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Protecting Threatened Bats At Coal Mines: A Technical Interactive Forum

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Proceedings of Protecting Threatened Bats at Coal Mines:
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Ramada Plaza
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Edited by:
Kimery C. Vories
Anna K. Caswell
Tina M. Price

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FOREWORD

On March 1, 1999, the Office of Surface Mining Reclamation and Enforcement (OSM) convened its first multi-agency, multi-interest group, steering committee in order to initiate planning for its first technical interactive forum on the subject of Bat Conservation and Mining.

This forum on Protecting Threatened Bats at Coal Mines is the fifth in a series of OSM sponsored technical interactive forums and workshops 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 third forum in 2004 was conducted in response to increasing efforts by the U.S. Fish and Wildlife Service to protect the federally endangered Indiana bat (*Myotis sodalis)* and the need for OSM, the U.S. Fish and Wildlife Service, and the State Mining Regulatory Authorities to work more closely together during the permitting, mining, and reclamation activities of surface coal mines that could potentially impact the Indiana bat or its habitat. The fourth workshop in 2007 was in response to the U.S. Fish and Wildlife Service published announcement inviting the public to comment on a revised draft Indiana bat recovery plan. This revised recovery plan had the potential to impact coal mining and reclamation operations in the States of Alabama, Arkansas, Illinois, Indiana, Iowa, Kentucky, Maryland, Missouri, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. The goal of the workshop was to bring together representatives of coal mining related constituencies who would be potentially impacted by the revised Indiana Bat Recovery Plan. The product of the workshop was comments from each of the affected parties to the Fish and Wildlife Service.

The current challenges associated with protecting bat species at coal mines in response to the outbreak of the White-Nose Syndrome (WNS) are daunting. Prior to 2006, we were dealing with only one endangered species whose range covered most of the coal mining regions of the Eastern and Midwestern U.S. Although great efforts were being expended to minimize impacts to the summer habitat of the species, improvements to the bat population were primarily in response to greater protection of the underground habitat. The challenges of finding a unified approach to protecting that species' summer habitat during coal mining permitting and mining operations across so many states with two OSM regions, three US FWS regions and multiple US FWS field offices has required unprecedented cooperation between these states and federal agencies. The potential impacts of White-Nose Syndrome (WNS), however, are expected to add more bat species to the endangered species list, expand the geographic region where bat species are imperiled to possibly include the western U.S., and increase the number of federal and state agencies involved. How this cooperation will hold up under the weight of these additional WNS impacts will truly be a test of unprecedented, historic proportions.

Kimery C. Vories
Steering Committee Chairperson

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Coal Research Center, Southern Illinois University Carbondale

WELCOME

Thomas Shope, Regional Director
Appalachian Region, Office of Surface Mining Reclamation and Enforcement
Pittsburgh, Pennsylvania

Good Morning and Welcome to the third OSM-sponsored Technical Interactive Forum on protection of threatened and endangered bats associated with coal mine operations. The current challenges associated with this topic are daunting. On the one hand, OSM looks with great satisfaction at the progress that has been made by the many abandoned mine land programs whose construction of bat gates and other bat-friendly closures at mines all across the country protect important underground bat habitats. We look forward to the uniform implementation of the recently developed Range-wide Indiana Bat Protection and Enhancement Guidelines jointly developed by USFWS, IMCC, and OSM. On the other hand, we look with shock at the recent devastation of eastern and midwestern bat populations infected with the White-Nose Syndrome that now threatens to move many of these species toward extinction. The results of this forum should focus on better ways for all of us to work cooperatively in the critical time ahead, searching for proven methods to protect these species that result in a positive working relationship between all concerned.

I have looked forward to being here today at the beginning of two and half days of discussion and information-sharing on this important environmental topic. This is an excellent opportunity for communicating problems, solutions, and concerns related to protecting bats associated with coal mining and reclamation.

The goal of the current forum is to create an interactive environment that brings OSM, related federal agencies, states, industry, and academia together to exchange technical innovations in the areas of bat protection, mitigation, and conservation, share successes and failures, and discuss how to better implement protection and mitigation strategies related to mine permitting and mined land reclamation.

We are already off to a very good start after that excellent field tour yesterday where most of you were able to visit these excellent examples of protective measures to protect bats by mining programs in West Virginia. I would like to offer a special thank you to the field tour organizers Bob Fala and Cindy Lawson from the West Virginia DEP, and our own Sammy Pugh from OSM.

I would like to commend the support and commitment of our cosponsors West Virginia DEP, Bat Conservation International, and Jackson Environmental Consulting Services whose sponsorship support has been essential in being able to ensure that we can provide all of the ingredients for a quality experience at this event.

I would like to thank the Steering Committee who has been working hard to organize this event since November of 2007. They include:

- Dave Waldien, Mylea Bayless - Bat Conservation International
- Bernard Rottman - Black Beauty Coal
- Gregory Conrad - Interstate Mining Compact Commission
- Ramona Briggeman - IN Division of Reclamation
- Richard Wahrer - KY Dept. for Surface Mining, Reclamation & Enforcement
- Christy Johnson-Hughes, T.J. Miller - USDOI FWS
- Jerry Legg, Jon Lawson - VA Dept. of Mines Minerals & Energy
- Bob Fala, Cindy Lawson - WV Dept. of Environmental Protection
- Kimery Vories (Chairperson), Brian Loges, Craig Walker, & Sammy Pugh - OSM

Please feel free to contact any of the Steering Committee members with questions or concerns about this or future events.

It is always true that the more we know, the more options we have. I am optimistic that constructive dialogues, such as those held here, will lead to a better understanding of how best to protect and mitigate bats and bat habitat associated with coal mining.

I commend all the forum participants for being part of this valuable information exchange. The public and the coalfield residents can only benefit from the information that is shared and the knowledge that is gained at this event. I thank you for applying your minds to the task and I wish you success in your efforts on behalf of the coalfield environment.

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 fifth technical interactive forum co-sponsored by OSM on Bat Conservation and Coal Mining and the third forum on threatened and endangered species of bats. The proceedings of these forums are available on OSM's National Technology Transfer Website at www.techtransfer.osmre.gov.

The Steering Committee has worked hard since November of 2007 to provide you with the opportunity for a free, frank, and open discussion on the status of efforts to protect bat species protected by the Endangered Species Act at SMCRA permitted coal mining and reclamation operations and how these activities may be impacted by White-nose Syndrome.

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 science.

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. A basic assumption of the interactive forum is that no person present has all the answers or understands all of the issues.

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;
- The forum is being recorded in order to capture the interactive discussions for the proceedings. 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. OSM will mail all registrants a copy of the proceedings. 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.

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;
- 25-plus minutes of participant discussions 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 yellow 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.

SUCCESSFUL PARTNERSHIPS FOR THE EFFECTIVE MANAGEMENT, RESEARCH, AND CONSERVATION OF BATS

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Abstract

The coal industry, state and federal wildlife managers, conservationists and researchers face numerous and complex challenges for effective resource management in the 21st century. The diversity of bats within the coal regions of the United States poses additional management issues because some species are dispersed in tree-roosts during warm months, hibernate for extended periods in caves and mines even on active coal mining sites in winter, or migrate throughout the region in spring and fall. Even as new technologies and management practices are developed to better manage natural resources for bats and to remain in compliance with environmental regulations, emerging threats, such as White-nose Syndrome (WNS) and wind-energy development, will most certainly undermine past management successes and disrupt how various constituencies work together effectively. The emergence of WNS and development of wind-energy facilities in North America have changed how different groups collaborate to address these and other challenges. The establishment and maintenance of successful partnerships involve courtship, engagement, communication, sharing, encouragement, and trust by all partners. Effective partnerships should engage diverse parties to mobilize resources across a wide spectrum of local, state, and federal agencies and non-government organizations to support common management, conservation, and research agendas. We suggest that effective partnerships for the conservation of bats at coal-mining and wind-energy projects for the 21st century can best be founded and sustained based on respect for the mission of others.

Introduction

Partnerships in natural resource management can assume many forms and are generally defined as a relationship between two or more organizations or individuals. They may be informal in nature or be more formally defined based on comprehensive legal contracts or agreements (e.g., Memorandum of Understanding) that explicitly outline the specific rights and responsibilities among the parties. Most agreements will include several elements (Powledge 2008) that explain:

- The purpose of the agreement;
- The responsibilities of each party;
- The arrangement for parties to commit financial and other resources;
- An understanding of how the agreement is administered; and
- How the agreement may be modified and terminated.

The nature of the work that brings organizations to the table to establish a partnership often dictates specific responsibilities of individual parties to capitalize on their individual expertise and available resources. Also, partnerships may be established for short- or long-term projects based on local or regional conservation, management, or research needs. In general, partnerships involve close cooperation among participating parties, but on occasion, some partnerships may be established where one or more organizations assume a more active role and others take a more supportive but less active role. An example of one such partnership is the Appalachian Regional Reforestation Initiative (ARRI), which is a more formal partnership consisting of participants that have signed agreements to follow current reforestation practices and to participate in regional research efforts. Another such partnership is the Bats and Wind Energy Cooperative (BWEC), formed as a collaboration of government, non-government, industry, and academic partners to address how best to reduce adverse impacts of wind-energy developments on wildlife.

