu-fee to protect a cave which provides habitat for the gray bat.

An in-lieu-fee proposal in this situation is not common in Virginia; therefore, the applicant located a potential mitigation project for which to provide funding. Sites that we considered suitable were sites that provided habitat for an equal or greater number of eastern small-footed bats or T&E species. The sites also needed to be as close to the project area as possible.

Applicants locating sites is atypical for in-lieu-fee payments in that normally the agency receiving the money is responsible for locating the project site(s). In this case, input from the consultant helped expedite the permitting process, while allowing the agency to appropriately direct funding to the project.

There are many instances where the original mitigation design could be used to create low to moderate cost bat habitat. Examples of cases where the design might be successful include deep mine portals or contour surface mines that intercept deep mine works where the depth of cover is less significant. In this case, however, payment of the in-lieu-fee insured the required mitigation was commensurate with the impact.

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INDIANA BAT HABITAT AND MINE PLANNING: AN INDUSTRY PERSPECTIVE

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Abstract

The Indiana bat (*Myotis sodalis*) was among the first species to receive formal recognition and listing as endangered by the United States government. The range of the Indiana bat covers much of the Eastern United States. Included within this geographic territory are seventeen (17) States that have either an active or inactive coal industry. Given the extent of coal mining throughout the eastern United States and the land disturbances associated with surface mining and the surface affects of underground mining, the potential for conflicts between coal mining operations and conservation efforts for the Indiana bat is obvious. Conservation measures undertaken by the coal industry for the Indiana bat are primarily directed to habitat management. Certain habitat features which hold particularly high value for the Indiana bat may require some level of avoidance. Habitat destruction is usually minimized to the extent possible during the mining process. General wildlife habitat restoration is a routine part of most mine reclamation plans, and these restoration efforts can be directed towards specific habitat enhancement measures for the Indiana bat. Other specific efforts include work scheduling to avoid disturbances to the species during certain periods of its annual cycle. Regulation of the coal industry under ESA for conservation of the Indiana bat has evolved through the years. The process has not necessarily been consistent from State to State in the Illinois Coal Basin, specifically with regard to the detail of policies and procedures, and the changing of these requirements over time. Additionally, the entire process, since formalization of the 1996 Biological Opinion by the U.S. Fish & Wildlife Service, has been carried out by guideline and internal policy of the State regulatory agencies, which in the everyday working world of the coal industry has taken the weight of rule. Implementation of protective measures for the species has grown progressively stricter. A strong concern exists within the coal industry as to new and ever more restrictive conservation measures in the future.

Introduction

The Indiana bat (*Myotis sodalis*) was among the first species to receive formal recognition and listing as endangered by the United States government. It was officially listed in March 1967 under the Endangered Species Preservation Act of 1966, the precursor to the Endangered Species Act of 1973 (ESA), which in its basic form is the statute we still serve today. It is noteworthy that this species was recognized from the outset as imperiled, and redress to its decline was brought to the forefront during the nationwide environmental movement of the 1960s and 1970s. Population levels of the Indiana bat have continued to decline overall, although recent population data indicates that the rate of decline is significantly reduced. A great concern still exists as to the future of the species.

The range of the Indiana bat covers much of the eastern half of the United States. Included within this geographic territory are seventeen (17) states that have either active or inactive coal mining. Some of these states have very limited coal resources with minor historic production levels. Several states have non-existent coal industries today. Coal production levels vary by state and include anthracite and bituminous along with some lignite. Mining format is both surface and underground. Given the extent of coal mining throughout the eastern United States, and given the land disturbances associated with surface mining and the surface affects of underground mining, the potential for conflicts between the coal industry and conservation efforts for the Indiana bat is obvious.

Protection and enhancement measures undertaken by Black Beauty for the Indiana bat are primarily directed to habitat management and work scheduling concerns. Habitat features that hold particularly high value for the Indiana bat, such as riparian zones and stream corridors are usually avoided. Habitat destruction is usually minimized during the mining process to the extent possible, and habitat restoration following mining disturbance is a routine part of most mine reclamation plans. Specific habitat restoration efforts to enhance habitat for the Indiana bat are undertaken, specifically with regards to reforestation efforts. Other species-specific efforts include work scheduling to avoid disturbances to the species during certain periods of its annual cycle.

Regulation of the coal industry under ESA for conservation of the Indiana bat has evolved through the years. The process has not necessarily been consistent from state to state within the Illinois Coal Basin, specifically with regard to the detail of policies and procedures as implemented by both State and Federal offices. Included also are continuously changing conservation requirements. The entire process since formalization of the 1996 Biological Opinion by the U.S. Fish & Wildlife Service (FWS) has been carried out by guideline and internal policy of the regulatory agencies, which in the everyday working world for the coal industry has taken the weight of rule. These requirements continue to grow more stringent.

General Conservation Approach

Conservation efforts to minimize impacts to Indiana bats from coal mining operations are focused primarily on regulatory schemes and general management practices that eliminate disturbances to bats when they are present, reduce disturbance to suitable habitat, and restore suitable habitat in the land reclamation process. Habitat is typically divided into two distinct types including hibernacula (winter habitat) and summer habitat. Specific concerns arise where an individual(s) or population of Indiana bats are encountered on prospective mine sites and, in such instances, protective conservation measures are required to address the affected individual(s) or population.

Indiana bats utilize hibernacula from early fall through the winter period. Hibernacula may include caves and abandoned underground mines. Caves and cave systems are uncommon in the Illinois Coal Basin proper. However, abandoned underground mines are common in areas of past mining. Most abandoned underground mines and caves do not provide suitable habitat for Indiana bats. Summer habitat includes roosting and foraging areas. The past understanding of habitat utilization and site selection by Indiana bats identified riparian zones and floodplain forests as the preferred habitat type. This view has changed as research has identified varied habitat utilization. Upland forests have been confirmed as a suitable habitat type for roosting by Indiana bats. Old fields and pastures with scattered trees have been identified as foraging areas by Indiana bats. The existence of Indiana bats at any particular location is associated with the availability of nearby roost sites, which include standing live or dead trees with exfoliating or sloughing bark. Roosting sites are distinguished between consideration of early spring and fall locations, and the use of maternity roost sites by maternity colonies. Foraging areas include forested habitats in riparian, floodplain and upland areas, forest clearings, old fields, along borders of agricultures fields, woody fencerows, woody ditchbanks, farm ponds and other types of water bodies. The understanding of summer habitat selection by Indiana bats has expanded, and the definition of summer habitat now includes almost all forested and fragmented forest landscapes in the Eastern United States.

Where potential hibernacula are present within a mine plan area, surveys are required to determine the presence or absence of Indiana bats. If bat use is detected, surveys will be required to identify the species type(s) utilizing the hibernacula. The presence of Indiana bats or other threatened or endangered species will require protective conservation measures on a site-specific basis and these measures will be negotiated with the state regulatory authority (SRA) and FWS. This may ultimately require some degree of site avoidance. Consideration of roosting sites where threatened or endangered species are identified will similarly require protective measures negotiated with the SRA and FWS, and may also require some degree of site avoidance.

General conservation measures undertaken by the coal industry in the Illinois Coal Basin for protection of the Indiana bat are primarily directed to habitat management. The practices are outlined in guidance documents for the states of Illinois, Indiana and Kentucky. Timber harvest and tree clearing activities on mine sites are limited to periods of the year when bats are not present. Minimization of habitat destruction, particularly along riparian corridors and habitats of unusually high values such as wetlands, is undertaken to the extent possible. And the reduction of habitat disturbance is pursued for non-essential support areas within the mining permit area. General wildlife habitat restoration is a routine part of most mine reclamation plans, and these restoration efforts are directed towards specific habitat enhancement measures for the Indiana bat.

Indiana Bat Protection and Enhancement

Assessment of Future Mine Areas

Future mine plan areas need to be assessed to determine if any Indiana bat issues or concerns are present. Contacts with the SRA and/or the FWS will identify the existence and locations of any known Indiana bat populations and ESA designated critical habitats. If the records check does not indicate presence of Indiana bats or ESA critical habitats, a determination must still be made as to the existence of suitable habitat and the relative value of that habitat.

Suitable summer habitat for the Indiana bat is characterized as forested stream corridors, riparian zones, forested floodplains, forested uplands, forest edges, water bodies including ponds, lakes and impoundments, and wetlands. This definition includes almost all forested and fragmented forest landscapes in the Eastern United States. Therefore, suitable habitat is found on most mine plan areas in the region. Further, summer habitat may include individual trees that are (1) living and exhibit exfoliating bark, crevices or cavities, and (2) dead, dying trees or severely injured trees that exhibit sloughing bark. Suitable winter habitat includes potential hibernacula and is characterized by caves or abandoned underground mine openings.

Habitat surveys must be performed to determine the type and quality of habitat that exists within the permit area. If potential hibernacula sites are identified or potential suitable summer habitat exists, a decision must be made to verify presence or absence of Indiana bats. Surveys may involve use of bat detection devices to determine if the cave or abandoned underground mine is being utilized by bats of any species. Mist net surveys may be mandatory to identify the species type utilizing the hibernacula site. Mist-net survey protocols are standardized for both summer habitat and for cave or mine openings. Results of the survey may demonstrate existence of Indiana bats and other species of threatened or endangered bats, as well. The decision to perform mist-net surveys is time sensitive due to specific netting season dates, and requires preplanning to accomplish mist-net surveys at the appropriate times of year. The decision to mist-net can be driven by time constraints, as well as cost. If no Indiana bats are found by the surveys, the coal operator may assume probable absence of the species within the permit area. If Indiana bats are found, protection and enhancement measures will be required. The other approach to addressing Indiana bat concerns within a future mine plan area is to assume presence and proceed with protection and enhancement planning to minimize disturbance and avoid the potential for an incidental take of the species.

Mine Permitting Procedures

An assessment of future mine plan areas will determine the actual presence or likelihood of Indiana bat presence, and identify the need for any further survey work and specific permit objectives.

Where Indiana bats or critical habitats are known to exist within the proposed permit area or within a predetermined distance of the proposed permit area, contact with the SRA and FWS should be undertaken early in the permit application process to coordinate address on Indiana bat issues. The distance usually set for consideration is a 5.0 mile radius of the permit area. Early contact will allow for coordination and development of specific mine plans to protect the identified population. Such a plan will be negotiated and may involve various measures to assure protection of the identified population. This plan could require modification of the mining plan.

Where high value habitat exists within a proposed permit area, and it will exist in some form or another on most sites, specific address to Indiana bat conservation will be required in the mining permit application. The existence of high value habitat is typically addressed in the permit application under the fish and wildlife resource information section. Habitat features may be specifically referenced for the species, or are sometimes addressed in a more general sense, by the descriptions of the premine land use and plant community information.

Should mist-net surveys be employed, the findings are presented to confirm presence or probable absence of the Indiana bat for permit processing purposes. Again, where Indiana bats are identified by the survey, early coordination with the SRA and FWS is advisable prior to application preparation. In the absence of mist net survey data, specific measures must be undertaken where high value habitat exists to reduce the likelihood of potential take of an Indiana bat. This is accomplished primarily by removing potential roosting habitat during a period of the year when bats are not present. Tree removal dates for several states in the Midwest United States are provided in Table 1. If caves or abandoned mine entries are present and bats are using them, a protection plan is required to address closure of the cave or mine entry.

Table 1. Approved Tree Removal Periods

State	Tree Removal Period	
	From	To
Illinois	September 30	April 1
Indiana	September 15	April 15
Kentucky	November 15	March 31
Missouri No	ne	None
Ohio	September 15	April 15

Black Beauty has traditionally addressed Indiana bat conservation by removing high value habitat features during the winter timber harvest period. We typically coordinate this with the SRA and commit to this process in the permit documents. We have conducted mist-netting on one occasion in the past where the FWS required site survey work for a particular location, which they felt held a high potential for Indiana bat inhabitation. The survey did not identify the presence of Indiana bats. We have not encountered any situations where caves or mine openings (*i.e.* potential hibernacula) were present within or adjacent to our mining permit areas. There are other efforts, which we undertake in the mine planning and permitting process for the protection and enhancement of Indiana bat habitat. The integrity of riparian corridors is maintained to the extent possible and stream buffer zone variance requests are limited. Habitat loss is minimized on mining support areas with careful design, location, and construction of sediment ponds, ditch systems, stockpiles, roads, etc. Road systems and stream crossings are designed and constructed to reduce disturbance to streams and floodplains. Postmine forest and wildlife habitat acreages are proposed in approximate premine amounts. Water resources are almost always proposed in the reclamation plan. Wetland disturbances are held to a minimum. Wildlife habitat restoration plans are developed and implemented to restore high-quality habitat within the permit area and interface with habitat types and values adjacent to the permit area.

Land Reclamation Practices

Federal and State surface mine control and reclamation regulations require that restoration of sites disturbed by coal mining operations be carried out contemporaneously, and that a demonstration be made as to proof of vegetation success and productivity. Land uses, vegetation reestablishment efforts, and wildlife habitat restoration and enhancement plans are detailed in the mining permit document.

The reclamation process begins with proper grade restoration. Site stability, proper slopes, and topography that compliment the surrounding landscape are important aspects to achieving high quality land reclamation. Proper soil handling and replacement is a critical process to achieving land reclamation success. Soil resource investigations are undertaken on all permit areas to identify the quality and quantity of soil materials. Black Beauty routinely obtains soil substitution plans, which allow us to utilize and replace the most desirable soil materials within the permit area. All topsoil materials are removed and replaced to a uniform thickness throughout the permit area. An exception to this is the occasional use of a topsoil substitute material on nonprime areas where an A/B mix or excess prime soil B horizon material is identified as being a more productive soil material. This occurs when an existing soil type has a rocky or highly eroded topsoil horizon. A substitution plan for subsoils is also employed. High quality subsoils exist in certain prime soil types, and these prime subsoils are retrieved from deeper intervals and substituted for less desirable subsoil materials of other soil types. Erosion control structures such as terraces, tiling and dry dams are frequently installed at the time of soil replacement. When erosion problems are apparent in the initial years following soil replacement, terracing, drydams, tiling and other measures are implemented as control measures.

Topsoil replacement operations are concentrated during the months of May through October to take advantage of favorable weather and ground conditions, and to allow for establishment of vegetative cover for erosion control. Land leveling, deep soil tillage, and installation of erosion control systems are completed as soon as practicable following topsoil replacement. Cover crops (temporary vegetative cover) and mulching are used extensively to control erosion and aid the establishment of permanent vegetation. Permanent vegetation is, likewise, established as soon as practicable following topsoil replacement and completion of appropriate land management practices.

Standard soil test sampling and analysis procedures are conducted for texture, pH, buffer pH, nitrogen, phosphorus and potassium to provide accurate soil amendment recommendations. Soil amendments are applied accordingly. Straw or hay mulch is applied at the rate of 1.5 tons/acre. Mulch is applied to areas of replaced topsoil that cannot be immediately revegetated, due to the season or ground conditions.

The restoration of cropland involves standard agronomic practices for production of wheat, soybean, and corn crops. These grains are harvested and yields compared to NRCS and State agricultural agency target yields for site and soil types. Success is demonstrated by meeting 100% of the target yields on prime farmland and 90% of the target yields on non-prime farmland. Pasture establishment includes various grasses and legumes that are typically grown in the area, and are planted and managed utilizing standard agronomic practices for production of forage crops. Warm season grasses may also be utilized. Success is demonstrated by a 90% ground cover of the approved pasture species and by meeting 100% of the target yields on prime farmland and 90% of the target yields on non-prime farmland. Forest reestablishment success is measured by an 80% survival rate over three growing seasons and 450 live trees per acre at final bond release, with a 70% ground cover of herbaceous vegetation for erosion control. Wildlife habitat reestablishment is measured by an 80% survival rate over three growing seasons and 225 to 250 live trees per acre at final bond release, with a 70% ground cover of herbaceous vegetation for erosion control. Table 2 identifies the tree and ground cover species typically employed for reforestation and wildlife habitat restoration and enhancement on Black Beauty mine properties. Warm season grass plantings are sometimes utilized as wildlife habitat along with the establishment of moist soil or wetland sites. Success standards include establishment of the intended vegetation type and erosion control.

Table 2. Reforestation & Wildlife Habitat Restoration
Tree and Ground Cover Species

Plant Species	Seeding or Planting Rate	Method of Application
Orchard Grass	10.0 lb/ac	Broadcast
Red Clover	6.0 lb/ac	Broadcast
Brome Grass	10.0 lb/ac	Broadcast
Red Top	20.0 lb/ac	Broadcast
Bluestem	4.0 to 8.0 lb/ac	Broadcast
Buffalo Grass	4.0 to 8.0 lb/ac	Broadcast
Gama Grass	4.0 to 8.0 lb/ac	Broadcast
Buffalo Grass	4.0 to 8.0 lb/ac	Broadcast
Indian Grass	4.0 to 8.0 lb/ac	Broadcast
Switchgrass	4.0 to 8.0 lb/ac	Broadcast
Rye Grass perennial]	10.0 lb/ac	Broadcast
Ladino Clover	2.0 lb/ac	Broadcast
Alfalfa	8.0 lb/ac	Broadcast
Birdsfoot Trefoil	10.0 lb/ac	Broadcast
Korean Lespedeza	15.0 lb/ac	Broadcast
Yellow Poplar	726 trees/ac	Mechanical or Hand
White Oak	726 trees/ac	Mechanical or Hand
Bur Oak	726 trees/ac	Mechanical or Hand
Pin Oak	726 trees/ac	Mechanical or Hand
Northern Red Oak	726 trees/ac	Mechanical or Hand
Southern Red Oak	726 trees/ac	Mechanical or Hand
White Ash	726 trees/ac	Mechanical or Hand

Plant Species	Seeding or Planting Rate	Method of Application
Green Ash	726 trees/ac	Mechanical or Hand
Virginia Pine	726 trees/ac	Mechanical or Hand
White Pine	726 trees/ac	Mechanical or Hand
Eastern Red Cedar	726 trees/ac	Mechanical or Hand
Sugar Maple	726 trees/ac	Mechanical or Hand
Red Maple	726 trees/ac	Mechanical or Hand
Silver Maple	726 trees/ac	Mechanical or Hand
River Birch	726 trees/ac	Mechanical or Hand
Sweet Gum	726 trees/ac	Mechanical or Hand
Sycamore	726 trees/ac	Mechanical or Hand
Black Walnut	726 trees/ac	Mechanical or Hand
Black Locust	726 trees/ac	Mechanical or Hand
Gray Dogwood	726 trees/ac	Mechanical or Hand
Red-osier Dogwood	726 trees/ac	Mechanical or Hand
Hawthorn	726 trees/ac	Mechanical or Hand
Sumac	726 trees/ac	Mechanical or Hand
Elderberry	726 trees/ac	Mechanical or Hand
Crabapple	726 trees/ac	Mechanical or Hand

A general wildlife habitat restoration and enhancement plan with upland and lowland habitat types is included in the permit. The plan includes restoration of wildlife habitat on areas designated with the specified postmine land use of wildlife habitat; and in addition, the plan may be integrated into other approved postmine land use types as a general means to improve and enhance wildlife habitat on the postmine landscape. Habitat enhancement features include the type and configuration of vegetative components reestablished, as well as the retention of temporary and permanent water bodies. These efforts provide food, water, cover and an increased amount of edge for wildlife. Woody plantings are arranged in two forms including strip and group plantings. Strip plantings typically are composed of desirable evergreens and flanked with rows of wildlife shrubs. Strip plantings are intended to break up large open areas, furnish travel lanes, and provide food and cover. They are established along field borders, drainways, fencerows, and property lines. Group plantings are comprised of deciduous trees, primarily oak, ash, walnut, locust, and maple and a combination of wildlife shrubs and conifers. Pines are not planted in large blocks, but primarily utilized as windbreaks and cover. Group planting are of a random plant mix and pattern. The groupings are usually one acre or less and furnish islands of food, cover and loafing areas in herbaceous plantings.