Why Are Partnerships Important? Management issues facing the coal industry in the 21st century are daunting, fast-paced and often extend beyond the physical boundary of given coal-mining project sites. The complexities and demands of effectively managing natural resources (e.g., coal mining and bats) can often exceed the financial and staffing capacity of individual organizations, even if they have the required knowledge to address the issue. Thoughtful and engaged leaders of individual organizations will be able to recognize when partnerships will enhance the organization's mission and help unite others in a common cause. The true power of successful partnerships can be realized when all members are committed to common goals and objectives that are achieved through individual parties bringing their expertise and resources to the project. The Office of Surface Mining's Protecting Threatened Bats at Coal Mines: A Technical Interactive Forum is one example of an effort to bring together various stakeholders involved in coal mining to exchange information and ideas. This forum provides a unique opportunity to bring together representatives from federal and state agencies, conservation organizations, and academia to discuss the latest information on bat conservation and to convey new ideas about management and technologies to the general public and to other participating organizations. Benefits of these and other partnerships are often realized after the partnership is formed, such as the restoration of native forests and implementation of science-based strategies to mitigate adverse impacts on different species,

What Makes a Partnership Successful? Successful partnerships require leadership and hard work that brings all parties together for a common cause. There are six simple elements involved in establishing and sustaining successful partnerships:

1. The **courtship** element is the first step that involves the salesmanship of one party trying to convince another of the values of working together and the efforts of the other party to resist those efforts. Being able to "sell" someone on collaborating and pooling the skills and resources of the partnership allows it to start to take shape.
2. **Engagement** involves commitment. Once potential members of a partnership are convinced there is value in collaborating during the courtship stage, all parties must step forward and determine their level of commitment to the partnership.
3. Effective **communication** involves "listening twice as much as talking" to help ensure that each member of a partnership truly understands the needs and expectations of the others. Good communication is critical throughout the process of developing and sustaining a partnership because even small lapses of communication can rapidly jeopardize past progress.
4. Members of any effective partnership must **share** information regarding the accomplishments of the group and the continuing commitment of each organization to the collaborative project. It is only through generous sharing of information will partnerships be able to adjust to changing circumstances and new information.
5. **Encouragement** by all members of a partnership helps ensure the collaboration works well together and shares important information. This may include encouraging partners to publish data through diverse professional and public outlets, allowing access to project sites, and to continue as an active member of the partnership when times are difficult.
6. **Trust** is earned, and is the most important element of any partnership – as building blocks are to solid foundations. Trust allows partners to believe in the level, types of support, and commitment of an organization to a collaborative project. And perhaps most importantly, trust allows partners to more easily recover and move past lapses in communication or misunderstandings.

It is only when all six of these elements are inherent parts for all parties involved in the development and implementation of a partnership will any collaboration operate at its maximum capacity and achieve its full potential. The 2009 Range-Wide Indiana Bat Protection and Enhancement Plan Guidelines is a more formal example of a partnership between federal and state agencies to promote the conservation of Indiana bats (U.S. Fish and Wildlife Service, Interstate Mining Compact Commission, Office of Surface Mining, Reclamation and Enforcement 2009). All six elements of a successful partnership had to be present for the agencies to create these guidelines.

The Changing Faces of Partnerships: Crises in conservation and management often bring about changes in how organizations can most effectively work together. Currently, natural resource managers and bats are facing two unprecedented threats in the United States, White-nose Syndrome (WNS) and wind-power development. WNS is an emerging fungal disease of hibernating bats that has killed over a million hibernating bats in the eastern United States and Canada since its discovery in New York in 2006 (Bat Conservation International 2009). In some regions of North America, wind-energy facilities are causing unprecedented fatalities of bats, especially of migratory tree-roosting species (Arnett et. al., 2007; Arnett et. al., 2008).

Many organizations were poorly prepared for the emergence of WNS within their respective regions and the rapid spread of the fungal pathogen associated with this disease across North America. Unfortunately, over four years after its discovery there is only a draft National Plan to guide the federal response to WNS, and some states continue to find themselves ill prepared for the discovery of WNS within their jurisdiction; in some cases, organizations do not appear to even be aware of the true magnitude of the threat. In 2010, as a direct result of the threat of WNS to the survival of hibernating bats, three species of bats (little brown myotis, *Myotis lucifugus*; northern long-eared myotis, *M. septentrionalis*; and eastern small-footed myotis, *M. leibii*) have been proposed for federal listing under the Endangered Species Act (Kunz and Reichard 2010, The Center for Biological Diversity 2010).

Similarly, the unprecedented bat fatalities first reported in 2004 of migratory tree-roosting species at wind-energy facilities along the Appalachian ridge tops (Fiedler et. al., 2007), and later elsewhere in agricultural landscapes, have served as wakeup calls to the wind-energy industry, government agencies, non-governmental organizations, general public, and the scientific community that renewable energy developments are not always impact free. USFWS guidelines for assessing impacts of wind-energy development on bats and birds, developed in part by wildlife biologists (Kunz et. al., 2007) and the USFWS (2003), are under development by the Wind Turbine Guidelines Federal Advisory Committee (March 2010) and will be out for public review in 2011.

The magnitude of threats from WNS and wind-power development invites a comprehensive, multi-investigator, multi-tiered approach that includes the cooperation of natural resource managers, wildlife biologists, and academic, government, and non-governmental scientists. There are opportunities for all private, state, and federal land management organizations and the public to be part of local, regional and even national efforts to monitor and hopefully slow the spread of WNS, mitigate its current impact, and search for a viable cure. In the face of the unprecedented threat of WNS, individual coal companies and the industry as a whole, have an opportunity to step forward and take a leadership role in developing partnerships to help battle WNS. Similar opportunities exist for organizations to collaborate to address conservation, management, and research needs to address impacts of wind-energy development on bats and birds.

Conclusion

More often than not, resource management on a specific site is significantly impacted directly or indirectly by forces beyond the physical footprint of the project area. Effective partnerships can help mobilize key organizations with the knowledge and resources (e.g., equipment, personnel, and funding) to more efficiently meet the conservation and management challenges of bats within coal-country today. Emerging conservation and management issues, such as WNS, require new ways of thinking and acting as the devastating biological impact of this rapidly spreading disease realigns historic approaches to conservation and management of bats throughout North America. Sustainable and successful partnerships go through a process to establish and maintain, and involve courtship, engagement, communication, sharing, encouragement, and trust by all of the partners. Only when all of the parties involved in a partnership recognize and respect the strengths of others will the full potential of the partnership be achieved or maintained.

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Christy Johnson-Hughes is currently a National Energy Coordinator for the U.S. Fish and Wildlife Service. She has been with the FWS over 10 years. She handles coal mining, oil & gas, nuclear, transmission, and wind issues. She has worked in several program areas, including Endangered Species and Federal Activities (now Conservation Planning Assistance). She spent 3 years in West Virginia working on coal mining issues. Christy has also participated in various bat-related activities, including surveys, trapping, tracking using transmitters, and habitat evaluation for Indiana bats. At this time, she is part of the team developing products discussed in the Surface Coal Mining Memorandum of Understanding (MOU) among the federal agencies, including stream mitigation measures, interagency coordination procedures, and GIS mapping.

Session 1

White-Nose Syndrome Impacts on Bats and Mining

Session Chairperson:
Mylea Bayless
Bat Conservation International
Austin, Texas

Current Status of the Research and Management of White-Nose Syndrome
Jeremy T. H. Coleman, U.S. Fish and Wildlife Service, Hadley, Massachusetts

How White-Nose Syndrome May Affect T&E Species, Their Recovery, and Coal Mining Permitting
Mike Armstrong, U.S. Fish and Wildlife Service, Frankfort, Kentucky

INTERACTIVE PANEL DISCUSSION: Opportunities for Expanding Existing Protection and Enhancement Guidelines in the Prospect of Additional North American Bat Species Gaining Protection under the Endangered Species Act
Brian Loges, Office of Surface Mining Reclamation and Enforcement, Alton, Illinois

Kentucky Representative: Management Opportunities for Addressing White-Nose Syndrome
Dr. Richard Wahrer, Kentucky Department of Natural Resources, Frankfort, Kentucky

West Virginia Representative: Management Opportunities for Addressing White-Nose Syndrome
Ashley Carroll, WV DEP Division of Mining and Reclamation, Charleston, West Virginia

Pennsylvania Representative: Management Opportunities for Addressing White-Nose Syndrome
Geoff Lincoln, Pennsylvania DEP Bureau of Mining and Reclamation, Harrisburg, Pennsylvania

CURRENT STATUS OF THE RESEARCH AND MANAGEMENT OF WHITE-NOSE SYNDROME

Jeremy T. H. Coleman
U.S. Fish & Wildlife Service
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Abstract

White-nose Syndrome (WNS) has continued to spread in 2010 and is anticipated to continue its rapid advance into new territory. In 2010, newly affected bat hibernacula were confirmed in Tennessee, Ontario, and Quebec, and the fungus *Geomyces destructans* has been detected on bats in Delaware and farther west at three sites in Missouri and Oklahoma. The fungus and/or the disease have now been found on bats in 14 U.S. states and 2 Canadian provinces. In 20 hibernation sites with both pre- and post-WNS infection bat population counts, the cumulative decline has been 92% in the two or three years since the sites were documented as infected, with colony losses at some sites exceeding 99%. Thus far, there has been no clear evidence of resistance among affected bat species, and several smaller colonies are on the brink of extirpation. Mortality rates continue to vary between species and between sites, with *Myotis lucifugus* and *M. septentrionalis* being the species most notably affected and drier hibernacula appearing to be least affected sites. Six hibernating species in the eastern U.S. have been confirmed to be affected by WNS, and new discoveries in Missouri, Oklahoma, and Virginia will potentially add *M. grisescens, M. velifer*, and *M. austroriparius* to the list of affected bats. The presence of the fungus *G. destructans* continues to be the common link between affected sites, and the implication that the fungus is the cause of WNS continues to provide the most parsimonious explanation. The need to further understand the etiology of WNS drives much of the WNS research currently underway. The revelation that *G. destructans* has been found on bats in Europe without observed mortality has provided important new avenues of investigation. A National Plan is in development to guide the research and management of this disease, and a recent influx of funding has provided some much-needed support for these efforts.

Background on White-Nose Syndrome

Discovered in 2007 near Albany, New York, the first evidence of White-nose Syndrome (WNS) was recorded in photographs of affected bats in Howe's Cave, Schoharie County, NY, in 2006 (Blehert et al. 2009, Turner and Reeder 2009). By spring 2010, WNS was detected in nearly 160 hibernacula in 14 states and two Canadian provinces (Fig. 1), representing an apparent spread of approximately 950 km from the handful of sites initially discovered in eastern New York to the sites confirmed with WNS in Sullivan and Carter Counties, eastern Tennessee. Increased vigilance in surveying for the disease and improved diagnostic procedures are likely responsible for the detection of the fungus *Geomyces destructans* (*Gd*), in the absence of mortality and other field signs associated with the disease, at multiple additional sites in Tennessee, Missouri, and western Oklahoma in spring, 2010. The detection in western Oklahoma represents an apparent spread of some 2200 km from the index sites in eastern New York. Cutaneous infection by *Gd*, and the resulting damage to soft tissues, is associated with WNS and has come to characterize the disease (Gargas et al. 2009, Reichard and Kunz 2009, Meteyer et al. 2009). Although the exact mechanism(s) leading from fungal infection to death is still a topic of research and debate (see Kunz et al., this volume), evidence to date suggests that *Gd* is likely the causative agent behind WNS and that the fungal infection is not a secondary effect of some other pathogen (Chaturvedi and Chaturvedi 2009, Cryan et al. 2010).

The unexpected emergence and rapid spread of WNS, coupled with virulence and novelty of the disease, has presented wildlife managers with considerable biological and social challenges. There are currently over 100 agencies, non-government organizations (NGOs), and universities involved in the response to WNS, and the management of such a response is rife with complex coordination and resource needs. To enhance coordination between state, federal, and tribal agencies, and the many private and non-government partners that have, and will, engage this issue, a national WNS plan has been developed that will guide the collective response to WNS by providing structure and oversight to the efforts to research and manage this disease. The national plan builds on the many accomplishments that have been made to date, and formally establishes seven working groups that will continue the work of many of the teams established in 2008.

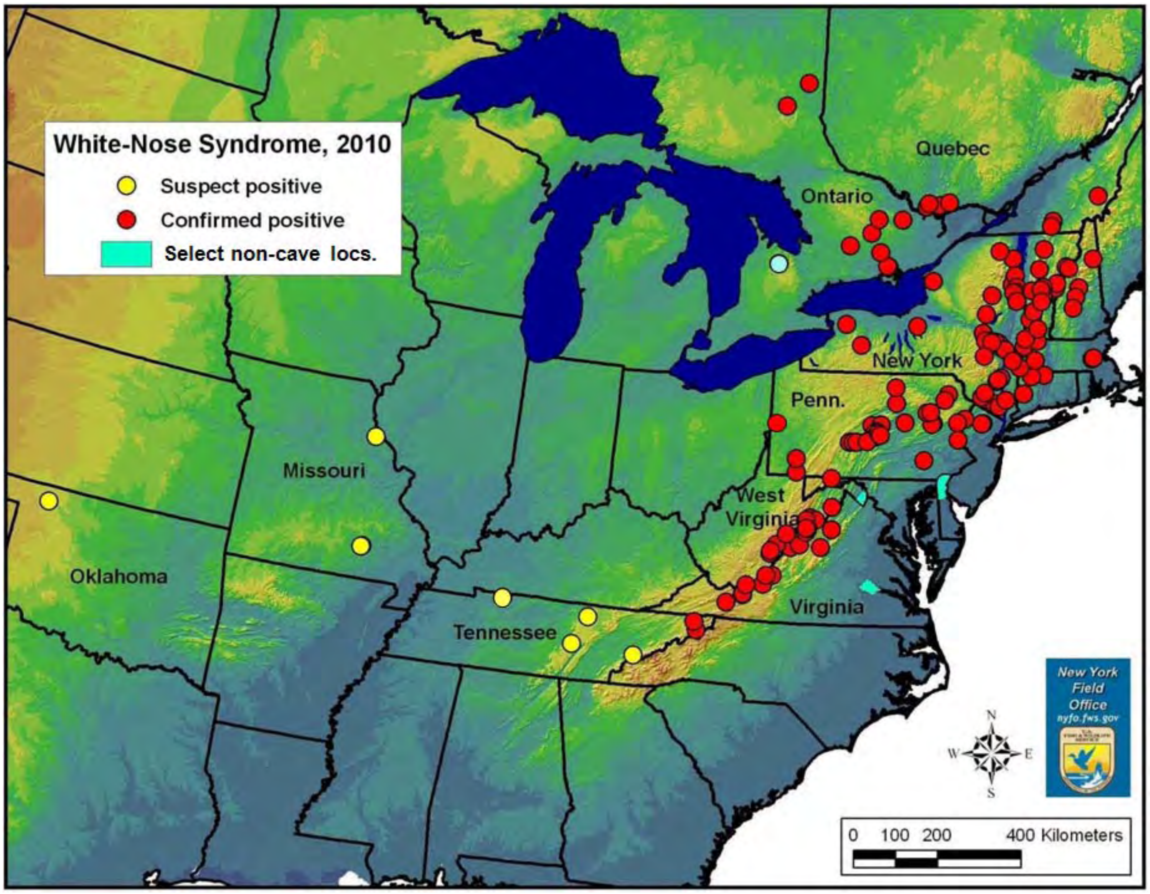


Figure 1. Known geographic distribution of WNS and detections of *Geomyces destructans* as of June, 2010. Over 160 locations are represented.

Status of North American Bats

White-nose Syndrome appears to be a disease of hibernating bats. Of the 45 species of bats in North America, 25 species are known to hibernate in winter, and of these 25, six have been confirmed with WNS to date including: the little brown bat (*Myotis lucifugus)*, Northern long-eared bat (*M. septentrionalis*), Indiana bat (*M. sodalis*), eastern small-footed bat (*M. leibii*), tricolored bat (*Perimyotis subflavus*), and big brown bat (*Eptesicus fuscus*). *Geomyces destructans* has been detected on three additional hibernating bats, gray bat (*M. grisescens*), cave bat (*M. velifer*), and southeastern bat (*M. austroriparius*), but no evidence of clinical fungal infection was found and no mortality has been reported for these species (USGS 2010, VDCR 2010).

Perspectives on the Current Known Distribution of WNS

White-nose Syndrome has spread rapidly from the original sites in Albany and Schoharie Counties, New York, to eastern Tennessee. This represents a spread of approximately 900 km (560 mi) in 3 years. Considering the May, 2010 observation of *Gd* on a bat in western Oklahoma, the apparent spread of the fungus has now reached a distance of approximately 2,200 km (1,370 mi). This means that *Gd* is now about as close to Seattle, Washington, and to the southern border of Mexico as it is to Albany, New York. Although not a prediction that WNS will turn up in Washington or Guatemala within the next three years, this does provide some perspective on the potential for WNS to spread great distances in the next few years. It is also important to note that we do not know the actual current distribution of *Gd* in North America, and that it is likely more widespread than we know at present. This observation has considerable implications for the potential for human transmission of the disease, and for the importance of avoiding contact with affected environments and strict adherence to decontamination procedures, regardless of proximity to known affected sites.

What we Know about WNS

- Over 95% bat mortality at many affected hibernacula
- WNS spreads rapidly and behaves like a pathogen
- All 6 northeastern North American cave bat species are affected
- WNS fungus detected on 3 additional bat species
- There is still no evidence of bacterial, viral, or parasitic cause
- Susceptibility to WNS may differ by bat species or with microclimate
- A specific fungal infection is common to affected sites
- The fungus can persist in caves in the absence of bats (USGS 2009)
- Bats can become infected from an affected environment (Hicks et al. 2010)

What we know about *Geomyces Destructans*

- A newly described fungal species (Gargas et al. 2009)
- Optimal growth for the fungus is at 5-14° C (Gargas et al. 2009)
- The fungus invades skin tissue of hibernating bats (Meteyer et al. 2009)
- Genetically similar fungal isolates are found at multiple affected hibernacula in the U.S.
- Bat-to-bat transmission has been demonstrated (USGS 2009)
- WNS conidia (spores) have been found sticking to the caving gear of cave explorers (Okoniewski et al. 2010)
- A morphologically identical fungus to *G. destructans* has been found on European bats (Martínková et al. 2010, Puechmaille et al. 2010, Wibbelt et al. 2010)

Despite the fact that *Gd* is psychrophilic ("cold-loving") and can grow only at cooler conditions, temperatures throughout much of the U.S. are conducive to the survival and possible growth of this species in the winter. Therefore, it is important to note that the southern U.S. could potentially be susceptible to WNS as winter temperatures are low enough for *Gd* to survive on infected bats that might exit caves prematurely (Fig. 2). It is also noteworthy that spores of many fungi are generally known to tolerate environmental conditions that are outside their optimal growth conditions, and are able to remain viable for years, if not decades. Additional research into the persistence of *Gd* under various environmental conditions is needed.

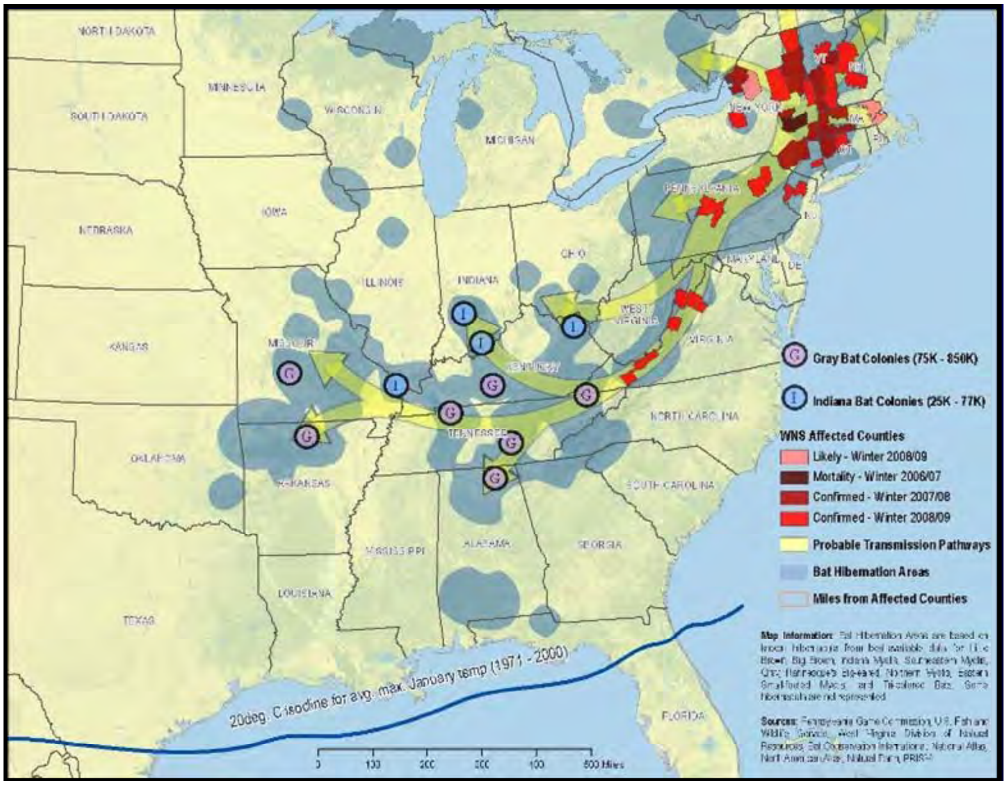


Figure 2. 20° C isocline for average maximum January temperatures in North America. Figure prepared by Bat Conservation International and Eric Britzke, US Army Corps of Engineers, Engineer Research and Development Center.