Warm season grasses are developed in blocks of 10.0 acres or less. These permanent species may include, but are not limited, to big and little bluestem, gama grass, Indian grass, and switchgrass. These fields are managed for hay production as well as wildlife benefit. Hay production or mowing for management of these grasses as wildlife habitat occurs after 15 July. Additionally, warm season grass plantings are periodically burned to manage stand integrity and vigor. Brush piles are occasionally constructed into any of the above mentioned wildlife areas for cover features. Such areas are constructed with any combination of rocks, branches, limbs, roots, trunks or trees. Water resources, both seasonal and permanent, are constructed when a situation arises that is advantageous.

Wetland units are sometimes restored as an integral part of the reclamation plan. Such wetlands may include either shallow water and emergent marshlands or forest plantings with mixed deciduous bottomland hardwood trees. Reconstruction of wetlands occur under authority of Clean Water Act Section 404 permits for authorized wetland disturbances, or as wildlife habitat enhancement efforts integrated into the approved postmine land use plan.

Black Beauty will produce approximately 27M tons of coal in 2004 and will disturb around 1,800 acres. Annual disturbed acreage figures will vary with new mine development, expansion at existing mining operations, and changes to operating conditions for different coal seams at existing mines. Final reclamation activities are completed on approximately the same acreage, annually, and final bond (Phase III) release tracks accordingly.

Table 3 summarizes these figures for coal production, acres disturbed, and acres receiving final bond (Phase III) release during the past six (6) years.

Table 3. Coal Production, Land Disturbance & Land Reclamation

Year Tons	Coal Production	Land Disturbance Acres	Land Reclamation (Phase III Release) Acres
1999 19	M	1,800	1,400
2000 22	M	1,300	1,300
2001 26	M	2,200	2,400
2002	25 M	2,100	300
2003 25	M	1,400	3,000
2004	27 M*	1,800*	3,200**

* 2004 projections.
** 2004 Phase III bond release to date.

Land use patterns on Black Beauty mine sites include between 65%-70% agricultural land uses (primarily cropland and pasture), 25% - 27% forest and wildlife habitat land uses, and 3% - 10% other types of land uses such as residential, industrial & commercial, water, roads, etc. Modification of these premine land uses in the postmine state includes insignificant changes to the agricultural land uses. Forest and wildlife habitat typically increase about 10% during reclamation on Black Beauty permits. Postmine forest acreages decrease slightly while postmine wildlife habitat increases significantly. Water resources increase in the postmine state and comprise 5% of the final reclaimed acreages.

Land use changes are a balance of existing land uses within the permit area that effectively utilize slope and setting to compliment the final reclamation plan of the permit area. These land use modifications involve minor changes and relocations. Black Beauty does not typically pursue large or expansive land use changes where one type of land use is replaced with another. There are instances, however, where a property owner stipulates by lease agreement specific postmine land uses. In these instances, we are obligated to replace a desired land use. We do routinely seek approval for an increase of water resources in the postmine state. Water resources comprise 1% of the premine area and about 5% of the postmine area. Land use changes are compatible with adjacent land uses and also comply with existing local land use policies and plans. Table 4 summarizes the premine and postmine land use patterns on Black Beauty mine sites.

Table 4. Premine & Postmine Land Use Patterns

Land Uses	Premine	Postmine
Agricultural (Crop & Pasture) 65%-70%		65%-70%
Forest & Wildlife Habitat	25%-27%	30%-37%*
Water	1%	5%
Other (Residential, Commercial, Roads, etc)	3%-9%	1%-3%

* Postmine forest and wildlife habitat typically increases about 10%. Forest decreases slightly, while wildlife habitat increases.

Perspective on Regulatory Process

The ESA is a fairly straightforward environmental law. It requires the identification and listing of species in need of protection. It requires that protective measures be identified to assist the recovery of the listed species. It provides for consideration of the listed species, prior to any federal action that potentially would affect them. And it provides for punishment of any entity which harms a listed species. Interestingly, however, the law does not identify what can and cannot be done. It does not direct the regulated community in a manner as to the conduct of business so as to assure compliance. The ESA provides no warning of potential conflicts.

There are numerous criticisms of the ESA concerning both its content and implementation. This is the case with most environmental legislation. Although some criticisms have merit and other criticisms are suspect, there are shortcomings in the implementation of the ESA for protection and recovery of Indiana bats that directly impact the coal industry. Decisions made on conservation and protection measures are not necessarily based on scientific findings, particularly for protection of summer habitat. Many of these measures take a shotgun approach for the protection of individuals or populations that have a possible, not verified presence. There is a significant effort made for conservation measures on mine sites where there is no evidence that Indiana bats are present and, in fact, are probably not present. Implementation of conservation efforts for Indiana bats and all threatened and endangered species should be based on verifiable effectiveness of those measures. This brings up the point that there is no reward for beneficial conduct under ESA. Cost and, more importantly, the tremendous regulatory uncertainty, are other troubling issues.

The implementation of protective measures under ESA for the Indiana bat has grown stricter in recent years. Conservation measures have been undertaken through the use of policies, regulatory guidance memoranda, and other regulatory initiatives, and have not undergone outside review or comment. Scientific research has unquestionably expanded knowledge of the life history of the species and particularly its biology and behavior during the non-hibernating period. And implementation of new conservation measures based upon this information has afforded the species additional protection. There are several areas where changes in protective measures have affected the conduct of business with the coal industry.

The definition of suitable habitat has changed significantly in recent years. Further, the definition of high value habitat, that is, habitat requiring protection, has expanded significantly in recent years. The original definition of high value habitat focused upon hibernacula and the surrounding area to some predetermined distance, and maternity colony sites. Later, summer habitat was added which included riparian zones, stream corridors, and bottomland forest settings where the understanding of habitat selection indicated maternity colonies were most likely to occur. In recent years, the definition of suitable summer habitat for roosting and foraging has expanded to include forested stream corridors, riparian zones, forested floodplains, forested uplands, forest edges, water bodies including ponds, lakes and impoundments, and wetlands. Notably, foraging areas now include old fields, borders of agricultures fields, woody fencerows, woody ditchbanks, farm ponds and other types of water bodies. Pastures with scattered trees have been identified as foraging areas by Indiana bats. Suitable summer rooting habitat may include individual trees that are (1) living and exhibit exfoliating bark, crevices or cavities, and (2) dead, dying trees or severely injured trees that exhibit sloughing bark. All forested and adjacent areas in any landscape setting can now be characterized as suitable habitat. Given the status of the species as endangered, the habitat is afforded a defacto status as "high" value. This present definition of suitable/high value habitat includes most mine plan areas in the range of the Indiana bat. As a result, without a mist-net survey demonstrating probable absence of the species, a mitigation plan addressing conservation measures for the Indiana bat must be implemented project wide.

The definition of roost tree has also changed in recent years. Tree size (DBH) has been used as an in-field measurement technique for determining a potential roost tree and the minimum size has ranged from 16" DBH down to 5" DBH in recent years, depending on what agency official you are conferring with and what political domain you are standing in. The list of tree species utilized by Indiana bats continues to increase and a summarization of various state and federal documents yields up to twenty-seven (27) different tree species. Table 5 summarizes the list of tree species identified as suitable roosting habitat for Indiana bats. The listing has continued to grow. Most forested areas in the eastern United States will include many of these tree species.

Table 5. Tree Species Utilized by Roosting Indiana Bats

Tree	Species
Shagbark Hickory	*Carya ovata*
Shellbark Hickory	*Carya laciniosa*
Bitternut Hickory	*Carya cordiformis*
Pignut Hickory	*Carya glabra*
Mockernut Hickory	*Carya tomentosa*
White Ash	*Fraxinus americana*
Green Ash	*Fraxinus pennsylvanica*
Black Ash	*Fraxinus nigra*
White Oak	*Quercus alba*
Post Oak	*Quercus stellata*
Northern Red Oak	*Quercus rubra*
Southern Red Oak	*Quercus falcata*
Black Oak	*Quercus velutina*
Scarlet Oak	*Quercus coccinea*
Shingle Oak	*Quercus imbricaria*
Chestnut Oak	*Quercus prinus*
American Elm	*Ulmus americana*
Slippery Elm	*Ulmus rubra*
Silver Maple	*Acer saccharinum*
Red Maple	*Acer rubrum*
Sugar Maple	*Acer saccharum*
Black Cherry	*Prunus serotina*
Persimmon	*Diospyros virginiana*
Sassafrass	*Sassafrass albidium*
Eastern Redbud	*Cercis canadensis*
Black Locust	*Robinia pseudoacacia*
Eastern Cottonwood	*Populus deltoides*

The restriction on timber harvest, tree clearing, tree removal, etc. is another protective measure that has changed in recent years. Table 1, Approved Tree Removal Periods identifies the current restrictions. These dates have changed in recent years in several of the noted states. The changes have created confusion at some Black Beauty facilities with keeping track of what dates apply where. Black Beauty has one mining operation with three different restrictions on timber removal periods, depending upon the mine permit area. Of the three (3) states, Illinois, Indiana and Kentucky in the Illinois Coal Basin, each has different timber removal dates at the present time, as does neighboring Ohio. Missouri has no timber removal restrictions.

It is important to note that the justification for the increased protective measures of recent years is based primarily on intuitive principles. The implementation of protective measures and their ongoing modifications, obviously have a probability of affording some level of additional protection to Indiana bats. However, the relative value of these protective measures has not been subjected to any scientific analysis, and their respective merits have not been qualified or quantified as to relative protection afforded the species. How many Indiana bat maternity colonies have been shielded from disturbance by the implementation of timber harvest restrictions and subsequent modifications to these harvest period dates? What is the operational and economic impact on the coal industry, and the entire regulated community for that matter, as a result of the implementation and subsequent changes of these dates? What is the net positive affect of these restrictions on Indiana bat populations? What level of incidental take is occurring with and without the current conservation measures? The basis and justification for implementation of current conservation measures is anecdotal, not scientific.

The implementation of protective measures for conservation of the Indiana bat has impacted the coal industry and will continue to impact the industry. The lead-time for reserve evaluation, permitting, and initiation of mining operations has been increased because of the requirements to assess mine plan areas for Indiana bats. Delays in the permitting process are real in those instances where portal surveys or other mist-net surveys are required. Also, if Indiana bat populations are identified in the immediate mine plan area, permit delays most definitely will occur. The potential for regulatory entanglements is real and threatening. Certainly, any additional work conducted by a coal operator on behalf of the Indiana bat is a direct cost; but in addition, the protection and enhancement measures frequently add minor incremental costs to otherwise standard work processes. These minor costs are often unaccounted for individually in economic assessments, but can add up to significant increases in overall costs. The biggest concern for the industry is the risk of encountering Indiana bats, and thereby preempting mining operations or causing the extent of operations to be reduced and restricted. The identification of Indiana bats within a mine plan area has the potential to require avoidance of sites such as hibernacula and maternity colony roosting sites. On smaller reserve areas, any reduction or restrictions on operations can render the reserve uneconomical for mining.

Regulation of the coal industry under ESA for conservation of the Indiana bat has evolved through the years, and moved cautiously to implement progressively stronger protective measures for the species. The process has not necessarily been consistent from state to state within the Illinois Coal Basin and elsewhere, specifically with regard to the detail of policies and procedures as implemented by both state and federal offices, and the changing of these requirements over time. Although this is not a problem in itself, it is an inconsistency that highlights the unknown aspects of the Indiana bat life history, especially the non-hibernating period. The entire process since formalization of the 1996 Biological Opinion by the U.S. Fish & Wildlife Service has been carried out by guideline and internal policy of the regulatory agencies. The Indiana bat recovery plan, although currently undergoing revision, was last updated and approved in 1983. That plan does not recommend or even contemplate the conservation and protection measures that are in force today. And in the everyday working world of the coal industry, the guidelines and internal policies have taken the weight of rule. These requirements have continued to grow more stringent in recent years, and there is every indication that this process will continue.

Summary

Black Beauty is committed to compliance with the ESA. We will continue to expend funds and take appropriate actions to protect and conserve Indiana bats and other threatened and endangered species in accordance with applicable State and Federal laws. Obviously, we feel that many of our efforts under the current regulatory process are not time or money well spent. Land disturbances resulting from coal mining do not now and will not in the future have a significant impact on the continued existence and recovery of the Indiana bat. The potential exists for isolated encounters between coal mining operations and this species. Such isolated encounters have the potential to be very costly and possibly preemptive for mining. Given the evolution in recent years of expanding habitat definitions and ever more restrictive conservation measures for the Indiana bat, there is concern about impacts on the coal industry from Indiana bats.

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Session 5

Guidance Development for Permitting

Session Chairperson:
Bob Fala
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Charleston, West Virginia

The Indiana Bat and the Kentucky Surface Mining Program: A Progress Report
Dr. Richard Wahrer, Kentucky Department for Natural Resources, Division of Mine Permits, Frankfort, Kentucky

Indiana Guidance, Problems, Highlights, Successes and Failures
Tim Taylor, Indiana Division of Reclamation, Jasonville, Indiana

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Protection of the Indiana Bat (Myotis sodalis) and the Tennessee Federal Program
Becky Hatmaker, U.S. DOI Office of Surface Mining, Knoxville, Tennessee

Chronicle of West Virginia Coal Program Permitting Considerations of the Endangered Indiana Bat (Myotis sodalis)
*Robert A. Fala, **Kevin G. Quick** and Andrew N. Schaer, West Virginia Department of Environmental Protection, Division of Mining and Reclamation, Charleston, West Virginia*

THE INDIANA BAT AND THE KENTUCKY SURFACE MINING PROGRAM: A PROGRESS REPORT

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ABSTRACT

The Kentucky surface mining program within the Department for Natural Resources (KDNR) has employed procedures for the protection of the Indiana bat since 1995. In 2001, representatives from the U.S. Fish and Wildlife Service (FWS), the Kentucky Department of Fish and Wildlife Resources (KDFWR) and KDNR authored the *"Guidelines for the Development of Protection and Enhancement Plans for the Indiana Bat*,*"* to aid the coal mining industry in understanding the options and protocols associated with mining in areas containing potential Indiana bat habitat. This document addresses two main strategies for the recovery of this Federally listed species: the protection of winter hibernacula and the restoration of summer roosting habitat. Designated critical habitats are located outside of the Kentucky coalfields though abandoned mine portals have been found to be minor hibernacula. Buffering these areas from mining or performing portal closures are two approaches utilized to minimize mining impact. In those mining areas that have been determined to be Indiana bat habitat, based on recorded occurrences, 70% of the reclaimed area must contain (bat-friendly) trees. To avoid a taking of this species, trees may only be removed from November 15 to March 31. To promote reforestation and enhanced fish and wildlife habitat as post mining land uses, KDNR is actively involved with the Appalachian Wildlife Initiative, sponsored by the Rocky Mountain Elk Foundation and has taken a leadership role from the States perspective relative to the implementation and development of the Appalachian Regional Reforestation Initiative, sponsored by the Office of Surface Mining. For several years, KDNR has provided the coal applicant consistent guidance and a variety of options to provide for the protection and enhancement of the Indiana bat. However, differences in opinion between KDNR and the FWS regarding the rationale for requiring mist net surveys remain unresolved.

Introduction

Today, much of the readily available coal resources have been mined in the eastern United States. With the depletion of reserves located in isolated areas, the more populated, geologically complex areas and environmentally sensitive reserves are now being developed. With the encroachment of proposed mining operations into localized regions with designated and protected streams and high value fish and wildlife habitat, the consultation process and requirements and approvals from State and Federal fish and wildlife agencies for mining to proceed, can easily slow and delay the application review process. Because of the high volume of surface mining applications and a substantial recent increase of submittals due to rising coal prices, the Division of Mine Permits in the Kentucky Department for Natural Resources has had to develop streamlined review processes that not only address site-specific concerns but also ensure consistency of review requirements for the coal industry.

Though a Federally listed threatened or endangered species may be present on, or adjacent to, a proposed mine site, it does not mean the permit application will be denied nor active operations suspended. When faced with a T/E species scenario, KDNR recommends to the coal applicant that the concerns are identified in a pre-application process, to communicate early and often with the State and Federal fish and wildlife agencies and present to the regulatory authority complete protection and enhancement plans for that particular species. Therefore, the purpose of this paper is to explain the Kentucky surface mine permitting process, summarize the evolution of the development of Indiana bat protection and enhancement plans, discuss the distribution of the Indiana bat in Kentucky, outline programs that the KDNR is involved of which the Indiana bat will benefit and specify the issues that remain unresolved between the FWS and KDNR for improved Indiana bat protection.

Kentucky Permitting Process

By State regulation, a preliminary application must precede the submission of an original or comprehensive permit application. Additionally, an on-site investigation must be conducted within 15 days of the preliminary application submission to the appropriate field office. The preliminary application contains only a brief overview of the mining proposal; however information regarding permit area boundaries, locations of the coal seam(s) to be mined, access roads, haul roads, spoil or coal waste disposal areas and sedimentation ponds must be identified on a map. The on-site inspection, also known as a "team walk" provides opportunities for the consulting agencies (FWS, KDFWR, Kentucky Division of Water-DOW, Corps of Engineers-COE, State Historic Preservation Officer-SHPO) to identify specific concerns and discuss these concerns with the coal company representatives. Footprints of the hollow fills and sediment structures can be verified with the COE performing their determination of jurisdictional waters.