The European Connection

Although bats are known to be infected with *Gd* at multiple locations throughout Europe (Fig. 3), to date no mass-mortality has been reported and no bats have been observed displaying the field signs of WNS as they are defined in North America (Martínková et al. 2010, Puechmaille et al. 2010, Wibbelt et al. 2010). [For current case definitions see: http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/] The revelation that *Gd* has likely been present on bats in Europe for over 15 years, without any observed mortality, has obvious implications for the origins of the fungus and has provided many important new avenues of investigation.

White-Nose Syndrome Fungus in Bats, Europe

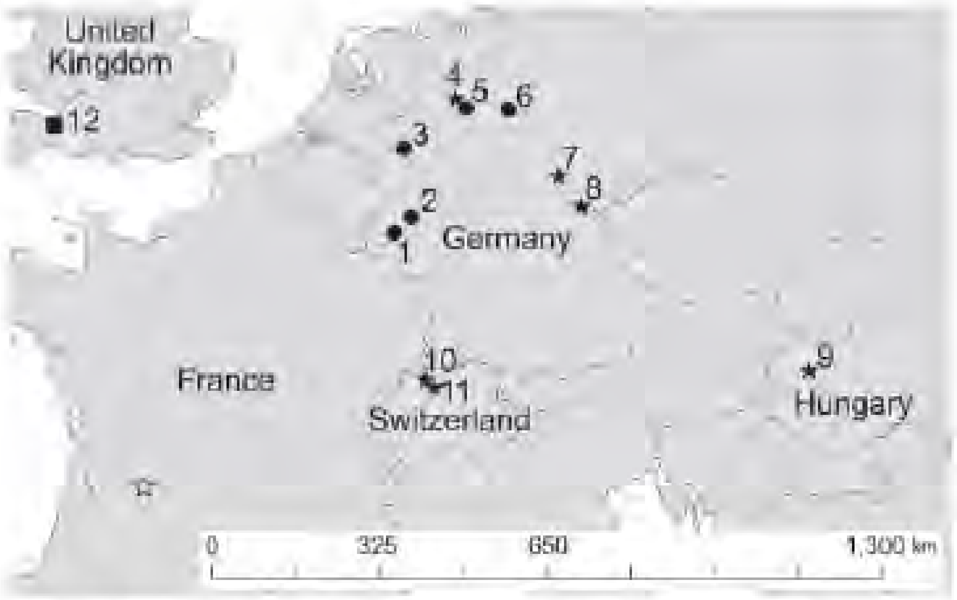


Figure 2. Locations in Europe of bats positive for *Geomyces destructans* by PCR alone (circles) or by PCR and culture (solid stars) and bats negative for *G. destructans* but positive for other fungi (square). Numbers for locations correspond to those in Table 2. Sites 7, 8, and 9 had additional bats that were positive for *G. destructans* only by PCR. Location of a bat positive for *G. destructans* in France (*16*) is indicated by an open star. Some sites had >1 bat species with evidence of colonization by *G. destructans*.

Figure 3. Presence of *Geomyces destructans* in Europe (reproduced from Wibbelt et al. 2010)

Collective Efforts in Response to WNS

Key Accomplishments to Date

At the first "national" WNS meeting held June, 2008 in Albany, New York, meeting attendees conceived a structured approach to organizing the efforts and activities of the WNS community, which includes biologists, researchers, and managers involved with all aspects of the response to the disease. That initial effort established the concept of task-oriented working groups, which were later populated by a wide mix of professionals, with a coordinating body to facilitate the efforts of the working groups and an oversight committee to handle policy and inter-agency decisions.

In 2008, the U.S. Fish and Wildlife Service (FWS) established a website to serve as the nexus for WNS information: http://www.fws.gov/WhiteNoseSyndrome. While there are now several excellent websites hosted by partner agencies and NGOs, it is still the intent of FWS to maintain this site as the central source for information and/or links to all other partner sites. At the time of this writing an overhaul of this website has been planned to improve on presentation and content accessibility.

To date the FWS has been able to fund research projects and provide support directly to state wildlife management agencies through various RFP initiatives and small grant opportunities. Funds to support these opportunities have come largely from internal Preventing Extinction Grants, State Wildlife Grants, some discretionary sources and base funding, and a one-time Congressional budget increase in FY 2010. The details of these grants can be accessed through the WNS website (see URL above).

The FWS hosted a structured-decision making (SDM) initiative in 2009 aimed at providing guidance to resource managers for planning actions in response to WNS (Szymanski et al. 2009). The SDM project focused on decisions to be made in 2010, and was helpful in elucidating knowledge gaps and in identifying three distinct geographic areas with similar management needs: (1) an area that is nearest the initially confirmed sites (index sites) that is considered to be saturated with affected hibernacula; (2) an area further removed from the index sites defined by a mosaic of affected and potentially unaffected hibernacula; and (3) an area defined as the region more than 250 miles from the nearest known WNS-affected hibernaculum, where it is less likely for WNS to spread in a single year through bat-to-bat transmission (Szymanski et al. 2009). While the SDM exercise did not provide the conspicuous answers that many had hoped for, it did help managers to better understand the options currently available and to focus energies on containing the disease by trying to slow the spread of WNS to more distant regions, i.e. Area 3.

To date the main focus of management actions has been on containment of WNS by attempting to limit contact with the infected bats and environments, and by adhering to an established decontamination protocol. The FWS developed the first decontamination protocol in February of 2008 based on other disease models. The protocol has been updated several times as WNS specific research has provided information to improve techniques. The FWS now has a single short protocol outlining the decontamination procedures (cleaning and disinfecting), and longer supplemental documents providing details for application to: 1) cave related activities, and 2) bat research. The current decontamination protocol, revised January, 2011, can be found at the following URL: http://www.fws.gov/WhiteNoseSyndrome/index.html Other state and federal agencies have subsequently released decontamination guidance specific to their particular lands, but these have all been based on the methodology contained in the FWS protocol.

In March, 2009, the FWS released an advisory intended to help slow the spread of WNS via human vectors. Through the advisory, the FWS recommends that people stay out of caves and abandoned mines in affected and adjacent states, and that no clothing, equipment, or gear be transported from affected to unaffected regions. These recommendations were made to help reduce human contact with infected environments and the potential for transport of *Gd* conidia (spores) to uninfected caves or mines. Like the decontamination protocol, the cave advisory is founded on an adaptive principle and has been revisited as research has made new information available. Thus, the recommendations contained in the advisory, and all future versions thereof, are not intended to be permanent or long-term. At the time of this writing, FWS is in the process of revising the advisory in coordination with state, federal, and private partners. In accordance with the guidance in the FWS advisory, all caves and abandoned mines on National Wildlife Refuges have been closed to general public access. Likewise many state and federal land-management agencies have also announced temporary cave closures to combat the spread of WNS. The FWS strongly supports compliance with all cave closures, advisories, and regulations in all federal, state, tribal, and private lands.

WNS National Plan

The purpose of the national plan is to guide federal, state, and tribal agencies, and their partners, in response to WNS. The plan was developed with multi-agency input including: FWS; US Geological Survey; National Park Service; US Forest Service; Department of Defense, Army Corp of Engineers; Animal and Plant Health Inspection Service; Bureau of Land Management; the Environment Division of the St. Regis Mohawk Tribe; and state wildlife conservation agencies from Kentucky, Missouri, New York, Pennsylvania, Vermont, and Virginia. The national plan establishes an organizational structure for responding to WNS with oversight up to the Washington level. The plan formally establishes seven working groups (Figure 4): (1) Communications, (2) Data and Technical Information Management, (3) Diagnostics, (4) Disease

Management, (5) Etiological and Epidemiological Research, (6) Disease Surveillance, and (7) Conservation and Recovery. The national plan will integrate with state and regional WNS response plans. It is not intended to replace planning at the local/regional level.

Generally speaking, the goals of the working groups established by the national plan include: (1) Communications - to develop and implement an effective plan for communicating information about WNS to partners and the public; (2) Data and Technical Information Management - to provide a mechanism for making WNS information accessible, in a timely fashion, to all state and federal agencies and others involved with the investigation and management of WNS; (3) Diagnostics - to establish laboratory standards, to ensure lab capacity, to provide timely reporting of diagnostic results, and to support WNS research; (4) Disease Management - to prevent or slow the introduction of WNS to new areas and control WNS to protect genetic diversity, to avoid unacceptable risks to other cave-obligate biota and natural systems, and to determine a course of action should WNS pose a threat to human health; (5) Etiology and Epidemiological Research - to identify critical research needs relating to the origin, transmission, pathogenesis, and impact of WNS on bats and the environment; (6) Disease Surveillance - to develop standards for WNS surveillance in affected and non-affected areas and to describe best practices for surveillance strategies; and (7) Conservation and Recovery - to develop standards for population monitoring, to establish criteria for prioritizing conservation and management activities, and to describe best practices for the recovery of bat populations of greatest conservation concern.

The national WNS plan is based on similar disease response plans that have effectively been implemented in the past, and is essentially a formalization of the coordinated efforts that were initiated in 2008. In October, 2010, the draft national plan was published in the Federal Register for 60 days to allow appropriate time for public comment. Once the plan is revised, a final version will be made available to the public. The final version of the plan is intended to be a static document that is unlikely to change. A WNS implementation plan will then be developed to address the goals and objectives detailed in the static plan. The implementation plan will, therefore, be where the protocols and prescriptive information can be found that guides the national response to this disease. Unlike the national plan, the implementation plan will be adaptive and will incorporate new information and guidance as it becomes available and/or necessary. Because the national plan incorporates the actions and efforts that have been in use to address WNS over the past three years, many elements of the implementation plan are already in service. As existing and future guidance will continually be improved upon, the WNS implementation plan will never be "completed."

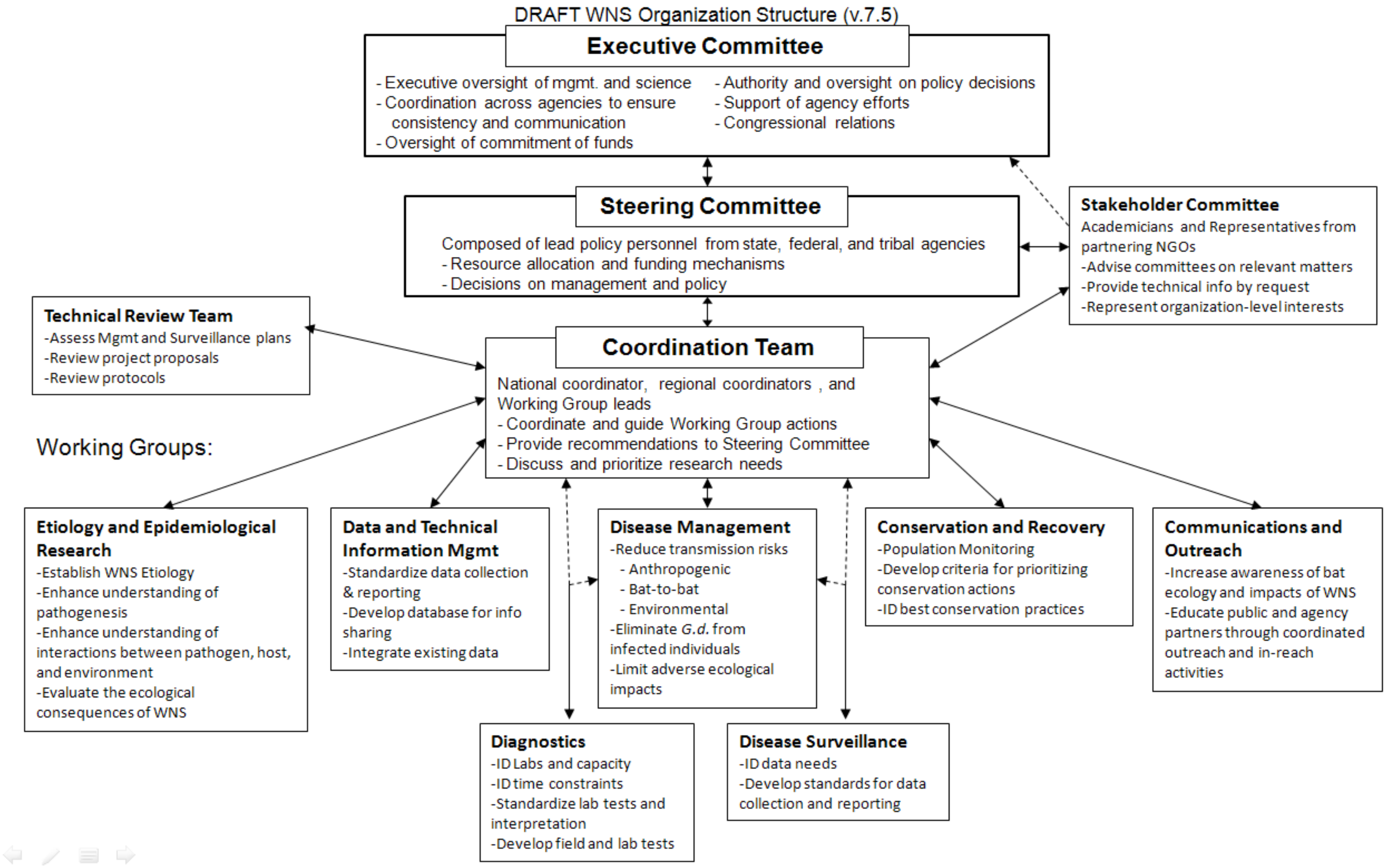
New Territory

Many of the challenges surrounding the management of WNS are due to the fact that we, collectively, have never before been confronted with this kind of situation, and we are lacking an appropriate model to follow. We also face a considerable lack of understanding regarding the etiology of WNS, the ecology of *Gd*, and the physiology and population dynamics of hibernating bats. Many of the challenges we must confront in managing WNS are:

- Significant bat mortality that is spreading rapidly
- Unknown ecological impacts both of the effects of WNS and potential control technologies
- Control technologies present additional biological and social challenges
- There are multiple novel threats to bats
- There are four federally listed species that are vulnerable now
- WNS has the potential to impact 25 of the 45 North American bat species
- We need science-based management solutions

The national plan will provide the structure for our collective response to WNS, but we must continue to improve our understanding of the dynamics of this devastating disease through research.

Figure 4. Organizational Structure for responding to WNS.



DRAFT WNS Organization Structure (v.7.5)

Executive Committee

- Executive oversight of mgmt. and science
- Coordination across agencies to ensure consistency and communication
- Oversight of commitment of funds
- Authority and oversight on policy decisions
- Support of agency efforts
- Congressional relations

Steering Committee

Composed of lead policy personnel from state, federal, and tribal agencies
- Resource allocation and funding mechanisms
- Decisions on management and policy

Stakeholder Committee

Academicians and Representatives from partnering NGOs
- Advise committees on relevant matters
- Provide technical info by request
- Represent organization-level interests

Technical Review Team

- Assess Mgmt and Surveillance plans
- Review project proposals
- Review protocols

Coordination Team

National coordinator, regional coordinators , and Working Group leads
- Coordinate and guide Working Group actions
- Provide recommendations to Steering Committee
- Discuss and prioritize research needs

Working Groups:

Etiology and Epidemiological Research

- Establish WNS Etiology
- Enhance understanding of pathogenesis
- Enhance understanding of interactions between pathogen, host, and environment
- Evaluate the ecological consequences of WNS

Data and Technical Information Mgmt

- Standardize data collection & reporting
- Develop database for info sharing
- Integrate existing data

Disease Management

- Reduce transmission risks
  - Anthropogenic
  - Bat-to-bat
  - Environmental
- Eliminate *G.d.* from infected individuals
- Limit adverse ecological impacts

Conservation and Recovery

- Population Monitoring
- Develop criteria for prioritizing conservation actions
- ID best conservation practices

Communications and Outreach

- Increase awareness of bat ecology and impacts of WNS
- Educate public and agency partners through coordinated outreach and in-reach activities

Diagnostics

- ID Labs and capacity
- ID time constraints
- Standardize lab tests and interpretation
- Develop field and lab tests

Disease Surveillance

- ID data needs
- Develop standards for data collection and reporting

Figure 4. Organizational Structure for responding to WNS.

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Jeremy T. H. Coleman is a wildlife biologist with the US Fish and Wildlife Service, and is the National Coordinator for White-nose Syndrome. As the National WNS Coordinator, his responsibilities include identifying priorities and coordinating actions targeting the research and management of the disease, and the conservation of affected bat species; leading efforts to develop guidance for a national/international response; maintaining the exchange of information between partnering agencies and organizations, and within the USFWS; pursuing and awarding funding for research and management; maintaining the WNS surveillance database; and responding to Congressional inquiry. He holds a MS and Ph.D. from Cornell University and has over 15 years experience with wildlife ecology and management.

Current Status of the Research and Management of WNS

All caves, sinkholes, tunnels and mines on this property are closed in an effort to slow the spread of White-Nose Syndrome (WNS). This ailment has killed hundreds of thousands of bats in the eastern United States and may soon threaten bats in Indiana.

Thank you for your cooperation.

Jeremy Coleman, PhD
National WNS Coordinator, USFWS
Protecting Threatened Bats at Coal Mines: A Technical Interactive Forum
South Charleston, WV, 30 August – 3 September, 2010

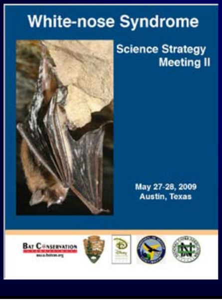
Acknowledgments

Thanks to:
Kimery Vories and the forum organizers

Contributors:
Anne Ballmann, David Blehert, Eric Britzke,
Paul Cryan, Alan Hicks, Andy Lowell, & Noelle Rayman

Collectors and Providers of surveillance data

"White-nose Syndrome (WNS) is a devastating disease of hibernating bats that has caused the most precipitous decline of North American wildlife in recorded history."



White-nose Syndrome
Science Strategy Meeting II
May 27-28, 2009
Austin, Texas

- Consensus Statement on WNS, Proceedings of the 2009 Science Strategy Meeting

Est. > 1 million bats by 2009

WNS – An Unprecedented Crisis

- WNS presents a novel disease and resource management problem
- Managing WNS poses considerable biological and social challenges, with complex coordination needs
- Over 100 agencies, NGOs, and universities involved
- A National Plan has been developed to build on accomplishments to date and enhance coordination

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What is White-Nose Syndrome?