The preliminary application is assigned to the Critical Resources Review Section (CRRS), composed of biologists and professional archaeologists. These personnel are tasked with providing copies of the preliminary applications to the consulting agencies for comment as well as determining the proximity of State designated waters and Federal lands to the proposed permit area. Aerial photographs are used to assess the degree of disturbance that is present in the vicinity of the area. As a result of a Memorandum of Agreement with the Kentucky State Nature Preserves Commission, CRRS has desktop access to the Natural Heritage database that lists the historical occurrences of State and Federally listed threatened and endangered species in relation to the proposed mining area.

Therefore, at the time of the on-site inspection, CRRS already knows if Indiana bats have been recorded (mist net capture, maternity colonies, hibernacula) on or near the permit area and use the "groundtruthing" walk to verify if potential Indiana bat habitat exists. Abandoned mine portals, if present, are examined externally to determine potential use by the bat. From these findings, it is then determined if a bat survey is needed (in consultation with FWS) or if the applicant wishes to assume presence of the Indiana bat and forego the survey. In the cases of a required survey or assumption of presence, a survey plan or a site-specific protection and enhancement plan must be submitted to CRRS before the application can be deemed administratively complete. These plans are forwarded to FWS and KDFWR for comment and modification. With this preliminary process, an approved plan can be inserted into the original comprehensive permit package and the technical review of the application is less time-consuming as the consulting obligations have been completed.

The Evolution of *Guidelines* for the Development of Indiana Bat Protection and Enhancement Plans

Why the need for Guidelines? The Kentucky surface mining program is quite active in permit actions compared to many of the eastern coal states. Proposed permit areas usually average less than 400 acres and have multiple private landowners. By regulation, KDNR has 65 working days to review a complete application resulting in either issuance or denial. KDNR employs 29 permit reviewers, each with a caseload of over 30 pending applications. It is imperative that the review process is efficient and streamlined which defines the need for documents such as the Guidelines for the Development of Protection and Enhancement Plans for the Indiana Bat (*Guidelines).* At the same time, all applications must be reviewed thoroughly with all the regulatory requirements addressed for inspection and enforcement purposes. Above all else, the regulatory authority must be consistent and predictable in their reviews and responses to the coal applicant. Table 1 enumerates the number of preliminary applications and coal explorations submitted to CRRS. Almost all of the coal explorations are notices that have a 21-day window of review before the exploration project begins. Given that there is little time to consult with the fish and wildlife agencies, CRRS must "speak" on their behalf in those areas where T/E species might be present. Specifically, Indiana bat *Guidelines* contain those issues of concerns and need to be addressed by the FWS allowing the CRRS to provide comment and conditions for the operation to proceed.

Table 1. CRRS Permitting Activity

	New Applications	Exploration Notices
2000 21	6	209
2001 33	0	258
2002 27	0	185
2003 22	7	182
2004	252	240

Protection and enhancement plans (PEP) for the Indiana bat were not incorporated in the permit application until 1995. More than likely these actions were prompted by the mist net captures in the coalfields performed by KDFWR and the Kentucky State Nature Preserves Commission (KSNPC). The earliest PEP did not specifically address the Indiana bat but just promoted fish and wildlife post mining land use enhancements including brush and rock piles (of little benefit to the bat). The fish and wildlife post mining land use required 30% of the permit area to be reclaimed with tree species. With very little guidance from the regulatory agency to the coal industry on this matter, the bat biologist consultants hired by the coal company developed site specific and detailed methodologies for surveys and reclamation strategies. Nonetheless, at this time KDNR entered into a funding MOA ($850,000/year) with KDFWR and KSNPC for assistance with fish and wildlife inventories and T/E species concerns and KDNR became much more cognizant of Indiana bat protection programs.

Because of the lack of written policy and procedures for IBPEPs, KDFWR and FWS provided KDNR with the first development of protection and enhancement document in 1997. By addressing the issues and implementing the procedures in this document, the coal applicant could experience "smooth sailing" through the consultation process with the fish and wildlife agencies. These new and approved *1997 Guidelines* detailed abandoned mine portal surveys, specific revegetation plans and introduced the assumption of presence alternative to mist net surveys. If the permit area was found to be within 10 miles of a hibernaculum or a historical mist net capture, the applicant could assume of presence of the Indiana bat and agree to winter tree clearing dates and reclaim a minimum of 70% of the disturbed area to "bat-friendly" tree species. The same restrictions applied to a mist net capture from a survey. If a survey resulted in no capture, an IBPEP was not required. The *1997 Guidelines,* however, were somewhat confusing to the coal industry and lacked enough detail that led to multiple consultations. Depending on the distance from a hibernaculum and the elevation of the permit area, multiple tree-clearing dates were listed in the *Guidelines* adding to the confusion.

In 1999, the Commissioner of KDNR convened a group of representatives from FWS, KDFWR and KDNR to write a revised set of guidelines that would better utilize updated biological information, methodologies and protocols that would allow innovative measures for site specificity. Drafts of this document were sent to the coal industry, Federal and State fish and wildlife agencies and the academic community for comment. Subsequently, reviewers from these entities attended a comment discussion and resolution meeting, hosted by KDNR. Details of these discussions and the main components of the present *2000 Guidelines* can be found in the <u>Proceedings of the Bat Conservation and Mining: A Technical Interactive Forum</u> (Wahrer 2001). The *2000 Guidelines* is a document that promotes a single tree-clearing period (November 15-March 31) and presents templates for study plans and survey reports. Though the FWS has never given a final approval to these guidelines due to outstanding issues of stream buffer zone variances, mist net location sites, and shallow watering areas, it is still being used and has been incorporated into 163 permit applications. Recently, a new FWS field office has opened in Kentucky and plans have been made to review and update the *2000 Guidelines.*

Distribution of the Indiana Bat in Kentucky

Though it is thought that the historical range of the Indiana bat covers the entire Commonwealth of Kentucky, recorded occurrences seem to be found in the areas known as the Mississipian Plateau or Pennyrile region. Often referred to as karst, the Plateau consists of a limestone plain characterized by sinkholes, sinking streams, springs, and caverns. Recorded hibernacula are found in these limestones with the Mammoth Cave system and the Carter Caves systems (arrows in Figure 1) being designated critical habitat for the bat. The limestone escarpments lie on the western edge of the eastern coalfields with Pine Mountain in the extreme southeastern portion of the State also exhibiting limestone cave systems. In the last five years, it has been found that Indiana bats have used abandoned mine portals for winter habitat though a census has not been performed. Figure 1 shows the occurrences according to the Natural Heritage database maintained by KSNPC. Ideally, all State and Federal agencies involved with Indiana bat surveys report their findings to KSNPC for the most current reflection of the distribution of the bat in Kentucky.

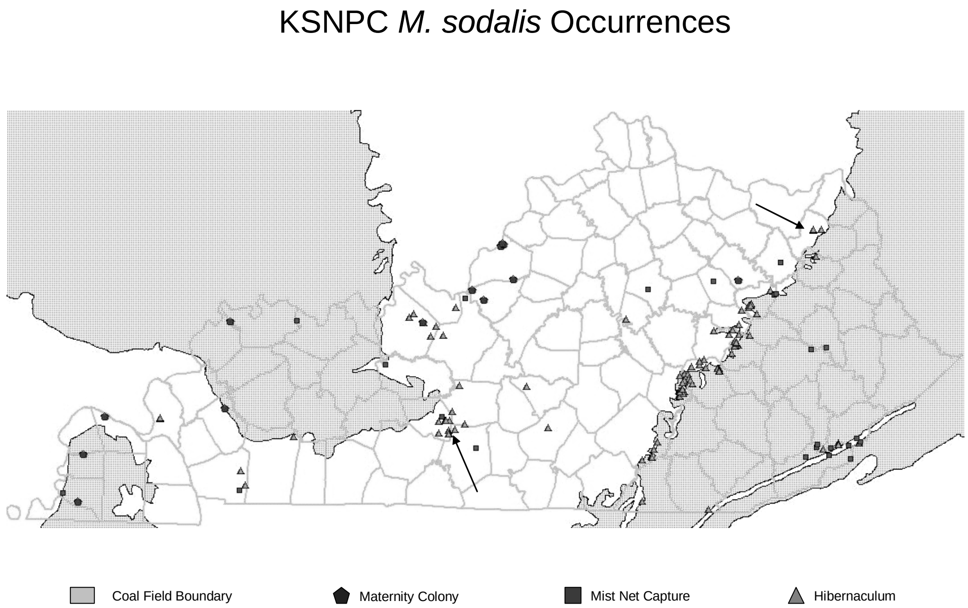

Figure 1.

The *2000 Guidelines* informs the coal applicant that if the permit area is within 10 miles of a hibernaculum or within 5 miles of a mist net capture, a mist net survey must be performed or presence is assumed. Because the majority of post-mining land uses are forestland or fish and wildlife habitat, assumption may only require the applicant to reclaim with more trees and abide by the November through March tree clearing period. By assumption, the applicant does not have to wait for the appropriate survey period before operations can begin. When the applicant has opted for a survey, it has been shown that there has been little success in mist net captures of the bat. KDNR has overseen 428 mist net nights with 8 Indiana bat captures (less than 2% success) in the last 9 years. Two mist-net captures have been recorded in central eastern Kentucky as a result of surveys required by the COE for Section 404 permit requirements. KDNR did not require surveys or assumption of presence due to the permit area outside the 10-mile or 5 mile buffer zones. Figure 2 shows the buffers for either a known occurrence or as a result of a mist net capture.

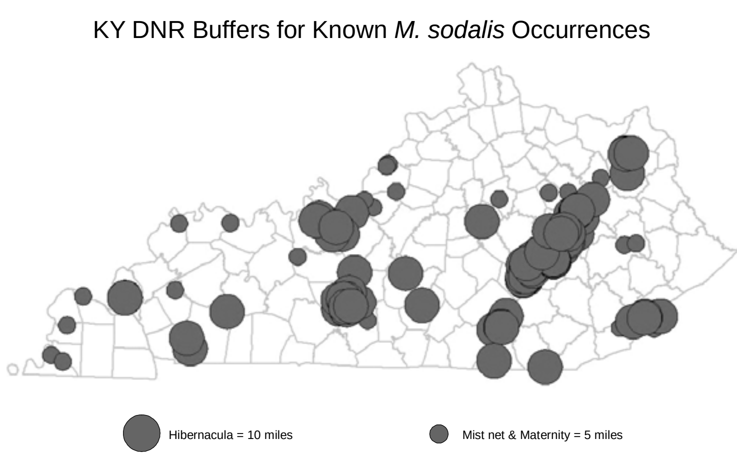

Figure 2.

Partnering Programs That May Benefit the Indiana Bat

KDNR is currently involved with other agencies in two programs, though not their purpose, that may restore and enhance Indiana bat summer habitat. Several eastern coal States and the Federal Office of Surface Mining have enacted the Appalachian Regional Reforestation Initiative (ARRI), a forestry reclamation approach based on the Kentucky Reforestation Initiative of 1997. The goals of this program are to plant more native high-value hardwoods on reclaimed mined lands and to increase the survival and growth rates of these trees. This can be accomplished by creating 4-6 feet of suitable rooting medium (topsoil and alternate material), reducing grading (limited compaction) establishing native and tree compatible ground cover species, and using sound tree planting practices. The *2001 Guidelines* recommends limited compaction; however, successful procedures could make limited compaction a requirement.

A second program, the Appalachian Wildlife Initiative, is being promoted by the Rocky Mountain Elk Foundation that will involve government agencies, conservation groups, and private landowners. Elk re-introduction in Kentucky has been quite successful. This program is targeting reclaimed mined lands to not only create and enhance elk habitat but to improve habitat for all fish and wildlife species. Replanting reclaimed areas with native grasses, shrubs, and trees is being advocated as well as permanently protecting contiguous lands through acquisitions, donations, and conservation easements. Eventually, successful efforts may be utilized in fish and wildlife post-mining land uses with an elevation to a managed level. Therefore, areas not covered by an IBPEP will still be restored to potential summer habitat for the Indiana bat.

Where Do We Go From Here?

In the past nine years, KDNR has issued over 300 SMCRA permits that contain strategies for the protection and enhancement of the Indiana Bat. The majority of these permits include enforceable permit conditions regarding restrictive tree clearing dates. Operators that have violated these conditions have been cited with fines assessed and mitigation measures (e.g., bat research funding, acquisition of conservation easements) ordered by the FWS. The Division of Mine Permits has invested over a million dollars in database assistance and the training of mining and State fish and wildlife personnel on T/E species information. Due to the many hibernacula found in non-coal strata and the detailed abandoned mine portal assessments and closure procedures, winter habitat in the coalfields of Kentucky has been well protected. Designated critical habitat is found outside the coalfields. The requisite post-mining land use for "Indiana bat permits" will restore summer habitat and the reforestation and fish and wildlife programs now being promoted will enhance these areas.

The title page footnote of the *2000 Guidelines* states "*this document was developed using the most current scientific research regarding the Indiana bat, its habitat, and biology. As new research expands knowledge of this species, revisions to this document may be necessary.*" Personnel from the Cookeville, Tennessee FWS field office were co-authors of the *2000 Guidelines.* However, with the recently opened FWS field office in Frankfort, Kentucky, the new staff has expressed a desire to review and update the *2000 Guidelines*.

One of the main (conflicting) issues is the rationale for mist net surveys. Currently, under the *2000 Guidelines*, the coal applicant may need to survey if an Indiana bat occurrence has been recorded within 5 miles of the proposed permit area or within 10 miles from a known hibernaculum. In lieu of a survey, the applicant may choose to assume presence of the bat. Because the local FWS office has stated that the Commonwealth of Kentucky is within the natural (historical?) range, surveys should be conducted to determine presence/likely absence of the bat or follow tree-clearing dates on all permit applications. The former FWS office had no concerns on this issue and agreed to the "distance from recorded occurrence" concept.

A revision to the *Guidelines* as to requiring surveys or assumption of presence on all new mining operation proposals has serious consequences. All surface mining operation proposals (highest in the nation) would be subject either to the 3½-month tree clearing period or a 90-day summer survey window. The number of forested fish and wildlife habitat post mining land uses would dominate though private landowner rights must be considered. A much more serious consequence would occur if all the coal applicants agreed to conduct summer surveys. With a capture success rate of less than 2%, an Indiana bat protection and enhancement program in the coalfields would be dramatically reduced.

Key to offering predictability and consistency of Indiana bat concerns to the coal industry is the resolution of differences between KDNR and the FWS. As it is now, the coal applicant may not be required (because of distance) to implement an IBPEP by the findings of the regulatory authority using the 1996 Biological Opinion yet be subject to required surveys through the COE 404 permitting process based on NEPA analysis. Obviously, this is unfair to the coal applicant who is presented with contradictory determinations. With this situation in mind, the 1996 Biological Opinion outlines a conflict resolution process that allows local offices to elevate their differences to regional and national levels. KDNR has been unsuccessful in attaining regional OSM intervention and FWS does not wish to elevate the issues. Any resolution will have to be accomplished at the lowest administrative level. KDNR and the FWS field office will be scheduling discussions for updating the *2000 Guidelines* utilizing the information presented at this Forum.

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Richard J. Wahrer is an Environmental Scientist with the Division of Mine Permits in the Kentucky Department for Natural Resources. He coordinates the Lands Unsuitable for Mining program, develops protection and enhancement plans for Kentucky's threatened and endangered species and is an OSM instructor for the OSM/USFWS Biological Opinion class. He holds a B.S. in Zoology and M.S. in Limnology from Stephen F. Austin State University and a Ph.D. in Aquatic Biology from Texas A & M University.

INDIANA GUIDANCE DEVELOPMENT FOR PERMITTING

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Abstract

The INDIANA Department of Natural Resources, Division of Reclamation is the authority in Indiana for the regulation of surface and underground coal mining permits and operations. In the permitting process the Division consults with the sister agency the Division of Fish and Wildlife and the US fish and Wildlife Service on all mining permit applications. To comply with state and federal surface mining law, the Endangered Species Act and the 1996 Biological Opinion the reclamation division has coordinated with the Indiana Division of Fish and Wildlife, the US Fish and Wildlife Service and OSM to develop a candidate specific conservation guideline for the Indiana Bat.

The presenter will review common circumstances on mine plan areas, anticipated results of conservation guidelines, and typical protective measures considered when suitable habitat is identified in a mine plan area. Information on Indiana woodlands and landowner actions will also be included.

Purposes of a plan

(1) Protect suitable habitat where practical
(2) Minimize disturbance to suitable habitat where practical
(3) Replace habitat lost to mining.

While more restrictions on timber harvest may appear to be the way to protect suitable habitat – in the long term the restrictions may do more harm.

Because to avoid timber harvest restrictions – which are contained in the conditions of approval on mining permits - timber is often harvested long before mining operations commence. Harvest by landowners is not controlled by mining regulations. Thus, it is likely that suitable habitat is removed – in many cases - before a permit application is proposed.

Having realistic, predictable Indiana Bat protective mechanisms may help protect woodlands proposed permit area by:

- Leave woodlands standing for a longer period of time before mining for the benefit of all.

- Timely removal individual trees identified as suitable habitat - rather than whole forest area - leaving the woodlands relatively intact until just in time – just before mining.

- Allow certain original forest lands to remain undisturbed if not immediately needed.

Some statistics on the 16 counties in the coal mining region of Indiana

1. There is NO designated **critical bat habitat** in the mining area of IN.
2. Suitable habitat is found in individual trees that may be colonized in summer months.
3. Most likely found in hardwood bottom lands, stream corridors, forested floodplains and adjacent slopes
4. 75% of coal production is from surface mining – and area mining.
5. There are no contour mines -No MOUNTAIN TOPS - No VALLEY FILLS.
6. Approximately 4,500 acres per year disturbed today for 24M tons surface mining.
7. Indiana has 4.5 million acres of forest lands 90 % in the southern part of the state.
8. 25% of those lands - approx 1.1 M acres - in 16 mining counties.
9. Approx 500 thousand acres disturbed by mining (or permitted) 1998.
10. 20 % of that acreage estimated forest - or ~ 100,000 acres
11. Forest mitigation guidance set by the Indiana Natural Resources Commission requires not less that 80 % of forest restoration.
12. Cumulative forest / wildlife restoration by coal mining reclamation is estimated to be over 200,000 acres – DOUBLE - the acreage that may have been disturbed by mining. A good portion of that 200,000 acres is now 30-50 years old.