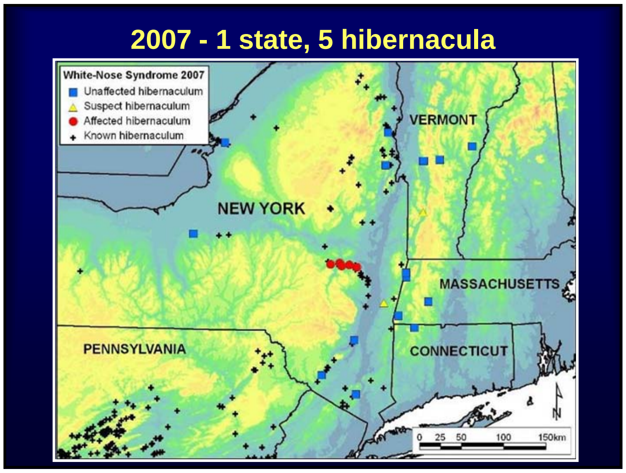
Bat Species in the U.S. & Canada

MIGRANTS OR SPECIES NOT KNOWN TO HIBERNATE

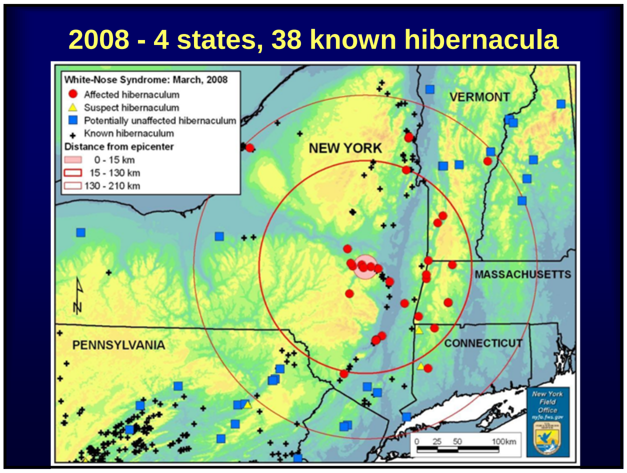
	Species name	Common name
1	*Mormoops megalophylla*	Ghost-faced bat
2	*Choeronycteris mexicana*	Mexican long-tongued bat
3	*Leptonycteris nivalis*	Greater long-nosed bat
4	*Leptonycteris yerbabuenae*	Lesser long-nosed bat
5	*Macrotus californicus*	California leaf-nosed bat
6	*Lasionycteris noctivagans*	Silver-haired bat
7	*Lasiurus blossevillii*	Western red bat
8	*Lasiurus borealis*	Eastern red bat
9	*Lasiurus cinereus*	Hoary bat
10	*Lasiurus ega*	Southern yellow bat
11	*Lasiurus intermedius*	Northern yellow bat
12	*Lasiurus seminolus*	Seminole bat
13	*Lasiurus xanthinus*	Western yellow bat
14	*Eumops floridanus*	Florida bonneted bat
15	*Eumops perotis*	Greater mastiff bat
16	*Eumops underwoodi*	Underwood's mastiff bat
17	*Molossus molossus*	Pallas' mastiff bat
18	*Nyctinomops femorosaccus*	Pocketed free-tailed bat
19	*Nyctinomops macrotis*	Big free-tailed bat
20	*Tadarida brasiliensis*	Brazilian free-tailed bat

SPECIES THAT HIBERNATE

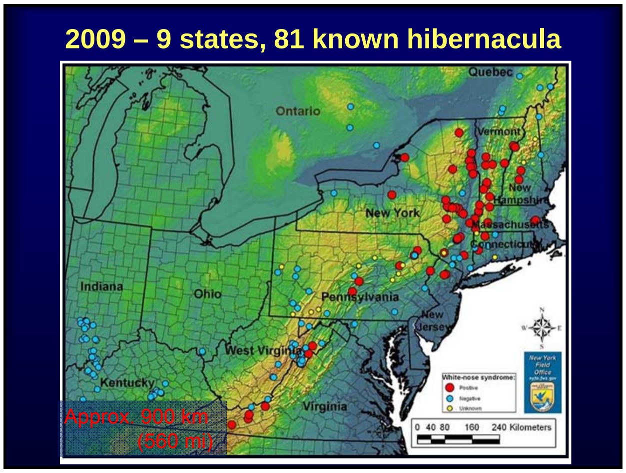
	Species name	Common name
1	*Myotis auriculus*	Mexican long-eared bat
2	*Myotis austroriparius*	Southeastern bat
3	*Myotis californicus*	California bat
4	*Myotis ciliolabrum*	Western small-footed bat
5	*Myotis evotis*	Western long-eared bat
6	*Myotis grisescens*	Gray bat
7	*Myotis keenii*	Keen's bat
8	***Myotis leibii***	**Eastern small-footed bat**
9	***Myotis lucifugus***	**Little brown bat**
10	*Myotis occultus*	Occult bat
11	***Myotis septentrionalis***	**Northern long-eared bat**
12	***Myotis sodalis***	**Indiana bat**
13	*Myotis thysanodes*	Fringed bat
14	*Myotis velifer*	Cave bat
15	*Myotis volans*	Long-legged bat
16	*Myotis yumanensis*	Yuma bat
17	*Nycticeius humeralis*	Evening bat
18	*Parastrellus hesperus*	Canyon bat
19	***Perimyotis subflavus***	**Tricolored bat**
20	*Corynorhinus townsendii*	Townsend's big-eared bat
21	*Corynorhinus rafinesquii*	Rafinesque's big-eared bat
22	***Eptesicus fuscus***	**Big brown bat**
23	*Antrozous pallidus*	Pallid bat
24	*Euderma maculatum*	Spotted bat
25	*Idionycteris phyllotis*	Allen's big-eared bat



2007 - 1 state, 5 hibernacula

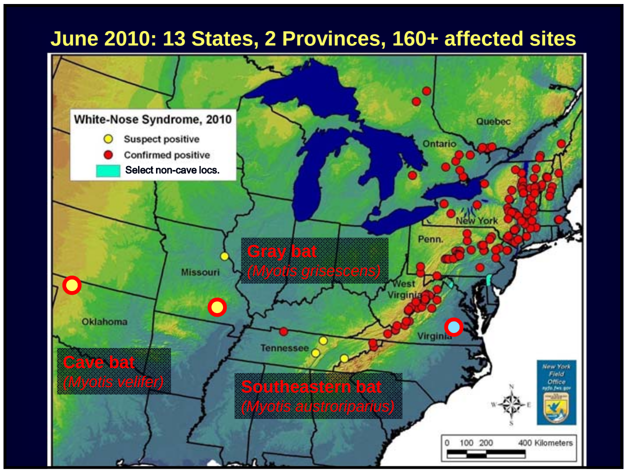


2008 - 4 states, 38 known hibernacula



2009 – 9 states, 81 known hibernacula

Approx. 900 km
(560 mi)

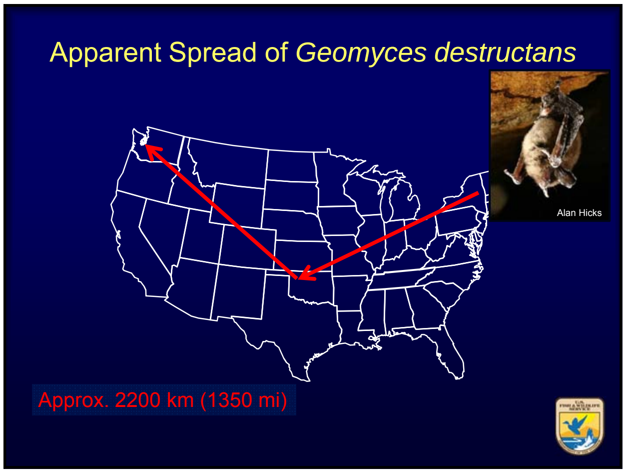


June 2010: 13 States, 2 Provinces, 160+ affected sites

Gray bat
(Myotis grisescens)

Cave bat
(Myotis velifer)

Southeastern bat
(Myotis austroriparius)



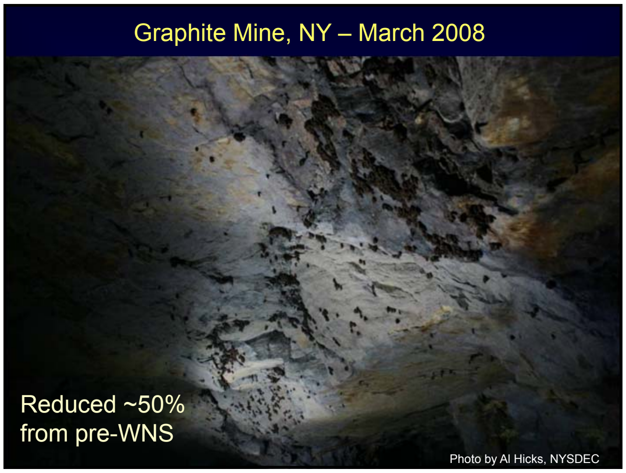
Apparent Spread of *Geomyces destructans*

Approx. 2200 km (1350 mi)

Alan Hicks

Glen Park, NY

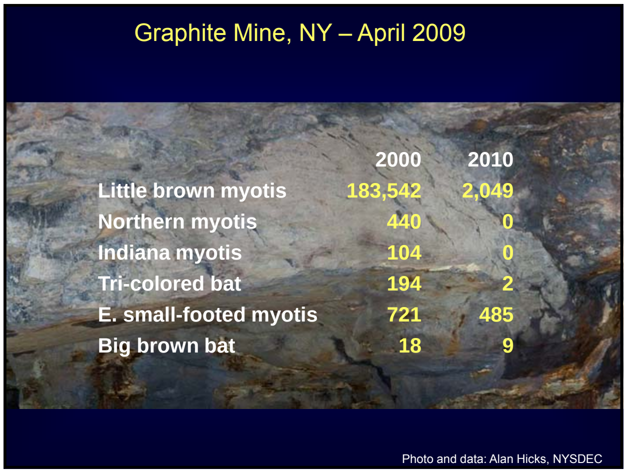
Photos Courtesy of Ray Rainbolt, Fort Drum



Graphite Mine, NY – March 2008

Reduced ~50%
from pre-WNS

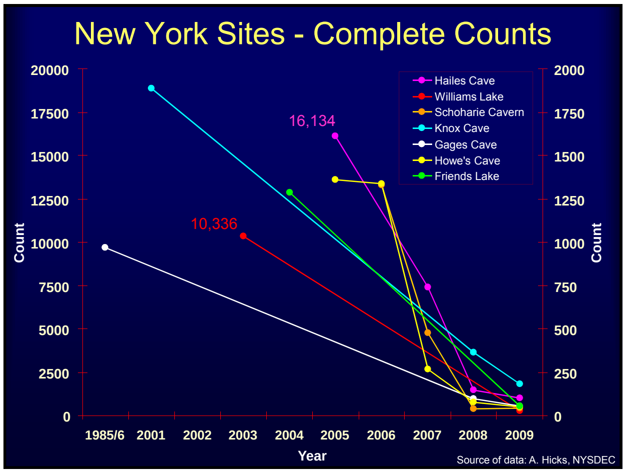
Photo by Al Hicks, NYSDEC



Graphite Mine, NY – April 2009

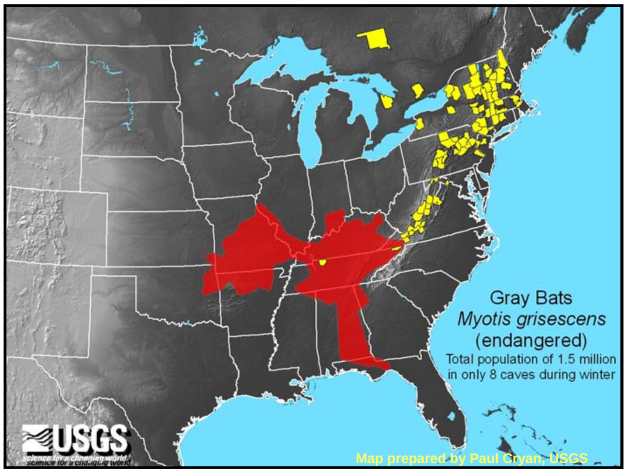
	2000	2010
Little brown myotis	**183,542**	**2,049**
Northern myotis	**440**	**0**
Indiana myotis	**104**	**0**
Tri-colored bat	**194**	**2**
E. small-footed myotis	**721**	**485**
Big brown bat	**18**	**9**

Photo and data: Alan Hicks, NYSDEC



New York Sites - Complete Counts

Source of data: A. Hicks, NYSDEC

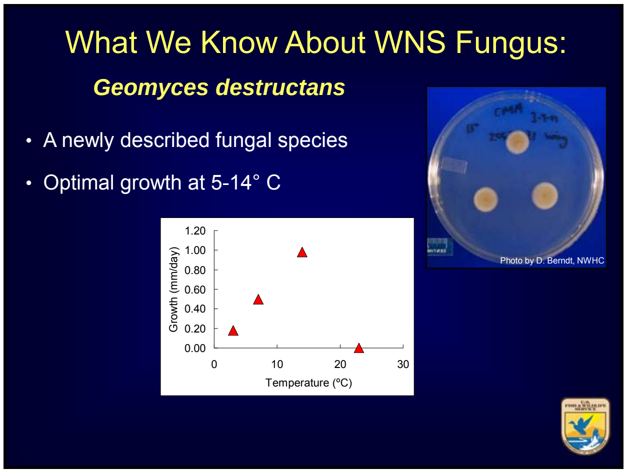


Gray Bats
Myotis grisescens
(endangered)
Total population of 1.5 million
in only 8 caves during winter

Map prepared by Paul Cryan, USGS

What We Know About WNS

- Over 95% mortality at many affected hibernacula
- Spreading rapidly, behaves like a pathogen
- All 6 northeastern N. Am. cave bat species affected
- Fungus detected on 3 additional bat species
- Still no evidence of bacterial, viral, or parasitic cause
- Susceptibility may differ by bat species or with microclimate
- A specific fungal infection is common to affected sites
- The fungus can persist in caves in the absence of bats
- Bats can become infected from an affected environment

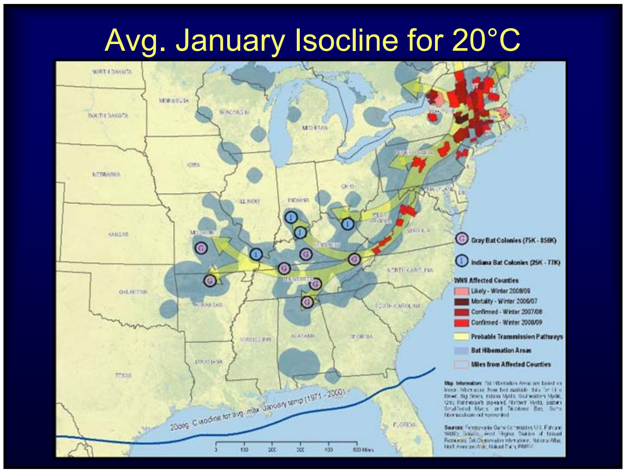


What We Know About WNS Fungus:

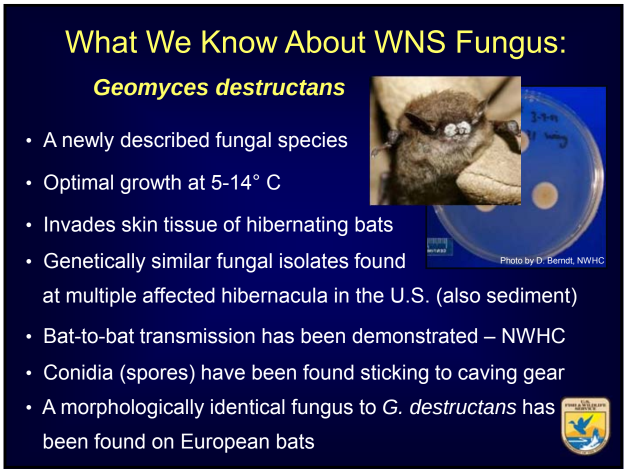
Geomyces destructans

- A newly described fungal species
- Optimal growth at 5-14° C

Photo by D. Berndt, NWHC



Avg. January Isocline for 20°C

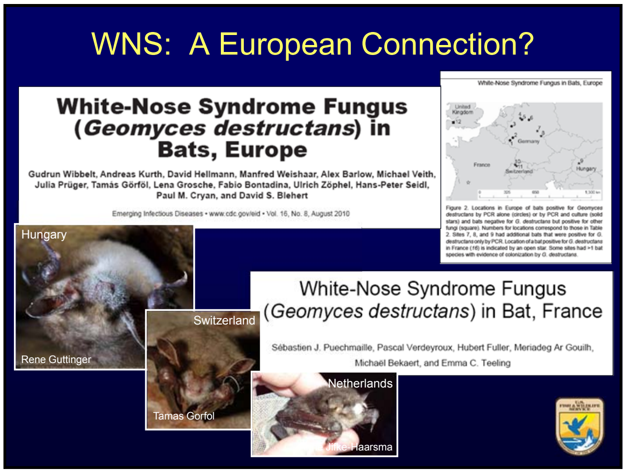


What We Know About WNS Fungus:

Geomyces destructans

- A newly described fungal species
- Optimal growth at 5-14° C
- Invades skin tissue of hibernating bats
- Genetically similar fungal isolates found at multiple affected hibernacula in the U.S. (also sediment)
- Bat-to-bat transmission has been demonstrated – NWHC
- Conidia (spores) have been found sticking to caving gear
- A morphologically identical fungus to *G. destructans* has been found on European bats

Photo by D. Berndt, NWHC



WNS: A European Connection?

White-Nose Syndrome Fungus (*Geomyces destructans*) in Bats, Europe

Gudrun Wibbelt, Andreas Kurth, David Hellmann, Manfred Weishaar, Alex Barlow, Michael Veith, Julia Prüger, Tamás Görföl, Lena Grosche, Fabio Bontadina, Ulrich Zöphel, Hans-Peter Seidl, Paul M. Cryan, and David S. Blehert

Emerging Infectious Diseases • www.cdc.gov/eid • Vol. 16, No. 8, August 2010

White-Nose Syndrome Fungus in Bats, Europe

Figure 2. Locations in Europe of bats positive for *Geomyces destructans* by PCR alone (circles) or by PCR and culture (solid stars) and bats negative for *G. destructans* but positive for other fungi (square). Numbers for locations correspond to those in Table 2. Sites 7, 8, and 9 had additional bats that were positive for *G. destructans* only by PCR. Location of a bat positive for *G. destructans* in France (*16*) is indicated by an open star. Some sites had >1 bat species with evidence of colonization by *G. destructans*.

White-Nose Syndrome Fungus (*Geomyces destructans*) in Bat, France

Sébastien J. Puechmaille, Pascal Verdeyroux, Hubert Fuller, Meriadeg Ar Gouilh, Michaël Bekaert, and Emma C. Teeling

Hungary

Rene Guttinger

Switzerland

Tamas Gorfol

Netherlands

Jitse Haarsma

General Research Priorities

- Disease transmission
- Cause of mortality
- Treatment and control
- Diagnostics
- Disease surveillance
- Etiology and persistence of *G.d.*
- Conservation efforts
- Population monitoring

Some Key Accomplishments in Managing WNS

- WNS investigation team
  - Coordination structure proposed in June 2008
  - Task Groups established
- FWS webpage – the nexus for WNS info
  - http://www.fws.gov/WhiteNoseSyndrome
- Research support and coordination (RFPs)
- Containment
- Structured Decision Making (SDM) initiative
- National and state planning

Management Has Focused on Containment

Decontamination Protocols

1st protocol - February 2008

- updated June 2009 & July 2010

(http://www.fws.gov/WhiteNoseSyndrome/cavers.html)

Cave Advisory – March, 2009

Due to threat of human transmission, USFWS recommends that people stay out of caves and abandoned mines to help slow the spread of WNS

- Currently under revision

States Affected by the March 2009 USFWS Advisory


Connecticut
Delaware
Kentucky
Maine
Maryland
Massachusetts
New Hampshire
New Jersey
New York
North Carolina
Ohio
Pennsylvania
Rhode Island
Tennessee
Vermont
Virginia
West Virginia

http://www.caves.org/WNS/ICS%20WNS%20Policy.html

USFS Emergency Closure Order

http://www.fs.fed.us/r9/docs/apr_2009_caves_closed/white_nose_info.pdf

State Closures

CAVES CLOSED

All caves, sinkholes, tunnels and mines on this property are closed in an effort to slow the spread of White-Nose Syndrome (WNS). This ailment has killed hundreds of thousands of bats in the eastern United States and may soon threaten bats in Kentucky. For more information, please visit:

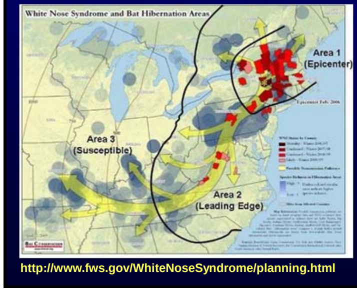
www.fws.gov/northeast_whitenose.html

Thank you for your cooperation.

US Army Corps of Engineers
Louisville District

Structured Decision Making Initiative

Decision Problem: What management measures should be taken this year (2009/2010) to control the spread and minimize the effects of WNS on hibernating bats?