Protection techniques currently used by the Division – in coordination with the Indiana Division of Fish and Wildlife and the US Fish and Wildlife Service.

- Division of Fish and Wildlife has staff member directly assigned to the Division of Reclamation. Duties include permit review, field assessment of proposed lands and field assessment of proposed bond release areas for Forest, fish and wildlife post mining land uses. The assignments offer credible consultation on such issues from a professional staff independent of the regulatory program.

- We employ a number of protection mechanisms to the benefit of the Indiana bat and other local wildlife WHERE PRACTICAL

- Habitat Avoidance:

    Where coal extraction will not occur - avoid impacts to forest resources where practical when building drainage control structure and mine facilities.

    Biologist and inspection staff review the mine plan proposals to determine whether some resource areas may be avoided altogether by relocation of mine facilities

- Minimize Impacts in non extraction areas:

    Reduce disturbance to forest resources where practical and on areas where auger mining may be sufficient.

Permit and field reviewers will examine perimeter areas near roads, homes and other restricted areas to identify areas of suitable habitat where mining disturbances could be limited. However, if the company has rights to the coal – undue restriction could bring legal problems.

- Selective tree cutting:

  The seasonal removal of INDIVIDUAL trees that might provide roost or maternity colony habitat during the last non-occupancy period before mining.

  Seasonal Harvest during the winter non occupancy period as recommended by the consulting agencies.

Tim Taylor is currently the Assistant Director of the Regulatory Program within the Indiana DNR, Division of Reclamation where he has been employed since 1973. The regulatory program includes permitting review, compliance, enforcement, complaint investigations, blasting issues, permit revocation, civil penalties and bond forfeiture. He is a member of the OSM National Technical Training Program Steering Committee and a participant of the Interstate Mining Compact Commission. He holds a BS in Forestry (1972).

MEASURES FOR PROTECTING THE ENDANGERED INDIANA BAT ON COAL MINE SITES IN OHIO

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Abstract

In 1996, the U.S. Fish and Wildlife Service (FWS) provided the U.S. Office of Surface Mining (OSM) a Biological Opinion that required State regulatory authorities and FWS field offices to develop and implement species-specific measures for threatened and endangered species on coal mining lands. In 2003, the Ohio Division of Mineral Resources Management (MRM), OSM, and the Ohio FWS field office signed a Memorandum of Understanding (MOU) that laid the ground work for meaningful coordination between the agencies for protection and enhancement of endangered and threatened species on coal mining operations. The major product of this MOU was a Policy Procedure Directive (PPD) that provided species-specific measures in the form of coal mining permit application requirements for the protection of the Indiana bat and its habitat. Although we are only in the first year of implementation, the PPD has thus far been very successful for all parties involved. The government agencies involved have developed excellent working relationships and have taken multiple opportunities to learn from each other. This has included multi-agency field trips to active mine operations, recently reclaimed strip mine sites, and bat surveys on sites before permit application submission. Although suitable habitat is often abundant, to date, no Indiana bats have been captured on proposed coal mining land in Ohio.

Background

In 1995, the Office of Surface Mining (OSM) requested initiation of formal consultation under section 7 of the Endangered Species Act (ESA) regarding the continuation of surface coal mining and reclamation operations under State and Federal regulatory programs pursuant to the Surface Mining Control and Reclamation Act (SMCRA). On September 24, 1996, the Washington Office of the U.S. Fish and Wildlife Service concluded section 7 consultation by issuing OSM a Biological Opinion (BO) and Incidental Take Statement (ITS). This national programmatic BO allows for incidental take of a Federally-listed species provided that the take is in compliance with the terms and conditions of the ITS. One of the terms and conditions states that a State regulatory authority must implement and require compliance with any species-specific protective measures developed by the local FWS field office and the regulatory authority. These protective measures are designed to anticipate incidental take.

In 2003, MRM, OSM, and FWS signed a Memorandum of Understanding (MOU) that laid the ground work for meaningful coordination between the agencies for protection and enhancement of endangered and threatened species on coal mining operations in Ohio. The MOU provided guidance to the mining industry, the public, and respective staffs of MRM, OSM, and FWS on how these agencies will meet their responsibilities regarding the regulation of coal mining and protection of threatened and endangered species. The first product of this MOU is a Policy Procedure Directive (PPD) that provides species-specific measures in the form of coal mining permit application requirements for the protection of the Indiana bat (*Myotis sodalis*) and its habitat as required by the Ohio Administrative Code, SMCRA, and ESA.

The Indiana bat is a Federally listed endangered species that may occur throughout all of Ohio. Since first listed as endangered in 1967, the Indiana bat population has declined by nearly 60%. Several factors may be contributing to the decline of the bat including the loss and degradation of suitable hibernacula, human disturbance during hibernation, pesticides, and the loss and degradation of forested habitat, particularly stands of large, mature trees. During winter, Indiana bats hibernate in caves and abandoned underground mines. After hibernation, Indiana bats migrate to their summer habitats where they usually roost under loose tree bark on dead or dying trees. During summer, males roost alone or in small groups, while females form larger, maternity colonies of up to 100 or more individuals in a roost tree. Each female in the maternity colony gives birth to one pup per year. Maternity colonies have been found in riparian bottomland as well as upland forest. Most maternity colonies use one or more primary roost tree(s) and multiple alternative roost trees.

The next three sections of this paper address protection measures that are specified in the PPD.

Addressing Indiana Bat Habitat

Hibernacula

Indiana bats hibernate between October and April in caves and abandoned underground mines, known as hibernacula. All hibernacula are considered areas in need of protection and essential for the continued existence of the Indiana bat. Identifying an Indiana bat hibernacula is rare. However, abandoned underground mine openings are common throughout the coal-mining region of Ohio and caves may also exist on sites that may be mined. In some cases, surface mining may eliminate caves and mine openings either by removing all or part of the coal seam that was previously mined underground or by other activities associated with the mining and reclamation operation.

Most underground mine voids and caves do not provide suitable habitat for bats. However, applicants are responsible for determining if Indiana bats are using such features. If openings/voids are potentially suitable, applicants must contact a person approved by FWS to conduct a survey to determine if Indiana bats are present.

If Indiana bats are detected using a cave or mine void, restrictions on activities that may impact the hibernacula will be required. FWS/MRM will require protection of caves or mine voids used by Indiana bats.

Summer Habitat

Indiana bats migrate to summer habitats where they usually roost under loose tree bark on dead or dying trees and on living trees with exfoliating bark, between April and September. Much of Ohio's coal mining region includes wooded tracts of land, both upland and in stream flood plains and corridors. Surface mining generally eliminates trees in the mined area. If high value habitat exists that is suitable for Indiana bats, applicants may assume that Indiana bats are present and conduct mining operations to prevent destruction of roosting habitat during the roosting period. Alternatively, applicants may conduct a survey to demonstrate the presence or probable absence of Indiana bats.

Addressing Potential Impacts to Indiana Bats

Because potentially high-value habitat suitable for Indiana bats exists on many tracts of land that may also be potential mining sites in Ohio, applicants must demonstrate one of the following three conditions.

- Demonstrate that high-value habitat suitable for Indiana bats does not exist on the proposed permit or adjacent areas.
- If high-value habitat suitable for Indiana bats exists on the proposed permit or adjacent area, conduct a survey to determine if Indiana bats are present on the proposed permit or adjacent areas.
- Or, if applicants choose not to conduct surveys and high-value habitat suitable for the Indiana bat exists on the proposed permit or adjacent area, MRM and FWS will assume presence of Indiana bats.

Survey results and determinations regarding the presence or probable absence of Indiana bats and high-value habitat suitable for Indiana bats on proposed permit and adjacent areas are valid for the life of the permit and subsequent renewals unless there is an unanticipated discovery of Indiana bats. If Indiana bats are discovered on the permit or adjacent area at any time during the mining and reclamation process, MRM, in consultation with FWS, will determine the extent of the discovery and whether there is cause to order a change to the mining and reclamation plan. Further details on each of these options are described below.

Applicant Responsibilities

Demonstrating that High-Value Habitat Suitable for Indiana Bats Does Not Exist

In addition to hibernacula, high-value habitat suitable for the Indiana bat may include, but is not limited to, forested uplands, forested stream corridors and could include individual trees.

Applicants may demonstrate that high-value habitat suitable for the Indiana bat does not exist on the proposed permit or adjacent areas. This demonstration must include the results of a habitat survey conducted following FWS criteria for identification of high-value habitat suitable for the Indiana bat. The survey results must be included in the site-specific fish and wildlife resource information in the permit application. MRM will use these guidelines in verifying applicants' demonstrations that high-value habitat suitable for Indiana bats does not exist on the permit and adjacent areas. FWS will also use these guidelines when evaluating fish and wildlife resource information and protection and enhancement plans and may also conduct field reviews to verify information submitted. FWS is available to assist permit applicants in site reconnaissance during development of permit applications.

If high-value summer roosting habitat and/or hibernacula do exist on proposed permit or adjacent areas, applicants must take one of the following two approaches. Applicants may conduct a survey to demonstrate presence or probable absence or assume that Indiana bats are present on the proposed area.

Survey to Demonstrate Presence or Probable Absence

Applicants may conduct a mist-net survey of the proposed permit and adjacent areas to demonstrate presence or probable absence of the Indiana bat by following FWS criteria. A person approved by FWS must conduct the survey.

If surveys find no Indiana bats, the applicant can assume that Indiana bats are either absent or only occur in very low numbers/low density. By including the survey results in the permit application, applicants have met their responsibility for providing site-specific resource information regarding Indiana bats.

If surveys find Indiana bats, applicants must contact FWS. The survey results must be included in the site-specific fish and wildlife resource information. Applicants, in coordination with FWS and MRM, must provide Indiana bat protection and enhancement plans that include as many of the measures listed below or other measures as practicable, using the best technology currently available.

Assume Presence of Indiana Bats

In lieu of conducting a survey, applicants may assume that Indiana bats are present on proposed permit and adjacent areas. When assuming the presence of Indiana bats, applicants must provide this decision in the site-specific fish and wildlife resource information in the permit application and provide protection and enhancement plans that describe measures applicants will take during mining and reclamation to protect and enhance Indiana bat habitat and to minimize the potential for incidental take. These protective measures and enhancements include, but are not limited to, those listed below.

Protective Measures

- MRM and FWS must be consulted on a case-by-case basis for proper protective practices for any identified hibernacula and in any cases that Indiana bats are identified.
- The integrity of all riparian corridors should be maintained to the extent possible. In areas where MRM has granted a stream buffer zone variance, impacts to riparian corridors should be minimized. Maintaining the maximum length of natural riparian zones and corridors is preferred.
- Remove trees determined to be suitable Indiana bat habitat **only** between September 15 and April 15. FWS is available to assist in identifying those trees on a site-specific basis.
- Design stream/floodplain crossings for haul roads and equipment access to minimize habitat loss.
- Applicants may propose other appropriate protective measures.

Enhancement Measures

- Restoring and/or maintaining natural riparian vegetation on the banks of streams, lakes, and other wetland areas.

- Where possible, maintaining natural riparian zones and corridors.

- When restoring streams and associated riparian zones, the tree planting mix must include at least four tree species identified by the FWS as species used by the Indiana bat. To promote diversity, no more than 25 percent of any individual tree species may be included in the planting mixture.

- Creating and enhancing open water sources; i.e., impoundments, wetlands, and small depressions, where practicable, and approved by landowners and MRM.

- Taking measures that will minimize compaction of rooting medium in order to enhance tree survival and growth.

- Where cropland or pastureland is the post-mining land use and where appropriate for wildlife and crop management practices, intersperse fields with blocks or rows of trees to break up large blocks of monoculture and to diversify habitat for birds and other animals (including Indiana bats).

- Applicants may propose other appropriate temporary or long-term measures that may enhance and/or restore habitat for the Indiana bat.

Agency Coordination

MRM's determination that a coal mining application is complete includes verification that the application contains fish and wildlife resource information and an Indiana bat protection and enhancement plan. Once the permit application is deemed complete, MRM send FWS a copy of the applicant's resource information and protection and enhancement plan. FWS reviews the information and may request a site visit before submitting comments or concurrence to MRM on the application.

Applicants are encouraged to develop their wildlife resource information and Indiana bat protection and enhancement plans by working closing with FWS prior to submitting their coal mine application. Advance coordination between applicants and FWS may result in FWS's written agreement on protection and enhancement plans that applicants may provide to MRM at the time of application submittal. If the applicant does not seek advanced coordination from FWS, FWS may provide comments on fish and wildlife resource information and protection and enhancement plans submitted by the applicant to MRM. Figure 1 depicts the step-down process that applicants follow to adhere to the Indiana bat PPD.

Highlights and Success

Although we are only in the first year of implementation, the PPD has thus far been very successful for all parties involved. The coal industry has expressed their appreciation for the predictability and streamlined nature of the permit application review process. The government agencies involved have developed excellent working relationships and have taken multiple opportunities to learn from each other. Most importantly, impacts to the Indiana bat are being minimized while coal operations continue in Ohio. The following are reasons why we have been successful in implementing conservation measures for the Indiana bat on coal mining lands in Ohio.

- Involvement of the coal industry while developing the PPD.
  While developing the Indiana bat PPD, we met with members of the Ohio Coal Association. We used these meetings as learning opportunities and to ease any concerns about their responsibilities under the ESA. Ohio Coal Association members reviewed drafts of the PPD and many of their comments were considered in MRM's final directive.

- Much of Ohio's surface mining is on previously-mined lands.
  It has been estimated that half of Ohio's surface coal mining is on previously-mined lands. Re-mining involves recovering coal on mine lands abandoned before SMCRA required reclamation practices. Due to the removal of young, low quality trees, re-mining may have less impact on potential Indiana bat habitat than a new surface coal mine. Mitigation of acid mine drainage sources through re-mining may provide long term benefits to various wildlife species. In addition, Ohio has less surface mining than other Appalachian states, thus alleviating extensive cumulative effect issues raised by more intensive and widespread mining in other states.

- Few known Indiana bat sites in the coal mining region of Ohio.
  Very few bat surveys have been conducted within the coal mining region of the state. Although suitable habitat is often abundant on coal mine sites, no Indiana bats have been captured to date. It is reasonable to assume that future surveys will detect Indiana bats, but until that time little conflict among agencies and the industry is anticipated.

- A good working relationship between MRM, OSM, and FWS.
  Regular meetings (usually monthly) were conducted over a two-year period before the implementation of the Indiana bat PPD. Over this time period, trust was built through educating each other about our individual agency authorities. Multiple field trips were held to gain a better idea of how coal can be mined in Ohio and how impacts to Indiana bat habitat can be minimized. Learning opportunities included trips to active mine operations, recently reclaimed strip mine sites, and bat surveys on sites before permit application submission. Taking the time to build a good working relationship is the primary reason for our success. This was aided by the concerted effort by all parties to gain an understanding of each agencies' roles and responsibilities.

Acknowledgements

I would like to acknowledge the rest of the "Bat Team" (past and present) – J. Applegate, D. Bates, J. Emmons, R. Gibson, T. Hines, K. Ricks, D. Schrum, S. Stiteler, and A. Zimmerman for their dedication in creating and/or implementing the first endangered species PPD (from which much of this paper was lifted). Thank you for continued coordination.

Sarena M. Selbo is a wildlife biologist with the Ohio Field Office of the U.S. Fish and Wildlife Service (FWS) where she focuses on endangered species consultation with Federal agencies (i.e. OSM, USFS, FHWA), recovery actions for threatened and endangered species, and education and management of invasive species. Sarena began working on coal mining issues surrounding the Indiana bat in 2002 and was an elemental partner in establishing species-specific conservation measures for the Indiana bat in coal mining areas of Ohio. Before coming to work for the FWS, Sarena was a research ecologist for the Ohio Department of Natural Resources, Division of Natural Areas and Preserves. Sarena received her Bachelors Degree in biology from the University of North Dakota and her Masters Degree in population ecology from The Ohio State University.

PROVIDING INFORMATION IN THE MINING PERMIT APPLICATION IN ACCORDANCE WITH PERMITTING PPD 2004-01: MEASURES FOR PROTECTING THE ENDANGERED INDIANA BAT

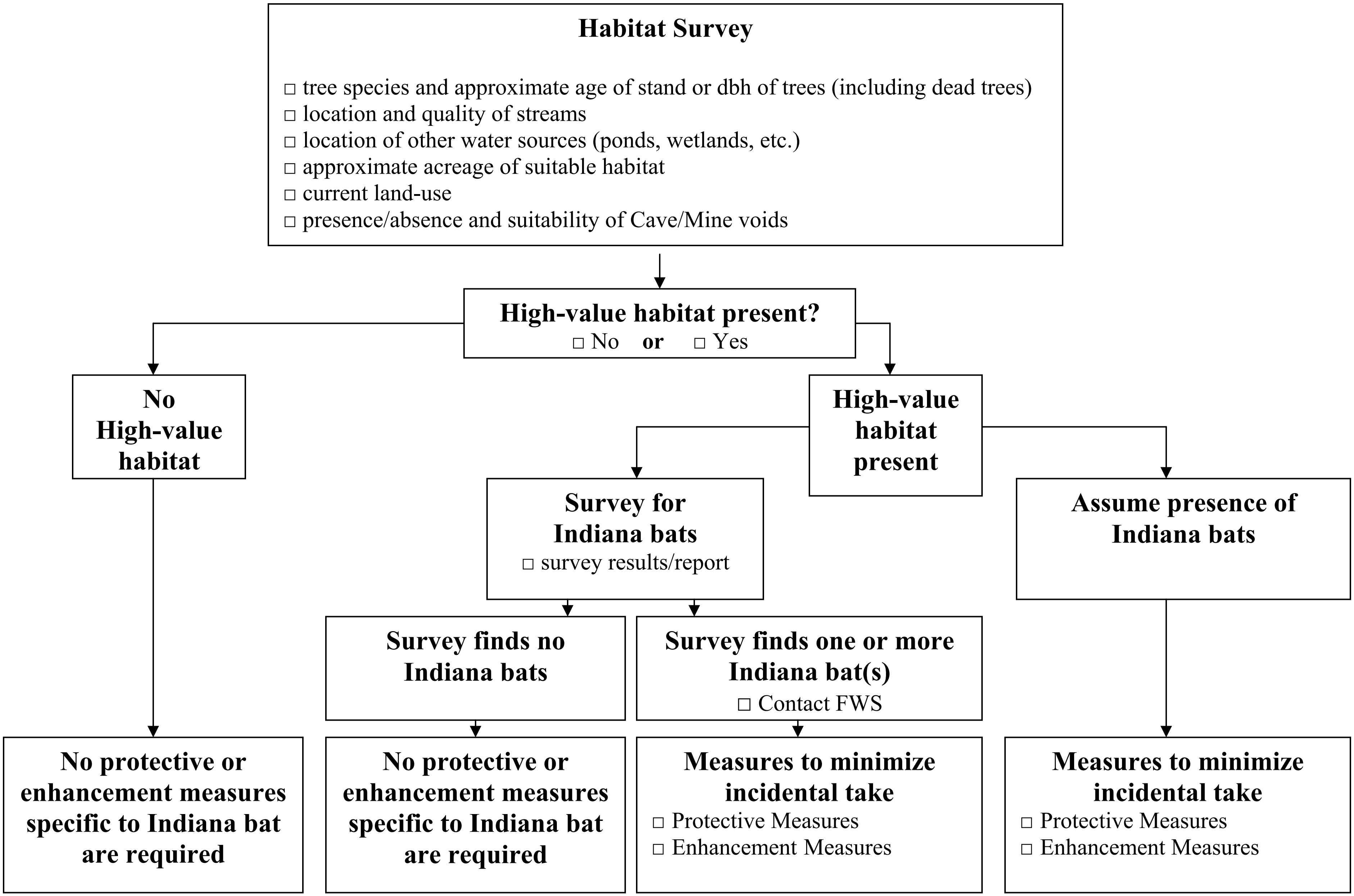

Figure 1.

PROTECTION OF THE INDIANA BAT (*Myotis sodalis*) AND THE TENNESSEE FEDERAL PROGRAM

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Introduction

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) created the Office of Surface Mining Reclamation and Enforcement (OSM) in the Department of the Interior. SMCRA authorizes OSM to oversee State regulatory programs and to provide Federal funding for their implementation. The Act also authorizes OSM to implement a Federal regulatory program in the States without approved regulatory programs. In Tennessee, OSM implemented the Federal regulatory program in October 1984 when the State repealed its surface mining law. The Knoxville Field Office (KFO) administers the program in Tennessee.

Prior to permit approval and issuance, KFO must make a number of written findings. Of particular importance to this forum is the finding at 30 CFR 773.15 (j) which states: "the operation would not affect the continued existence of endangered or threatened species or result in destruction or adverse modification of their critical habitats, as determined under the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq*.)" To make this finding, OSM must ensure that applicants provide effective protection and enhancement plans that minimize disturbances and adverse impacts on fish and wildlife and related environmental values, including compliance with the Endangered Species Act (ESA), during surface coal mining and reclamation operations. SMCRA and the ESA require that KFO consult directly with the U.S. Fish and Wildlife Service (FWS) to make the "no affect" finding.

Consultation Process

In Tennessee, consultation with FWS has been an evolving process. For many years, KFO placed the onus on the applicant to work with FWS, stepping in only to mediate differences during the process. Today, KFO brings FWS into the process as soon as an application is determined to be administratively complete. Agreed-upon items from the permit application are sent to FWS for their review. FWS is invited to attend the pre-mine site visit, and they generally do so. Each time an application is updated, FWS is provided new or revised permit information. This sharing of information and dialogue continues until FWS provides KFO with their letter of concurrence. The concurrence letter is taking longer to obtain because of stricter and more numerous requirements and recommendations from FWS. Coordination is not always quick and easy. Often there is give and take by the Service, by KFO, and by the applicant. There are times when an applicant agrees to any and all of the recommendations on the plate, because time is running out and he really needs his permit. KFO and FWS meet on an as-needed basis to share information and discuss concerns. To date, formal consultation has been avoided.

Mining and the Indiana Bat

The Tennessee coalfields are a narrow band of coal that extends from North to South, from Kentucky to Georgia. The Indiana bat habitat range encompasses the entire State of Tennessee. The majority of permits in Tennessee have the potential to directly impact the Indiana bat population. Current and proposed mining activity in Tennessee is affected by the location of at least seven known caves that have housed the Indiana bat within ten miles of the mining activity. One of these caves, New Mammoth Cave, was classified as a Priority 2 Cave in the 1983 Indiana Bat Recovery Plan. Priority 2 Caves are caves that house at least 500 Indiana bats. The population is in decline. The most recent survey of New Mammoth Cave recorded only 310 bats. To date, there are no known records of summer roost or maternity colonies of concern to Tennessee applicants.

Indiana Bat Guidance Document

In 2001, KFO began using Kentucky's "*Guidelines for the Development of Protection and Enhancement Plans for the Indiana Bat*," to help coal mining applicants understand their options and protocols associated with mining in areas containing known or potential Indiana bat habitat. KFO is currently working with FWS to develop a guidance document to address concerns specific to Tennessee. Prior to finalizing the document, Industry and various State environmental agencies will be invited to review and comment.

The Tennessee guidance document will assume that mining operations may affect the Indiana bat in situations where proposed surface mine disturbances are located within ten miles of a documented Indiana bat hibernaculum or within five miles of a site known to have been occupied by the species during a non-hibernation period. Generally, Indiana bats are presumed to use all habitats located within five miles of hibernacula records and within two miles of sites used by the species during non-hibernations periods.

The guidelines, as proposed, will give the applicant four options:

- assume summer presence where no open caves or portals are present
- assume presence where open caves or portals are present
- survey to demonstrate presence or probable absence in summer habitat where caves or open portals are not present
- survey to demonstrate presence or absence in summer or winter habitat where open caves or portals are present

The protection and enhancement plan, as proposed, will emphasize three things:

1. **Minimizing the potential taking of an Indiana bat.**
   Potential roost trees can only be cut between November 15th and March 31st. Portals and caves require assessment and possible survey prior to closing. To date, no Indiana bats have been found in the few structures surveyed in our region of concern. The desire of FWS is that a minimum 100-foot buffer zone be maintained along intermittent and perennial streams and wetlands. OSM can grant a variance to this requirement if a finding of no adverse affect can be made.
2. **Short-term habitat replacement**
   In Tennessee, tree girdling is the preferred option. The applicant is required to girdle one candidate tree, at least nine inches in diameter, every 500 feet along the perimeter of the permit. Girdling may not be required if the applicant can demonstrate that an adequate number of potential roost trees exist within one mile of the entire permit area at the time of regrading and revegetation. Bat houses may be used in addition to girdling.
3. **Long-term habitat replacement**
   Where trees are going to be planted, a non-competitive ground cover should be planted. If supported by the land use, a large portion of the permit area should be planted in trees. An appropriate success rate at final bond release will be determined. In Tennessee, 250 stems per acre has been suggested.

Appalachian Regional Reforestation Initiative (ARRI)

A new initiative is underway in the Appalachian Region that will help to provide good habitat for the Indiana bat. The initiative is called the Appalachian Regional Reforestation Initiative (ARRI). ARRI is a broad-based citizen/industry/government group working to encourage planting productive trees on reclaimed coal mined lands and abandoned mine lands. ARRI encourages the use of the Forestry Reclamation Approach (FRA) technology where trees are to be planted. Research conducted by the University of Kentucky and Virginia Polytechnic and State University has confirmed that highly productive forestland can be created on reclaimed mine land by using a FRA.

As a general guideline, FRA employs five steps:

- Create a suitable rooting medium for good tree growth that is no less than four feet deep and comprised of topsoil, weathered sandstone and/or the best available material
- Loosely grade the topsoil or topsoil substitutes established in step one to create a non-compacted growth medium
- Use native and noncompetitive ground covers that are compatible with growing trees
- Plant two types of trees; early succession species for wildlife and soil stability, and commercially valuable crop trees
- Use proper tree planting techniques

This initiative, among numerous other things, can and will provide good quality habitat for the Indiana bat.

Conclusion

As long as coal mining permits are issued in Tennessee, the potential to directly impact the Indiana bat population exists. The development of an Indiana bat guidance document specific to Tennessee will provide guidance to help coal mining applicants understand their options and protocols associated with mining in areas containing known or potential Indiana bat habitat. Hopefully, the guidance document will help reverse the decline of the Indiana bat population in Tennessee.

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CHRONICLE OF WEST VIRGINIA COAL PROGRAM PERMITTING CONSIDERATIONS OF THE ENDANGERED INDIANA BAT (*Myotis sodalis)*

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Division of Mining and Reclamation (DMR)
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Abstract

Following the initial (Interim Program) implementation of the Surface Mining Control and Reclamation Act of 1977 (SMCRA), West Virginia was granted State coal program primacy by USDI, Office of Surface Mining (OSM) in 1981. Early coal program considerations toward endangered species were addressed via a 1982 Memorandum of Agreement (MOA) between then WV Department of Natural Resources (DNR) Divisions of Reclamation and Wildlife Resources. A permit document arising from this MOA became well established as the State Wildlife Lands Inquiry, a map/computer database "Response." Endangered species information remains an important component of the State DNR response. This MOA was updated in 2003.

Direct "agency notification" (WVDEP to US Fish & Wildlife Service (the Service)) of coal proposals also remains a long-term program component. This agency notification of the Service was expanded via an April 1999 Memorandum of Understanding (MOU). The 1999 MOU sought improved coordination amongst the varying State and Federal agencies including the Service and related endangered species concerns. Particular interest was expressed in the relatively large class surface coalmines with valley fills.

Also around this time (late 1998 to present), a heightened national awareness toward surface coal mining in Central Appalachia prevailed. In response to written requests by the Service, WVDEP adapted an early direct applicant/Service notification procedure in September of 2002. This resulted in the inclusion of more specific habitat conservation measures toward the endangered Indiana bat. Prospective applicants correspond directly with the Service, select prescribed options and provided related documentation within the permit application up to closeout of site-specific consultation prior to permit issuance.

The greatest potential coal program/Indiana bat conflict is that between forest clearing activities and potential summer range utilization. As one of the most heavily forested States and per its proximity to known hibernacula, the Service lists the entire State as potential summer range. Modern era (post-1998) program highlights include the summer netting of four Indiana bats in advance of surface coal mining operations. These included two adult males and two post-lactating females, the latter representing the first likely state maternity colony documentation. Coal industry concerns include the operational constraints of timbering/mist-netting timeframes, interstate commerce and fairness issues per varying procedures in competing States and amongst in-State industries, particularly logging and natural gas.

Introduction/Background

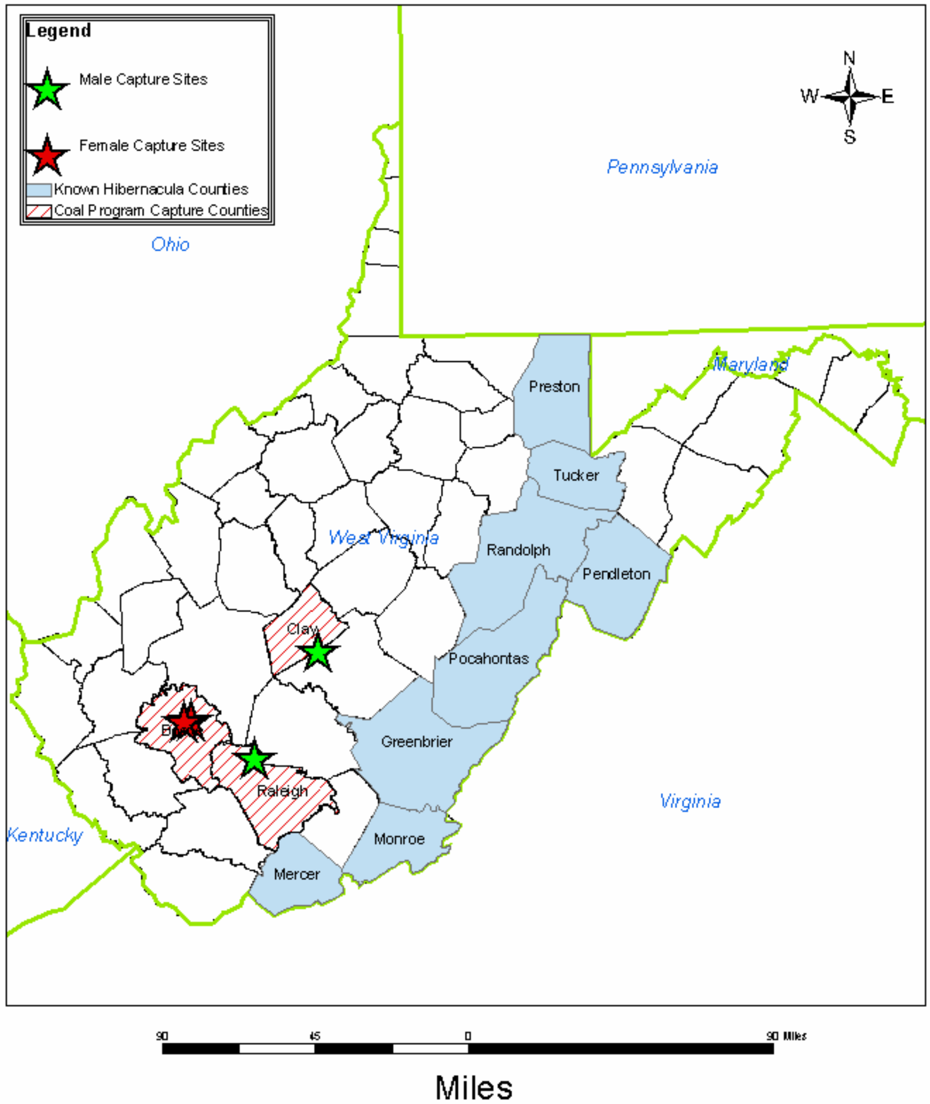
The Revised Recovery Plan (1999) lists the nationally known total hibernacula population of Indiana bats at 353,000. This represented a 60 percent decline since population surveys began in the 1960's. The most severely impacted states were Missouri, Kentucky and to a lesser extent Indiana. The Plan (1999) also indicates West Virginia's population as 11,660 or 3.3 percent of that total. The West Virginia population was characterized as "may be increasing." Stihler (2003) has subsequently confirmed increases at a number of West Virginia caves. The Plan (1999) lists seven Priority III and one Priority II cave hibernacula for the Mountain State. The priority II cave hibernaculum is Pendleton County's Hellhole, which per Stihler (2003) is the State's most important, wintering an estimated 9,000 Indiana bats. Stihler (2003) noted an updated total of 18 cave hibernacula, generally scattered along the State's Virginia bordering eastern front counties of Greenbrier, Mercer, Monroe, Pendleton, Preston, Randolph and Tucker. The Plan (1999) also listed Pocahontas County as harboring historical hibernacula. These sites are closely correlated with limestone parent materials and associated karst topography (Figure 1.).

The modern-era (post-1998) coal permitting baseline surveys have documented four Indiana bat nettings to date: two adult females and two adult males. Their proximal capture sites are also provided in Figure 1. Beverly and Gumbert (2003) netted the two post-lactating females in a baseline study associated with a Boone County surface coalmine proposal area. Since neither the Plan (1999) nor Stihler (2003) reported any prior known historical in-State maternity colony documentation, this would indicate the first of its kind for West Virginia. Also in concert with modern era (post-1998) coal related permit baseline studies, two adult male Indiana bats were netted. The first male capture added Clay County to the list of summer Indiana bat recordings (BHE Environmental, 1999). The second male did likewise for Raleigh County (BHE Environmental, 2003). These individuals were deemed to be transient or incidental in nature. A series of typical programmatic photos are provided in Figure 2.

WV Consultation Guidance/Conservation Measures/Recommendations

A (BO) Biological Opinion (1996) concluded formal Endangered Species Act (ESA) Section 7 consultation for the continuation and approval of surface coal mining and reclamation operations under Federal program and promulgated State programs pursuant to Title V of SMCRA (1977). This BO was programmatic in nature. It tiers down to the site-specific level and subsequent information addresses the consultation level at this level. Current site-specific conservation measures and recommendations relate mostly to the possibility for surface coal mine timber removal (clearing and grubbing) operation conflicts with that of potential summer range of the Indiana bat. There is also a concern over the mining through or inundation of pre-SMCRA (1977) or other portals underground workings that bats may be utilizing as cave/winter range surrogates. These measures are currently provided directly to the applicant via an individual permit basis applicant directed consultation inquiry with the Elkins, West Virginia USFWS Field Office. The applicant in turn provides all related correspondences up to and including options selected and the bat survey information to the point of the consultation closeout with the Service.

Figure 1
West Virginia Indiana Bat Information



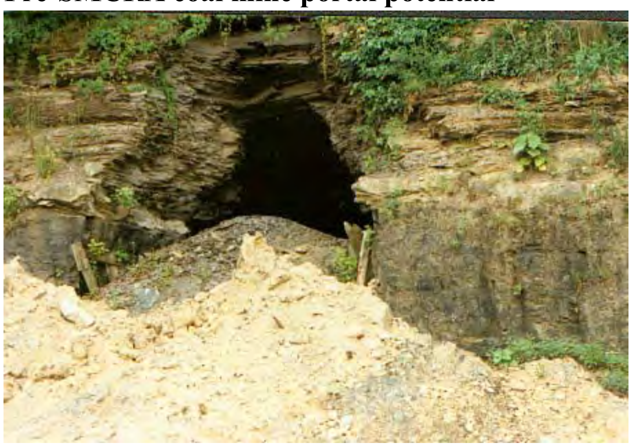
Data Sources: Beverly and Gumbert (2003), BHE Environmental Inc. (1999), BHE Environmental Inc. (2003), Indiana Bat Revis Recovery Plan (1999), Sthiler (2003)

Figure 2. Indiana Bat and Coal Mining Forum – Representative Photographs

Potential summer habitat for bats

Timber clearing in advance of coal mining

Pre-SMCRA coal mine portal potential



Surface coal mining operations after timber clearing

Mist net survey bat capture

Examining a mist netted specimen

All applicable information is documented in the State coalmine permit application at the appropriate section. State coal mine permits are generally not issued without completion of consultation. However, some may be issued conditionally if measures cannot be completed in a reasonable time period prior to issuance. The options and measures selected become enforceable conditions of the permit by the State Regulatory Authority (RA).

Current Service recommendations and considerations for potential Indiana bat summer range impacts are as follows:

- If proposal area impacts less than 17 forested acres, provide adequate documentation and no further consultation is necessary.
- If proposal area impacts more than 17 forested acres:
    - Option 1: Presume Indiana bats are present, select this option and indicate in writing that timber removal operations will be conducted only during hibernating season of November 15 to March 31. (Note: if an adequate percentage of roosting habitat is not available within a 2-mile radius of the proposal area centroid, a netting survey may be required).
    - Option 2: Conduct mist net surveys between May 15 and August 15 to determine if Indiana bats occupy on the site. If no Indiana bats are found, year-round timber removal operations may be conducted. (Netting plans must be reviewed by the Service for accordance with the Recovery Plan and be conducted by qualified persons with proper scientific collecting permits. See Appendices A and B respectively for current WV list of "Qualified Indiana Bat Surveyors" and "Mist Netting Guidelines", (USFWS 2004)

- If Indiana bats are captured, further consultation with the Service is necessary.

Regarding potential winter range (hibernacula) potential of proximal pre-law or other mine workings or openings (shafts, slopes, drifts, cracks, portals):

- If proposal area examinations reveal no existing mine workings or openings, provide documentation and no further consultation is necessary.
- If proposal area examinations reveal pre-law or other mine workings or openings, provide documentation and apply "Criteria for Determining Whether a Phase I Portal Survey Should be Conducted", see Appendix C (USFWS, 2004).
    - If Portal Survey Criteria are Negative, provide documentation and no further consultation is necessary.
    - If Portal Survey Determination is Affirmative, conduct "Phase I Mine Portal Survey", see Appendix D (USFWS, 2004).
- If Phase I Mine Portal Survey Determination is Negative, provide documentation and no further consultation is necessary.

If Phase I Mine Portal Survey Determination is Positive, further consultation with the Service is necessary.

Acknowledgements

The authors recognize the support, cooperation and early programmatic efforts of fellow WVDEP/DMR staff: F. Joe Parker, Director; Lewis A. Halstead Asst. Director Program Dev.; Kenneth W. Politan Asst. Director Permitting; Charles S. Sturey, Legislative Liaison; and Larry M. Alt; Supervisor Article 3 (coal) Permitting.

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Kevin G. Quick is employed as a Wildlife Biologist in the Permitting Section of WVDEP/Division of Mining and Reclamation for the last 1.5 years. He review permits as part of the headquarters review team and applications from the regional offices for quality control related to biological issues. He reviews and edits all Buffer Zone Analysis documents, Statewide. He aids in the development of operational policies and procedures related to the biological components of permitting within the Division of Mining and Reclamation Statewide. He served as the Logan regional biologist for two years prior to accepting my current position. Served as a inspection and enforcement inspector in the Logan region for 8 years prior accepting the regional biologist position. He holds an Associate in Science degree in Biology from West Virginia University at Parkersburg (1989) and a Bachelor of Science degree in Wildlife Resources from West Virginia University (1991).

APPENDIX A
Qualified Indiana Bat Surveyors*

BHE Environmental, Inc. Contacts: Russ Romme', Amy Henry 11733 Chesterdale Road Cincinnati, Ohio 45246 Phone: 513-326-1500 Fax: 513-326-1178	Environmental Solutions & Innovations, LLC Dr. Virgil Brack, Jr. 781 Neeb Road Cincinnati, Ohio 45233 Phone: 513-451-1777 Fax: 513-451-3321 Cell: 513-235-1076 email: vbrackesi@fuse.net
Mr. John MacGregor 102 Restk Court Nicholsville, Kentucky 40356 Phone 859-885-4363 Email: jrmacgregor@bigfoot.com	Dr. Karen Campbell Biology Department Albright College Reading, Pennsylvania 19614 Phone 614-921-2381
Hal Bryan Eco-Tech, Inc. Post Office Box 8 Frankfort, Kentucky 40602-0008 Phone: 502-695-8060 Fax: 502-695-8061 email: myotis2000@aol.com	Mr. Chris Sanders 121 Queen Ester Dr. Sayre, Pennsylvania 18840 Phone: 570-888-2290 Email: foom@clarityconnect.com
Joel Beverly Apogee Environmental Consultants LLC Post Office Box 338 Ermine, Kentucky 41815 Phone: 606-633-7677 Fax: 606-632-2626 email: joelbeverlv@hotmail.com	Dr. Phillip Clem University of Charleston 2300 MacCorkle Ave., S.E. Charleston, WV 25304 304-357-4793 fax: 304-357-4715
Dr. Lynn Robbins Southwest Missouri State University 901 South National Springfield, MO 65804 417-836-5366	Robert F. Madej R.D. Zande & Associates 1237 Dublin Road Columbus, OH 43215 800-340-2743 Fax: 614-486-4387
Mr. John Chenger Bat Conservation & Management 905 Thornton Drive Mechanicsburg, Pa. 17055 717-795-7527	

This list includes INDIVIDUALS who are qualified to conduct surveys for Indiana bats, this list may not include all individuals qualified to conduct such surveys. Inclusion of names on this list does not constitute endorsement by the U.S. Fish and Wildlife Service or any other U.S. Government agency. A scientific collecting permit will be required from the West Virginia Division of Natural Resources Non-Game Wildlife and Natural Heritage Program to sample for bats in West Virginia. Note that various techniques are used to sample for and study bats, including mist-netting, Anabat detectors, and radio-telemetry. Some individuals on this list may not be qualified to conduct all three techniques.

APPENDIX B

MIST NETTING GUIDELINES

Adopted from Appendix B of the Agency **Draft Indiana Bat Recovery Plan of March 1999**

RATIONALE A typical mist net survey is an attempt to determine presence or probable absence of the species; it does not provide sufficient data to determine population size or structure. Following these guidelines will standardize procedures for mist netting. It will help maximize the potential for capture of Indiana bats at a minimum acceptable level of effort. Although the capture of bats confirms their presence, failure to catch bats does not absolutely confirm their absence. Netting effort as extensive as outlined below usually is sufficient to capture Indiana bats. However, there have been instances in which additional effort was necessary to detect the presence of the species.

NETTING SEASON May 15-August 15

These dates define acceptable limits for documenting the presence of summer populations of Indiana bats, especially maternity colonies. Several captures, including adult females and young of the year, indicate that a nursery colony is active in the area. Outside these dates, even when Indiana bats are caught, data should be carefully interpreted: If only a single bat is captured, it may be a transient or migratory individual.

EQUIPMENT

Mist nets - Use the finest, lowest visibility mesh commercially available:

1. In the past, this was 1 ply, 40 denier monofilament-denoted 40/1
2. Currently, monofilament is not available and the finest on the market is 2 ply, 50 denier nylon-denoted 50/2
3. Mesh of approximately 1 1/2 (1 1/4 - 1 3/4) in (-38 mm)

Hardware - No specific hardware is required. There are many suitable systems of ropes and/or poles to hold the nets. See NET PLACEMENT below for minimum net heights, habitats, and other netting requirements that affect the choice of hardware. The system of Gardner, et al. (1989) has met the test of time.

NET PLACEMENT

Potential travel corridors such as streams or logging trails typically are the most effective places to net. Place the nets approximately perpendicular across the corridor. Nets should fill the corridor from side to side and from stream (or ground) level up to the overhanging canopy. A typical set is seven meters high consisting of three or more nets "stacked" on top one another and up to 20 in wide. (Different width nets may be purchased and used as the situation dictates.) Occasionally it may be desirable to net where there is no good corridor. Take caution to get the nets up into the canopy. The typical equipment described in the section above may be inadequate for these situations, requiring innovation on the part of the observers.

RECOMMENDED SITE SPACING:

Stream corridors - one net site per km of stream (3281').

Non-corridor land tracts - two net sites per square km of forested habitat (247.1 acres).

MINIMUM LEVEL OF EFFORT

Netting at each site should consist of:

** At least four net nights (unless Indiana bats are caught sooner) (one net set up for one night= one net night)
A minimum of two net locations at each site [at least 30 m apart (100'), especially in linear habitat such as a stream corridor]
A minimum of two nights of netting

Sample Period: begin at sunset; net for at least 5 hr
Each net should be checked approximately every 20 min
No disturbance near the nets, other than to check nets and remove bats

WEATHER CONDITIONS

Severe weather adversely affects capture of bats. If Indiana bats are caught during weather extremes, it is probably because they are at the site and active despite inclement weather. On the other hand, if bats are not caught, it may be that there are bats at the site but they may be inactive due to the weather. Negative results combined with any of the following weather conditions throughout all or most of a sampling period are likely to require additional netting:

Precipitation
Temperatures below 0°C (50°)
Strong winds (Use good judgment: moving nets are more likely to be detected by bats.)

MOONLIGHT

There is some evidence that small myotine bats avoid brightly lit areas, perhaps as predator avoidance. It is typically best to set nets under the canopy where they are out of the moon light, particularly when the moon is half-full or greater.

*Refers to number of sites: multiple sites do not have to be exactly this distance apart but in large project areas, sites should be spaced to provide coverage of the project area. One site consists of two nets placed at least 30 m apart.

** This reflects the incorporation of one additional net night from the Draft Recovery Plan

APPENDIX C

Criteria for Determining Whether a Phase I Portal Survey Should Be Conducted

1. Old deep mines are known to occur on site or could potentially occur on site.

2. Mine openings are found that are at least one foot in diameter (bats will use vertical shafts).

3. There is some amount of air flow in or out of entrance.

4. Passages should continue for some distance past openings*.

5. There is no evidence of toxic gases.

* Mine entrances that are flooded or appear to have been flooded in the past; entrances that have collapsed or are otherwise inaccessible to bats should be excluded from a Phase I Portal Survey. Foliage and other vegetation in front of mine openings do not stop use by bats. Bats may access mines via old open buildings such as a fan house.

APPENDIX D
Phase I Mine Portal Survey Data Sheet

Mine name (either the one currently proposed for remining or the abandoned mine proposed for AML work):

Location (including county):

Observers:

Latitude, Longitude

Date: T ime: Outside temperature:

Opening
Shaft or adit
Opening size
(height x width)
# of known entrances
(describe each)
Evidence of toxic gases*
Internal dimensions
Slope (up or down)
Stablility of entrance
Direction of airflow
Amount of airflow
(slight, moderate, heavy)
Air warmer or cooler than
outside temperature

Inside Mine*
Evidence of collaspe
Ceiling condition
Humidity
Amount of standing water
Evidence of past flooding
Greatest length visible through
any entrance
Rooms or chambers, size
Any visible side passages
Are portals suspected or known
to be connected
Guano sign or moth wings

Additional comments:

Photographs

*Entry of abandoned mine portals can be extremely dangerous because of the potential for ceiling collapse and presence of toxic gases. Safety or health problems may occur as a result of entering abandoned mines. The U.S. Fish and Wildlife Service does not authorize or regulate this activity.

WHERE DO WE GO FROM HERE?

PARTICIPANT RECOMMENDATIONS

1. We need to find better way to communication scientific results related to the Indiana Bat to the mine operators.

2. Concerning OSM's oversight role in Reg 8, OSM should be evaluating how the States are implementing the 1996 biological opinion.

3. Collect all of the mist net survey information that has been submitted to the State programs to determine if an analysis of that data would provide additional information.

4. The States need to being evaluating cumulative impacts of mining on the Indiana bat.

5. We need consistency and fairness in the conservation measures used to protect the Indiana bat. There at least needs to be regionalized guidelines so that States are treated fairly.

6. We need more emphasis on how the AML programs are impacting the Indiana Bat.

7. The industry and the Indiana Bat would be best served by a shared interagency and industry effort to develop a habitat conservation plan possibly in conjunction with a conservation bank that would result in a coordinated effort to protect the bat while minimizing the impact to the industry.

8. We need to focus on developing a plan to monitor the effects of mining and the effects of species protection mitigation on the Indiana bat.

SURVEY RESULTS

INDIANA BAT AND COAL MINING: A TECHNICAL INTERACTIVE FORUM PARTICIPANT COMMENTS AND RECOMMENDATIONS

CATEGORY OF PARTICIPANTS	# OF REGISTRANTS	% OF REGISTRANTS
TOTAL REGISTRATION	154	
TOTAL COMPLETING THE SURVEY	70	100
LEVEL OF SATISFACTION WITH THE FORUM		
EXTREMELY SATISFIED	35	53
VERY SATISFIED	25	38
SATISFIED	5	7
DISSATISFIED	1	1
VERY DISSATISFIED	1	1

COMPLIMENTS:

1. **Excellent use of agency knowledge and academic research.**
2. **Extremely beneficial to include academia in this forum so that regulators can be kept up to date and understand the life history of the species and the consequences of decisions.**
3. **Very well organized and planned. The information was very useful and informative.**
4. **Great organization and opportunities for networking with the presenters and speakers.**
5. **This was a very good conference. The organizer did a class A job.**
6. **Good Job! Timely Forum!**
7. **The best of the 3 Bat Related Forums conducted by OSM. Great Job!**
8. **Thanks to the steering committee for setting this up. Excellent information.**
9. **Great Forum! Good interaction with the participants of the forum. The forum was well facilitated and kept on schedule!**
10. **Keep up the good work! Keep these forums going.**
11. **The forum was well organized.**
12. **Overall the forum was well organized and very informative & I enjoyed it!**
13. **I really appreciated the openness of the discussions and the free and relaxed atmosphere to frankly discuss this controversial issue.**
14. **A very well coordinated and professional forum.**
15. **I really appreciated being able to obtain copies of the previous forums.**
16. **Very informative presentations.**

WHERE DID THE PARTICIPANTS COME FROM AND WHO DID THEY REPRESENT?

PARTICIPANT AFFILIATION	# OF REGISTRANTS	% OF REGISTRANTS
Consultant	54	35
State Mining Agency	26	17
U.S Fish & Wildlife Service	17	11
Office of Surface Mining	17	11
University	9	6
U.S. Army Corp of Engineers	7	5
Electric Power Industry	6	4
State Wildlife Agency	5	3
Forest Service	5	3
Coal Industry	5	3
Land Development	2	1
Bat Conservation International	1	1

REGIONAL REPRESENTATION	# OF REGISTRANTS	% OF REGISTRANTS
EAST	126	82
MID-CONTINENT	27	17
WEST	1	1

PARTICIPANT RATING ON USEFULNESS OF TALKS
4.0=EXCELLENT
3.0=GOOD
2.0=FAIR
1.0=POOR

SESSION 1 THE BIOLOGY AND LIFE HISTORY OF THE INDIANA BAT

PRESENTER	AVERAGE RATING	RATING RANGE
Richard Clawson	**3.2**	**4-1**
Virgil Brack	**3.3**	**4-2**
Dale Sparks	**3.2**	**4-2**
Allen Kurta	**3.5**	**4-1**

SESSION 2 FIELD TECHNIQUES FOR BIOLOGICAL ASSESSMENT

PRESENTER	AVERAGE RATING	RATING RANGE
James Kiser	**3.6**	**4-2**
Eric Britzke	**3.2**	**4-2**
Cal Butchkowski	**2.9**	**4-1**
Timothy Carter	**3.3**	**4-2**
Virgil Brack	**3.2**	**4-2**
Andy King	**3.3**	**4-1**

SESSION 3 CONSULTATION PROCESS

PRESENTER	AVERAGE RATING	RATING RANGE
Jim Serfis	**2.7**	**4-1**
Bill O'Leary	**3.3**	**4-1**
Len Meier	**3.3**	**4-1**
Todd Hagman	**2.7**	**4-1**
Ramona Briggeman	**3.0**	**4-2**
Tim Howard	**2.9**	**4-1**

SESSION 4 CASE STUDIES

PRESENTER	AVERAGE RATING	RATING RANGE
Rebecca Ijames	**3.0**	**4-1**
Joel Beverly	**3.2**	**4-1**
Richard Sherwin	**3.9**	**4-3**
Lance Debord	**3.0**	**4-1**
Bernie Rottman	**2.8**	**4-1**

SESSION 5 GUIDANCE DEVELOPMENT FOR PERMITTING

PRESENTER	AVERAGE RATING	RATING RANGE
Richard Wahrer	**3.9**	**4-2**
Tim Taylor	**2.6**	**4-1**
Sarena Selbo	**3.4**	**4-2**
Becky Hatmaker	**3.1**	**4-2**
Kevin Quick	**2.5**	**4-1**

SUGGESTIONS FOR IMPROVEMENT

BAT BIOLOGY

- Need more in depth delineation of habitats. What are the known characteristics of hebernacula and summer habitat.
- More on descriptive characteristics and lifecycle, mating, young, etc.
- What happened to these bats at the turn of the century when eastern forests were predominantly clear cut.?
- Since this would have almost decimated all of the habitat, how did this species survive?
- Need more on enhancement opportunities such as air flow, and related habitat issues.
- There are information gaps in the biology of the Indiana Bat and we need better guidance to direct research with limited funds.
- Effect of winter removal of roost trees.

REGULATORY

- What types of litigation have worked or failed.
- Need to facilitate small State-specific discussions.
- Needed representative from WV State Fish and Wildlife concerning capture of Indiana Bat.
- Explain why there are different requirements for different States. What is the biological basis for the

differences?

- There is a lot of confusion in the industry due to confusing USFWS personnel and policies.
- If the coal company goes bankrupt, who is responsible for the enhancement plan?
- What is the formal consultation process when a T & E species is found?
- Needed more input from different USFWS regions.
- Need a how to guide to permitting.
- Required information for addressing permit obstructions related to the Section 404 permit.
- Process for certifying "professional mammalogist" for bat identification.
- Discussion of USFWS determination of "cumulative impacts."

<u>POST MINING RESULTS</u>

- More on how well specific conservations plans are working.
- Monitoring of post mining land use.
- Need to present a post PEP and PDP monitoring report. Enhancement measures commonly are not implemented properly.

<u>ABANDONED MINE LAND ISSUES</u>

- AML issues and preplanning for bat surveys.
- Need to address AML impacts to portals, shafts, and roosting habitat.
- How do mine closures affect bat habitat climate.

<u>PARTICIPANTS</u>

- Need more industry participants and perspectives.
- Need more conservation minded mine operators and industry representatives.
- Need to have wildlife organizations discuss their habitat programs.
- More speakers from industry and consultants.
- Need more on adjacent landowner perspective.

<u>FORUM FORMAT AND TECHNIQUE</u>

- Less overlap on some of the speakers.
- Need to have a shorter more condensed event so that more people (especially industry) could come.
- Session chairs needed to have a list of questions for speakers to encourage discussion.
- More pictures, more interaction, less speaking.
- More science and less opinion.
- Less interaction and more speakers.
- Many speakers needed to use larger fonts and better contrasting colors.

FUTURE FORUM SUGGESTIONS

- Habitat Conservation Plans and what does the bat data tell us.
- Indiana Bat Identification and life history.
- More about other T & E species like mussels.
- Revegetation and Sections 404 Corp of Engineers permitting.
- Selenium and coal mining
- Abandoned deep mines as possible hibernaculum
- Look at cumulative impacts in NEPA, ESA, and SMCRA.
- Monitoring of pre and post mining and reclamation impacts to bats.
- Would like to see more on other bat species.
- Conflict resolution successes and failures.
- New technologies for mark and release capture.
- Stream restoration and mitigation.

APPENDIX 1: RECORDED DISCUSSIONS

Edited by
Kimery C. Vories
USDI Office of Surface Mining
Alton, Illinois

The following are the edited discussions that took place at the end of each speaker presentation and at the end of each topic session. The actual comments have been edited to translate the verbal discussion into a format that more effectively and efficiently communicates the information exchange into a written format. The organization of the discussion follows the same progression as that which took place at the forum. A topical outline has been developed to aid in accessing the information brought out in the discussions.

The topic of each question is shown in alphabetical order in **bold.** The individual speaker questions are listed in outline format under the appropriate topic session and presentation title. Questions during the interactive discussions are listed at the end of the session in the following format.

SESSION # AND TOPIC AREA
1. Presentation Title
    - **Subject of Question or Comment**

    SESSION #: INTERACTIVE DISCUSSION
    Subject of Question or Comment

OUTLINE OF DISCUSSION TOPICS

SESSION 1: THE BIOLOGY AND LIFE HISTORY OF THE INDIANA BAT
1. National Status of the Indiana Bat
2. History of the Indiana Bat: Hibernacula
    - **Tolerance of Indiana Bats to Gases found in Coal Mines**
3. Foraging Ecology of the Endangered Indiana Bat
    - **Comparison with Other Species**
    - **Use of Isolated Wood Lots**
4. Ecology and Behavior of Indiana Bats at Summer Maternity Roosts

SESSION 1: INTERACTIVE DISCUSSION
- **Factors Responsible for Extreme Negative Trends in Missouri and Kentucky**
- **Management Recommendations for Coal Mining**
- **Reasons for Shift in Populations from Southern US to Northern US**
- **Use of Reforested Areas**

SESSION 2: FIELD TECHNIQUES FOR BIOLOGICAL ASSESSMENT
1. Conducting Mist Net Surveys for the Endangered Indiana Bat
2. Acou stic Surveys
3. Indiana Bat Radio Tracking and Telemetry Studies: Getting Started
    - **Signal Distance to Bats**
    - **Software**
    - **Sources of Signal Interference**
    - **Transmitter Cost**
4. Summer Habitat Assessment
5. Field Techniques for Biological Assessment: Assessment of Potential Hibernacula and Swarming/Staging Habitat
    - **Duration of Sampling in Fall**
6. Interpreting Indiana Bat Survey Results: A U.S. Fish and Wildlife Service Perspective
    - **Definition of Taking**
    - **Requirements for Timber Harvests**
    - **Reestablishment of Continuous Supply of Large Dead Trees**

- **Surveys by USFWS**

SESSION 2: INTERACTIVE DISCUSSION

- **Differences between Artificial and Natural Roosts**
- **Sharing Roosts and Parasites**
- **USFWS Policy on Anabat**

SESSION 3: CONSULTATION PROCESS

1. The Consultation Process: Federal and State Requirements under SMCRA and ESA
   - **SMCRA versus Corp of Engineers Consultation**
2. Endangered Species Consultation under SMCRA: A State Regulatory Authority Perspective
   - **Coal Loss Associated with Roost Tree**
3. Protection of Indiana Bats During Coal Mining: Consultation and Cooperation of OSM and State Regulatory Programs
4. U.S. Army Corp of Engineers
   - **Aquatic Biological Assessments used by the Corp**
5. Indiana Division of Wildlife
   - **Age of Trees that could Produce Roost Tree Habitat**
   - **Harvesting Roost Trees During the Winter**
   - **Roost Tree ID Qualifications**
6. An Engineering View of the Potential Impacts by the Coal Mining Industry on the Indiana Bat
   - **Use of Artificially Girdled Trees**
   - **Use of Waterway Habitat by Bats**

   SESSION 3: INTERACTIVE DISCUSSION
   - **Bat Protection for Private Land Owners**
   - **Federal Opportunities of Funding Applied Science Projects**
   - **Habitat Conservation Plans for Protecting Species**
   - **Mining Requirements versus Timbering**
   - **Status of Other States Guidance**

SESSION 4: CASE STUDIES

1. Notable Roosts for the Indiana Bat (Myotis sodalis)
   - **Bat Use of Power Poles Wrapped in Black Plastic**
   - **Flying Distance to Cross River**
2. Indiana Bats in West Virginia: A Review
   - **Effort Necessary to Find Roost Trees**
3. Portal Exclusion Protocols
   - **Effect of Size of Portals**
4. The Use of In-Lieu-Fees to Mitigate Bat Habitat Loss at the Bull Run Surface Mine, Virginia: A Case Study
   - **Use of In-Lieu-Fees for Indiana bat**
5. Indiana Bat Habitat Management & Mine Planning: An Industry Perspective

   SESSION 4: INTERACTIVE DISCUSSION
   - **Air Flow Calculations for Closures**
   - **Constructing Artificial Roosts**
   - **Construction Materials for Bat Gates**

SESSION5: GUIDANCE DEVELOPMENT FOR PERMITTING

1. The Indiana Bat and the Kentucky Surface Mining Program: A Progress Report
   - **Are the Bat Protection Plans Working**
   - **Consensus Building Between the SRA and the USFWS**
   - **Relative Impact of Mining on Bats**
   - **Two Separate Approaches to Field Survey Requirements**
2. Indiana Guidance, Problems, Highlights, Successes, and Failures
3. Measures for Protecting the Endangered Indiana Bat on Coal Mine Sites in Ohio
   - **Different Requirements for SMCRA and Section 404 Permits**
   - **Habitat Destruction at Stream Crossings**
   - **Incidental Take Estimates**

- **Incidental Take under SMCRA and Section 404 Permits**
- **Suitable and High Value Habitat**

4. Protection of the Indiana Bat (*Myotis sodalis*) and the Tennessee Federal Program
   - **Requirements to Plant Trees**
   - **Requirement to Retain Water Sources**
5. Chronicle of West Virginia Coal Program Permitting Considerations of the Endangered Indiana Bat (*Myotis sodalis)*
   - **Source of 17 Acre Survey Threshold**
   - **Species Captured at Portals**

SESSION 5: INTERACTIVE DISCUSSION

- **Balancing Agency Involvement**
- **Landowner Involvement**
- **Landowner Involvement**
- **Length of Time Netting is Valid**
- **Post Reclamation Monitoring**

DISCUSSION BY SESSION

SESSION 1: THE BIOLOGY AND LIFE HISTORY OF THE INDIANA BAT

1. <u>National Status of the Indiana Bat</u> Richard Clawson, Missouri Department of Conservation, Columbia, Missouri

2. <u>History of the Indiana Bat: Hibernacula</u> Dr. Virgil Brack, Environmental Solutions & Innovations, Inc., Cincinnati, Ohio

Question: **(Tolerance of Indiana Bats to Gases Found in Coal Mines)** Are you aware of any research related to the use of coal mines as hibernacula and how air quality in these mines has impacted the bats? Has anyone looked at the tolerance of the Indiana Bats to gases associated with coal mines?

Answer: I am not aware of any research in this area.

3. <u>Foraging Ecology of the Endangered Indiana Bat</u> Dale W. Sparks**,** John O. Whitaker, Jr., and Christopher M. Ritzi, Department of Life Sciences, Indiana State University, Terre Haute, Indiana

Question: **(Comparison with Other Species)** In your study of the Indiana bat, do you also study other bat species so that you can make comparisons between species?

Answer: The answer is yes. There were eight other species that were present on this site. We have just published several papers on the results for the other species.

Question: **(Use of Isolated Wood Lots)** Based on your experience, how isolated must a wood lot be before it would not be used by the Indiana Bat? Have you been able to determine the level of connectivity that must be present to support use by the Indiana Bat?

Answer: We found that some bats would cross nearly a kilometer of open space, but we found these individual bats to be the exception. I suspect those individuals are outliers. We have not been able to look at this more closely because a lot of the small isolated woody lots are privately owned and we do not have permission to do the study. There are almost 500 acres of forest that have been planted in this area to restore connectivity between forested areas and the bats are using these reforested areas. We have found that Red bats are actually roosting in the reforested areas 9 to 10 years after they were planted.

4. <u>Ecology and Behavior of Indiana Bats at Summer Maternity Roosts</u> Dr. Allen Kurta, Department of Biology, Eastern Michigan University, Ypsilanti, Michigan

SESSION 1 INTERACTIVE DISCUSSION

Question: **(Factors Responsible for Extreme Negative Trends in Missouri and Kentucky)** Looking at the population status by State, I noticed the precipitous drop in population in the States of Missouri and Kentucky. Are you aware of any factors that may be driving the extreme negative numbers in these States?

Answer: In the States of Missouri and Kentucky, we have had several priority one caves that dramatically affected the numbers because they had such large populations. In the case of Bat Cave in Kentucky, it had historically had a population of 100,000 bats that is now in the 20s. There was a flood several years ago that destroyed thousands of bats in Bat Cave. This cave also experienced a catastrophic loss in the 50s when a sudden cold air drop prevented the bats from escaping and the floor of the cave was littered with bat bones for years afterwards. The bats that survived the flood in the 80s may have moved in to Laurel Cave which is close by. In Carter Cave Park, they have reopened Salt Peter Cave and are trying to restore the microclimate. In Missouri, the priority one and two caves have all gone down in population. Population losses can happen catastrophically as well as incrementally.

Question: **(Management Recommendations for Coal Mining)** Based on the data that has been presented today, what management recommendations could you make for coal mining operations?

Answer: I think that the answer will probably emerge over the next couple of days. I don't know how much subsurface extraction is taking place within the bat's range and whether those cavities could become quality hibernacula for the bat. On the surface, anything that could be done to retain snags, corridors that connect wood lots, and foraging habitat all have the potential to maintain and enhance habitat for the species.

Question: **(Reasons for Shift in Populations from Southern US to Northern US)** Your map of the population status of the Indiana Bat seemed to indicate a migration of the population to the northern States. Is the reason for this related to climate? Is there any research being conducted to document the reason for this population shift?

Answer: I do not think there is any migration occurring. I suspect that we have had a period of warmer winters and that the caverns and mines in the southern part of the range aren't as cool as they used to be and that those in the north are also not as cool as they used to be. This has perhaps led to differential survival that has depressed the populations in the south and has allowed the populations in the north to increase. Although the hypothesis fits, there is no data to back it up. We have been using data loggers in the caves for the past 5 to 6 years and hopefully we will start getting data that would begin to answer this question. Most of our hibernacula temperature data is too limited to tell us what is happening.

Answer: Another factor that is unrelated to climate is the amount of disturbance to these caves which is tremendously less that it was a number of years ago. Caves that had less than 100 bats ten years ago now have 10,000 bats.

Answer: In Illinois, we now have a mine that has been dramatically increasing in population to over 30,000 bats. That mine did not exist in the early 1980s. There is no way that reproduction could account for that many bats in that time period. This is one example where migration may be involved and bats are moving into an area because a good hibernacula is now available.

Question: **(Use of Reforested Areas)** You mentioned that Red bats have been using a reforested area. Are those areas planted or have they naturally reforested?

Answer: Although the area was planted, most of the trees appear to be volunteers.

SESSION 2: FIELD TECHNIQUES FOR BIOLOGICAL ASSESSMENT

1. Conducting Mist Net Surveys for the Endangered Indiana Bat James Kiser, Daniel Boone National Forest, Stearns Ranger District, Whitley City, Kentucky and John R. MacGregor, Kentucky Department of Fish and Wildlife Resources, Frankfort, Kentucky

2. Acoustic Surveys Dr. Eric Britzke, Clemson University, Clemson, South Carolina

3. Indiana Bat Radio Tracking and Telemetry Studies: Getting Started Cal Butchkoski, Pennsylvania State Game Commission, Petersburg, Pennsylvania

Question: **(Signal Distance to Bats)** How close do you have to be to the bat to be able to pick up the signal?

Answer: It varies, but in the summer it is basically line of sight. It could be a quarter of a mile or less. If you are shooting through a stand of heavy conifers you will lose the signal. In the spring prior to leaf cover, I can pick up a signal that is four miles away. Once I am in the airplane, I can usually get a signal at about 1.5 miles off each wing.

Question: **(Software)** What kind of software do you use?

Answer: The software is available from Joel Sartwell from the Missouri Department of Conservation. I will have a reference in the paper. It will do kernelling. I use it for triangulation and error estimates.

Question: **(Sources of Signal Interference)** Did changing cables help to reduce your signal interference?

Answer: Concerning interference in the airplane, routing of the cables is important. You do not want them too close to the laptop. The aircraft we were using was set up for telemetry with deer and the shielding of the cable had gone bad after 10 years of use. The shielding is most important in the cockpit where you have interference from a number of sources. We also found interference because the antenna had a direct metal to metal connection with the wing.

Question: **(Transmitter Cost)** What is the cost of the transmitters?

Answer: About $150. If the transmitter is recovered, you can replace the battery for $50.

4. Summer Habitat Assessment Dr. Timothy C. Carter, Department of Zoology, Southern Illinois University, Carbondale, Illinois

5. Field Techniques for Biological Assessment: Assessment of Potential Hibernacula and Swarming/Staging Habitat Dr. Virgil Brack, Environmental Innovations & Solutions, LLC, Cincinnati, Ohio

Question: **(Duration of Sampling in Fall)** Why would you sample for 5 hours at a mine portal in the fall?

Answer: This is the result of regulatory evolution. It has been my observation that most of the bat activity in the fall occurs in the first hour or two.

6. Interpreting Indiana Bat Survey Results: A U.S. Fish and Wildlife Service Perspective Andy King, U.S. Fish & Wildlife Service, Bloomington, Indiana

Question: **(Definition of Taking)** Has the U.S. Fish and Wildlife Service revised its definition of "taking" as a result of the supreme court decision with the spotted owl?

Answer: I am not familiar with the 1999 court decision with the spotted owl. This does seem to be an evolutionary process. I do know that the biologist's definition of "jeopardy" was different 10 and even 5 years ago based on court decisions.

Question: **(Requirements for Timber Harvests)** How are you addressing things like timber harvest that are outside of the section 7 jurisdiction.

Answer: I can only answer that from an Indiana perspective. Generally, we don't get involved in private timber harvests unless we get advance notice or have records of bats being present. In our office in Indiana we are now reviewing subdivisions that are near known hibernacula. I would expect you would find a wide variety of responses to this at different USFWS regions.

Question: **(Reestablishment of Continuous Supply of Large Dead Trees)** I have heard it recommended that the USFWS wants dead trees left on the site and yet a mining permit requires at least 80% survival of trees planted. How can this be done?

Answer: I don't know that it can. What USFWS wants to see for the Indiana Bat is a continuous supply of large dead trees and you need for them to be living in order to become large prior to dying. I don't know that this is being adequately addressed. Recent research by Purdue University on mined lands in Indiana was not finding productive tree growth on reclaimed lands.

Question: **(Surveys by USFWS)** Is there any program that would allow the U.S. Fish and Wildlife Service to conduct these bat surveys?

Answer: Yes and no. The U.S. Fish and Wildlife Service is not prohibited from doing surveys. The lack of staff and resources however, does not allow us to get out and do much field work.

SESSION 2 INTERACTIVE DISCUSSION

Question: **(Differences between Artificial and Natural Roosts)** I found a bat colony using a bridge. It had both Indiana Bats and Little Brown Bats. The last week in May we found pregnant Indiana Bats at this bridge. In August, we found some juveniles. During June and July, we did not find either so it did not appear to be a maternity roost. In other artificial roosts, you find mixed colonies of different species of bats. Has anyone determined that these maternity colonies in natural trees are all Indiana Bats or are they mixed just like the artificial roosts?

Answer: Of the dozen or so times I have netted natural roost trees, the bats exiting have all be Indiana Bats. It has been my observation that the natural roosts are single species but the artificial roosts many times have mixed species.

Answer: Although there are exceptions, it has been our experience that Indiana bats typically do not share roosts with other bats.

Answer: We have a church that has 20,000 lucifigus and about 50 to 80 sodalis. Sometimes the sodalis are grouped together, but most of the time they are mixed in with the lucifigus.

Comment: **(Sharing Roosts and Parasites)** This summer when we looked at our bat boxes at the Indianapolis airport. This bat box had been a primary roost for northern myotis from 1997 through 2002. In the summer of 2003 we found it occupied by Indiana bats. We have found in the past that the parasites for bats to be species specific. However, on this occasion we found Indiana bats with evening bat parasites and evening bats with Indiana bat parasites. These parasites are not even in the same genus. They would have to share the same roost or be in very close proximity to each other to share these parasites.

Question: **(USFWS Policy on Anabat)** What is the official USFWS policy on Anabat surveys?

Answer: There is no official USFWS policy on Anabat surveys. We have some field offices that are encouraging these surveys to assess whether or not a site is in need of mist-net survey or whether a harp trap needs to be done at a mine portal. It is valuable as a screening tool but it is not as valuable as mist netting for a stand alone survey. The Anabat does not allow you to distinguish between a male voice and female voice. There is no certification program to determine whether or not people are really qualified to operate Anabat equipment accurately.

SESSION 3: CONSULTATION PROCESS

1. <u>The Consultation Process: Federal and State Requirements under SMCRA and ESA</u> Jim Serfis, U.S. DOI Fish & Wildlife Service, Division of Endangered Species, Arlington, Virginia

Question: **(SMCRA versus Corp of Engineers Consultation)** If the requirements for endangered species are met under the SMCRA process through the 1996 Biological Opinion, shouldn't that satisfy the section 7 consultation process including consultation with the Corp of Engineers?

Answer: This information should be enough, however, it does not absolve the Corp of Engineers from their responsibility to provide a document that demonstrates that they have appropriately analyzed the permit action. It is possible that the Corp of Engineers permit may be a little different than the SMCRA permit as there may be some impacts that were not considered under SMCRA.

2. Endangered Species Consultation under SMCRA: A State Regulatory Authority Perspective Bill O'Leary, Illinois Office of Mines and Minerals, Benton, Illinois

Question: **(Coal Loss Associated with Roost Tree)** In the situation where you avoided the roost tree, was there a significant coal loss involved?

Answer: There was no significant coal loss because the tree was in a corner of the permit along a stream that was not underlain by coal. It was actually only about 200 feet from the coal preparation plant with lights and noise. The mine closed due to economics and there was no followup, but I think the bark fell off the tree the next year.

3. Protection of Indiana Bats During Coal Mining: Consultation and Cooperation of OSM and State Regulatory Programs Len Meier, U.S. DOI Office of Surface Mining, Alton, Illinois

4. U.S. Army Corp of Engineers Todd Hagman, U.S. Army Corp of Engineers, Louisville, Kentucky

Question: **(Aquatic Biological Assessments used by the Corp)** Is the Corp of Engineers using the aquatic biological assessments in order to minimize the effects of mining on higher quality streams?

Answer: Here in Kentucky, the Corp of Engineers has a protocol that is used after the site is assessed and gives us a ranking of the stream as compared to the least disturbed streams in the region all the way up to the most impaired streams. The mitigation requirements will be appropriate to the predicted impacts. The process is very quick and a will show you the possible mitigation requirements including the possible avoidance of the site.

5. Indiana Division of Wildlife Ramona Briggeman, Indiana Division of Fish & Wildlife, Jasonville, Indiana

Question: **(Age of Trees that could Produce Roost Tree Habitat)** Could you speak to the amount of time necessary for reforested mines to produce habitat for the Indiana bat?

Answer: Under SMCRA, it is possible that the trees might have only been in place for three growing seasons prior to final bond release. In Indiana, our short term goal is to develop a foraging matrix and travel lanes because we can do this within the bond liability period. We have been discussing the possibility of placing long term easements on the reclaimed area until the trees have matured enough to produce roosting habitat (could be 30-40 years).

Comment: **(Harvesting Roost Trees During the Winter)** You stated that operators could hire a biologist to mark roost trees so that they could be harvested when the bats are not present during the winter. This would allow the remainder of the trees to be harvested at any time as necessary for the operation. The Fish and Wildlife Service would support this type of activity.

Question: **(Roost Tree ID Qualifications)** What should the qualifications of the person who does this selection of roost trees be?

Answer: It should be someone who is familiar with the Indiana Bat and its roosting ecology. The Fish and Wildlife Service really hasn't developed any guidance for this as yet. Basically you are looking or dead or dying trees that have exfoliating bark.

6. An Engineering View of the Potential Impacts by the Coal Mining Industry on the Indiana Bat Tim Howard, P.E. Howard Engineering & Geology, Inc., Harlan, Kentucky

Question: **(Use of Artificially Girdled Trees)** Have you done any studies to document that bats are using the trees as roosts that have been girdled by the mine at the periphery of the area?

Answer: The industry does not have any proof that this effort has been successful.

Question: **(Use of Waterway Habitat by Bats)** Could you explain about the trees along the waterways?

Answer: We have observed along the stream buffer zones, that the bats do not necessary gather along these areas. Instead, we have observed that the bats in general gather around still water areas. Based on these observations, we feel that still water areas have a greater potential than streams to promote Indiana Bat populations. The establishment of buffer zones around still water habitat may better serve to repopulate the area with bats.

SESSION 3: INTERACTIVE DISCUSSION

Question: **(Bat Protection for Private Land Owners)** Is the Fish and Wildlife Service working with private landowners in your Section 10 process?

Answer: That is a mechanism that we should be looking into but we have yet to figure out how.

Question: **(Federal Opportunities of Funding Applied Science Projects)** What opportunities are there within Federal Agencies like OSM and the Corp of Engineers to fund the type of research needed to answer the questions raised by the mining industry? The F & W Service no longer has any significant research funds.

Answer: OSM has just this year established a more formal process for attempting to fund applied science projects that impact the regulation of coal mining. We now have a process and committee in place that can review and recommend proposals. The Director of OSM has proposed funding this activity in the FY 2005 and FY 2006 budgets.

Comment: **(Habitat Conservation Plans for Protecting Species)** Habitat conservation plans have not been discussed here yet. These plans need to be explored more because they have the potential of avoiding a lot of the problems associated with consultation on a case by case basis. It works best when you could have a State Mining Industry Council with a majority of the industry working with the appropriate State and Federal agencies to develop options that are most workable for everyone.

Question: **(Mining Requirements versus Timbering)** How is it that a mining company has to go through all of the permitting requirements and tree clearing restrictions while just across the road there is a timber operation that doesn't have to do anything or observe the seasonal restrictions? I

Answer: It goes back to the section 7 consultation. OSM is a Federal agency and its activities fall under the jurisdiction of section 7 of the Endangered Species Act. The deference is that the timber company is not under the jurisdiction of the Endangered Species Act but coal mining is.

Answer: Although section 7 would not apply to the timber company, Section 9 would if a taking of an endangered species occurs. This of course would be after the fact which is not the preferred method.

Question: **(Status of Other States Guidance)** What is the status of other States that need to address permitting of Indiana Bats on coal mines?

Answer: I talked briefly about five States, Kentucky, Indiana, Ohio, Tennessee, and Illinois. There has been some discussions in Virginia and West Virginia. In all other States that I talked to, endangered species are being handled on a permit specific basis rather than developing program guidance. In States like Missouri and Oklahoma, there is not a critical mass of issues related to the Indiana Bat and Coal Mining in order to make an effort worthwhile.

SESSION 4: CASE STUDIES

1. <u>Notable Roosts for the Indiana Bat (Myotis sodalis)</u> William D. Hendricks, Rebecca Ijames, M. Muller, L. Alverson, J. Timpone, and N. Nelson, Ecological Specialties, LLC., Symsonia, Kentucky

Question: **(Bat Use of Power Poles Wrapped in Black Plastic)** Why was the power pole wrapped in black plastic that were being used as a roost by bats?

Answer: This is a standard practice for utilities to prevent damage by woodpeckers.

Question: **(Flying Distance to Cross River)** How far did the bats have to fly to get across the river at this site?

Answer: About 0.25 miles.

2. Indiana Bats in West Virginia: A Review Joel Beverly and Mark W. Gumbert, Ermine, Kentucky

Question: **(Effort Necessary to Find Roost Trees)** How much effort was involved in finding the two roost trees in 2003-2004?

Answer: The first year, we probably netted for 72 nights at several sites. The following year we followed up in the vicinity of the drainage where we had found the bats the previous year. We did 36 nights of netting in the drainage.

3. Portal Exclusion Protocols Dr. Richard Sherwin, Department of Biology, University of New Mexico, Albuquerque, New Mexico

Question: **(Effect of Size of Portals)** Are there any size of openings that are too small for bats?

Answer: I have not worked with the Indiana bat, but for species in the West, they fly through openings that are six inches tall and are roosting in places that only my graduate students can get to.

4. The Use of In-Lieu-Fees to Mitigate Bat Habitat Loss at the Bull Run Surface Mine, Virginia: A Case Study Lance Debord and Heather McDonald-Taylor, D.R. Allen & Associates, Abingdon, Virginia

Question: **(Use of In-Lieu-Fees for Indiana bat)** Does the U.S. Fish and Wildlife Service see any opportunities for use of In-Lieu-Fees for the Indiana Bat situation?

Answer: As a policy, the U.S. Fish and Wildlife Service always tries to protect existing habitat rather than creating new habitat. I don't think we would be very comfortable mitigating an Indiana bat hibernacula.

Answer: A section 7 situation requires that you do good things for the individuals you are affecting not just the species. If this were in a Habitat Conservation Plan context, we could do things for the Indiana bat in an adjacent county even though the impacts where occurring at a coal mine elsewhere.

5. Indiana Bat Habitat Management & Mine Planning: An Industry Perspective Bernie Rottman, Black Beauty Coal Co., Evansville, Indiana

SESSION 4 INTERACTIVE DISCUSSION

Question: **(Air Flow Calculations for Closures)** Do you need to do any air flow calculations in order to place a bat gate in a pipe and use it as a bat friendly closure?

Answer: Air flow in abandoned mines is dynamic by its very nature. As soon as we stop mining and stop managing the air flow, it changes all of the time. My experience has been that the most important factor is getting structural integrity in the gate. It would be different for caves because caves are a much more stable environment. Normally there is so much change going on that the difference of one inch of space at the portal is not significant. It is important to maintain vertical air flow and to make sure that the openings are not accessible to small children or animals.

Question: **(Constructing Artificial Roosts)** Has there been any interest in constructing artificial roosts?

Answer: In West Virginia, there has been some interest in artificial roosts. I am currently working on a project where some of the mitigation will be artificial roosts such as the rocket style boxes by Dorson and McGregor. These will be built around the perimeter of the project. They will also require that ponds be constructed specifically for wildlife in close proximity to the artificial roosts.

Question: **(Construction Materials for Bat Gates)** Concerning the materials that you use to construct bat friendly closures, what materials are best to build a closure with?

Answer: There is no body of information that really demonstrates the relative superiority of any particular material. There was some work that showed that round bars were more effective for Myotis virginianus but there was no repetition of this work. I don't think that there is any information available, that for any species in any portion of its range, that would argue one gate construction versus another in terms of being more or less effective for that species.

I would lean toward the materials that you can obtain most effectively that will anchor well to the material and that will have structural integrity.

Answer: Although there is no behavioral difference in bat response to gates made out of different materials, there is a significant difference in the strength of the gates made with Manganal steel versus four inch angle iron or two by four inch tubular steel. If your major concern is to keep people out, then you may prefer to put in the four inch angle iron on the two by four tubular steel because the one inch Manganal bars are just not that strong.

Answer: The best information that is available on all aspects of bat gate design, construction, and materials can be found in the OSM "Proceedings of Bat Gate Design: A Technical Interactive Forum." Copies can be obtained by contacting Kimery Vories with OSM at (618) 463-6463 x 103 or by e-mail at kvories@osmre.gov.

SESSION 5: GUIDANCE DEVELOPMENT FOR PERMITTING

1. The Indiana Bat and the Kentucky Surface Mining Program: A Progress Report Dr. Richard Wahrer, Kentucky Department for Natural Resources, Division of Mine Permits, Frankfort, Kentucky

Question: **(Are the Bat Protection Plans Working)** The Indiana Bat protection plans have been in place since 1995. Has there been any monitoring of these sites using the wildlife ponds and the survival of hardwoods and whether or not this is working for Indiana bats?

Answer: There has not been much in the way of monitoring. There has been the OSM oversight study where we gave OSM all of the permits that had Indiana bat protection plans. OSM is going to take a look at these sites and tell us how we are doing. Although Kentucky can recommend the reduced grading practices for reforestation we can not require it.

Question: **(Consensus Building between the SRA and the USFWS)** It is my understanding that if the SMCRA regulatory authority and the U.S. Fish and Wildlife Service can not come together in the permitting process then the biological opinion is not being followed.

Answer: I don't know that the biological opinion means that everyone has to be happy. I think the biological opinion allows consultation to go forward and that there is discussion between the two agencies. Concerning the conflict resolution option, don't go there because things will only get worse. Resolve it at the lowest possible level because you lose control and things get out of hand when it is elevated.

Question: **(Relative Impact of Mining on Bats)** It has been said that mining does not have a large enough impact on the landscape to affect the Indiana bat. When you look at the map of the location of mines in Kentucky, it would seem from their abundance that impacts could be happening.

Answer: I agree. Concerning cumulative effects, regulatory agencies have a tough time dealing with this. Most Kentucky permits are quite small ranging from 200 to 400 acres. It is our hope that there are adjacent areas that the bats can use during mining and reclamation. The question is how much land must be affected before you start to have an impact on the biology and populations of the bat.

Question: **(Two Separate Approaches to Field Survey Requirements)** Concerning the need for separate surveys for Threatened and Endangered species under the SMCRA permit and the Corp of Engineers permit, you indicated this was unfair to the applicant. How could these two processes be integrated so that it is fair?

Answer: Kentucky bases its surveys on recorded occurrences and databases. The U.S. Fish and Wildlife Service, however, has determined that the entire State of Kentucky is Indiana bat habitat and so, in every case, field surveys are necessary to identify the specifics of their location. We see this more as a research approach to produce new information on the location and ecology of the species. Kentucky has concentrated on winter habitat protection. When you survey everything and 98 percent of the operators do not capture Indiana bats, then they have no requirements for restoring forests that would provide Indiana bat habitat. Kentucky thinks that we need a better way to determine the need for a survey rather than to automatically require one in all cases.

2. Indiana Guidance, Problems, Highlights, Successes, and Failures Tim Taylor, Indiana Division of Reclamation, Jasonville, Indiana

3. Measures for Protecting the Endangered Indiana Bat on Coal Mine Sites in Ohio Sarena Selbo, U.S. Fish & Wildlife Service, Reynoldsburg, Ohio

Question: **(Different Requirements for SMCRA and 404 Permits)** Have you had any issues where the requirements for Corp of Engineers Section 404 permits were different from the SMCRA permit?

Answer: In Ohio, we have not had any conflict between our 1996 protection plan process with State SMCRA programs and the Corp of Engineers Section 404 process. Although we have done separate consultations in the past, it is our plan to have only one consultation process in the future under the 1996 biological agreement.

Question: **(Habitat Destruction at Stream Crossings)** Please elaborate on your requirement to avoid habitat destruction at stream crossings.

Answer: Our concern is that stream crossing should avoid high quality habitat for the bats.

Question: **(Incidental Take Estimates)** Concerning dual reviews and incidental take, does the State make an estimate of incidental take?

Answer: The way the biological opinion is set up, the States are supposed to make an estimate of incidental take when possible. Since incidental take is very hard to estimate, we are keeping a record of acres of trees that are being harvested under the assumed presence option.

Question: **(Incidental Take under SMCRA and 404 Permits)** Do you see a difference in approach under the biological opinion that allows incidental take and Section 7 consultation which would be applicable under the 404 permits that would not allow incidental take?

Answer: Section 7 consultation does allow incidental take if you go through formal consultation and you end up with a biological opinion and an incidental take statement. If you do an informal Section 7 consultation then you do not get to the level of incidental take.

Question: **(Suitable and High Value Habitat)** Concerning the terms "suitable habitat" and "high value habitat," what do they mean?

Answer: Technically, they have different meanings, but from the Indiana bat point of view the USFWS in Ohio feels that suitable habitat is high value habitat.

4. Protection of the Indiana Bat (*Myotis sodalis*) and the Tennessee Federal Program Becky Hatmaker, U.S. DOI Office of Surface Mining, Knoxville, Tennessee

Question: **(Requirements to Plant Trees)** You said that in Tennessee 70 percent of the permit must be reclaimed to a land use that is planted to trees. Is this because of the existing predominance of trees in Tennessee or are you changing land uses from non tree areas to tree areas?

Answer: Actually, our plan requires that 70 percent of the land use be restored to trees. This has usually been the recommendation of the U.S. F&WS. This does not always happen. In Tennessee, most or land uses are undeveloped that would essentially include forestry. Until recently, we required 500 stems per acre of trees be established on these lands. The operators have to plant twice this amount to ensure that at least 500 stems are available at bond release.

Question: **(Requirement to Retain Water Sources)** Are you putting upland water sources in your reclamation plans?

Answer: We do encourage treatment ponds to be retained wherever possible. Since the land owners do not want the liability of the ponds, we have allowed the operators to strike the dam back resulting in the transformation of the pond into a wetland.

5. Chronicle of West Virginia Coal Program Permitting Considerations of the Endangered Indiana Bat (*Myotis sodalis*   Robert A. Fala, Kevin G. Quick and Andrew N. Schaer, West Virginia Department of Environmental Protection, Division of Mining and Reclamation, Charleston, West Virginia

Question: **(Source of 17 Acre Survey Threshold)** Concerning the 17 acre threshold for conducting bat surveys, what is the source of that requirement?

Answer: That is the requirement of the USFWS Elkens Regional Office.

Question: **(Species Captured at Portals)** What species besides Indiana bat do you catch when you trap at your portals?

Answer: We have not done that much portal trapping. We have captured the Indiana bat, the Big Eared bat, some pips, and some browns that show up on some AML portal reclamation projects.

SESSION 5: INTERACTIVE DISCUSSION

Question: **(Balancing Agency Involvement)** Could you explain how the USFWS and WV are going to be working together in the future to balance the responsibility between these agencies?

Answer: The State of WV has made a lot of progress in this area to the point that if a permit does not complete the consultation process, it is not issued until it does. We are working on the development of a permitting guidance document similar to what has been developed in Ohio. Because we are a large agency with a lot of permits the USFWS wants us to take a more active part in the process so that only in the cases where we determine that the Indiana bat is present do we call in the USFWS.

Question: **(Landowner Involvement)** How can landowners be more involved in the process of protecting the Indiana Bat?

Answer: Landowners are allowed to be involved through commenting in a SMCRA permitting process. This is especially a concern if lands adjacent to a mining permit are involved in mitigation for the Indiana bat.

Question: **(Landowner Involvement)** How do the landowners want to be involved in the process?

Answer: In the Boone Country incident where 3 female Indiana bats were discovered, the landowners found that they could not get any information as to what was going on between the State and the industry. The landowners want to be informed as to actions that could affect them. We want to be able to join the process and work for solutions.

Question: **(Length of Time Netting is Valid)** What do the different States require in terms of the amount of time a mist net survey is good for?

Answer: In West Virginia, a survey is good for 3 seasons. In Illinois, a survey is only valid for one season because of the transient nature of roost trees. In Ohio, it is good for the life of the permit or five years. If a mine in Kentucky has not begun operation within 12 months after a survey is conducted it must be redone. Several of the States have not done surveys yet.

Answer: The USFWS does not yet have any guidance on the length of time a survey should be valid for but wants to develop such guidance. We have noted that Indiana bats show a strong site fidelity to their maternity areas. Because of this, we usually have not recommended surveys on an annual basis unless there has been a lot of habitat alteration that would force them to change their habits.

Question: **(Post Reclamation Monitoring)** Most of the States are working on developing protection and enhancement plans to improve the permitting process. Are any of the States working on monitoring programs to determine how well these protection and enhancement plans are working?

Answer: Some of the States are working on this, but it is still too early in the program to begin to assess relative success or failure.

INDIANA BAT AND COAL MINING
A TECHNICAL INTERACTIVE FORUM
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