-Initial focus on Area 3

-Strategies are mainly limited to containment until more is known about WNS pathology and potential treatment

http://www.fws.gov/WhiteNoseSyndrome/planning.html

WNS National Plan

Purpose:

To guide the response of Federal, State, and Tribal agencies, and partners to WNS

Multi-agency input: USFWS, USGS, NPS, States, USFS, DOD, APHIS, BLM, St. Regis Mohawk Tribe

Establishes an organizational structure with oversight up to the Washington level

Formally establishes 7 working groups:

1. Communications
2. Data and Technical Information Management
3. Diagnostics
4. Disease Management
5. Etiological and Epidemiological Research
6. Disease Surveillance
7. Conservation and Recovery

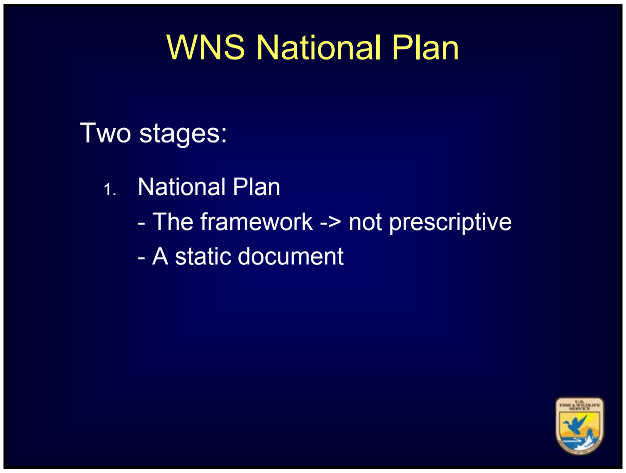
WNS National Plan

A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats

DRAFT

18 June 2010

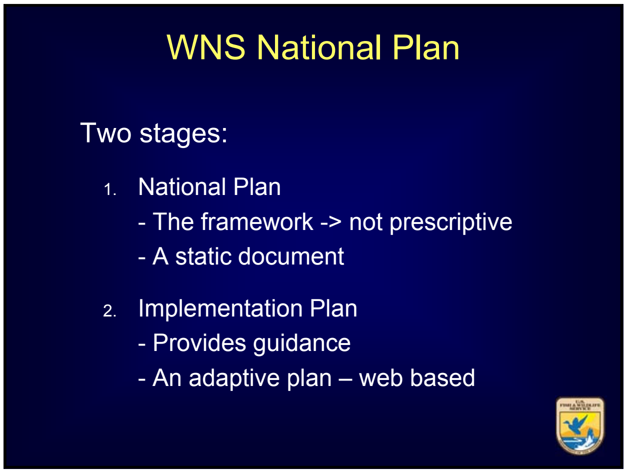
- **Integrates with State Plans**
  - **Not a replacement for planning at the local/regional level**



WNS National Plan

Two stages:

1. National Plan
   - The framework -> not prescriptive
   - A static document



WNS National Plan

Two stages:

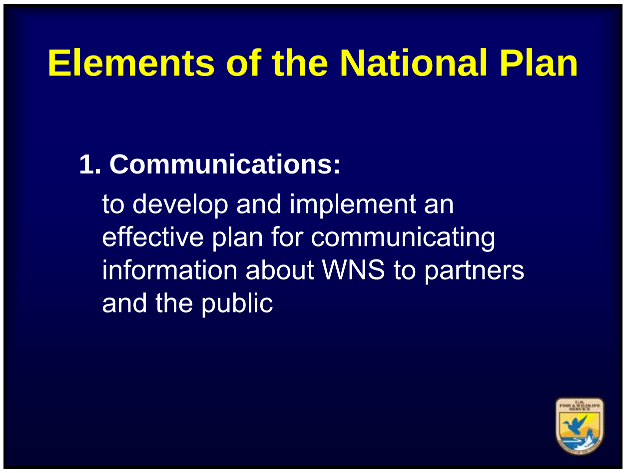
1. National Plan
   - The framework -> not prescriptive
   - A static document
2. Implementation Plan
   - Provides guidance
   - An adaptive plan – web based

The WNS National Plan Steering Committee

Martin Miller	USFWS
Pattricia Bright	USGS
Scott Darling	VT FWD
Dennis Krusac	USFS
Pat Ormsbee	USFS
Jonathan Sleeman	USGS
Margaret Wild	NPS

The WNS National Plan Writing Team

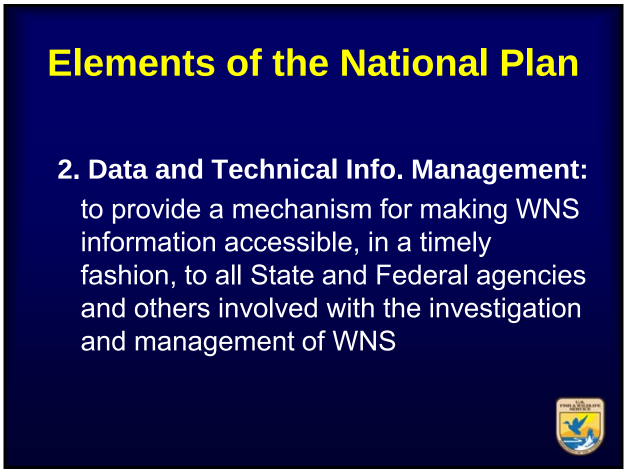
Jeremy Coleman	USFWS
Anne Ballmann	USGS
Les Benedict	St. Regis Mohawk Tribe
Eric Britzke	ACOE
Kevin Caslte	NPS
Walt Cottrell	Pennsylvania
Paul Cryan	USGS
Thomas DeLiberto	APHIS
Tony Elliot	Missouri
Becky Ewing	USFS
Al Hicks	New York
Rick Reynolds	Virginia
Jessica Rubado	BLM
Brooke Slack	Kentucky
Lisa Williams	Pennsylvania



Elements of the National Plan

1. Communications:

to develop and implement an effective plan for communicating information about WNS to partners and the public



Elements of the National Plan

2. Data and Technical Info. Management:

to provide a mechanism for making WNS information accessible, in a timely fashion, to all State and Federal agencies and others involved with the investigation and management of WNS

Elements of the National Plan

3. Diagnostics:

1) to establish laboratory standards
2) to ensure lab capacity
3) to provide timely reporting of diagnostic results
4) to support WNS research

Elements of the National Plan

4. Disease Management:

1) to prevent or slow the intro. of WNS to new areas and control WNS to protect genetic diversity
2) to avoid unacceptable risks to other cave-obligate biota and natural systems
3) to determine a course of action should WNS pose a threat to human health

Elements of the National Plan

5. Etiology and Epidemiological Research:

to identify critical research needs relating to the origin, transmission, pathogenesis, and impact of WNS on bats and the environment

Elements of the National Plan

6. Disease Surveillance:

1) to develop standards for WNS surveillance in affected and non-affected areas
2) to describe best practices for surveillance strategies

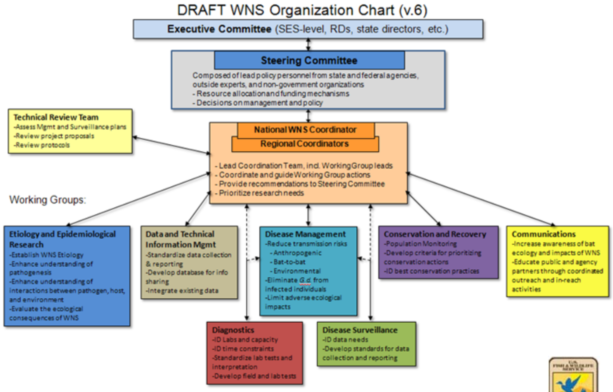
Elements of the National Plan

7. Conservation and Recovery:

1) to develop standards for population monitoring
2) to establish criteria for prioritizing conservation and management activities
3) to describe best practices for the recovery of bat populations of greatest conservation concern

Timeline

- Agency concurrence
- Fall 2010 - National Plan to be published in Federal Register for public comment
- Implementation Plan to follow
  - ❖ Individual products as they are available/necessary
  - ❖ Never to be “completed”



DRAFT WNS Organization Chart (v.6)

Executive Committee (SES-level, RDs, state directors, etc.)

Steering Committee

Composed of lead policy personnel from state and federal agencies, outside experts, and non-government organizations
- Resource allocation and funding mechanisms
- Decisions on management and policy

Technical Review Team
-Assess Mgmt and Surveillance plans
-Review project proposals
-Review protocols

National WNS Coordinator

Regional Coordinators
- Lead Coordination Team, incl. Working Group leads
- Coordinate and guide Working Group actions
- Provide recommendations to Steering Committee
- Prioritize research needs

Working Groups:

Etiology and Epidemiological Research
-Establish WNS Etiology
-Enhance understanding of pathogenesis
-Enhance understanding of interactions between pathogen, host, and environment
-Evaluate the ecological consequences of WNS

Data and Technical Information Mgmt
-Standardize data collection & reporting
-Develop database for info sharing
-Integrate existing data

Disease Management
-Reduce transmission risks
  - Anthropogenic
  - Bat-to-bat
  - Environmental
-Eliminate *G.d.* from infected individuals
-Limit adverse ecological impacts

Conservation and Recovery
-Population Monitoring
-Develop criteria for prioritizing conservation actions
-ID best conservation practices

Communications
-Increase awareness of bat ecology and impacts of WNS
-Educate public and agency partners through coordinated outreach and in-reach activities

Diagnostics
-ID Labs and capacity
-ID time constraints
-Standardize lab tests and interpretation
-Develop field and lab tests

Disease Surveillance
-ID data needs
-Develop standards for data collection and reporting

Region	Coordinator	Location
National	Jeremy Coleman	Cortland, NY
National	Noelle Rayman	Cortland, NY
National	Ann Froschauer	Hadley, MA
1	Russ Holder	Boise, ID
2	Paul Barrett	Albuquerque, NM
3	Richard Geboy	Bloomington, IN
4	Mike Armstrong	Frankfort, KY
5	Alison Whitlock	Hadley, MA
6	Clark McCreedy	Cheyenne, WY
8	Larry Rabin	Sacramento, CA
NWRS R9	Donita Cotter	Arlington, VA
NWRS R9	Will Meeks	Arlington, VA

Congress of the United States
Washington, DC 20510

May 5, 2009

The Honorable Ken Salazar
Secretary
U.S. Department of the Interior
1849 C Street, NW
Washington, D.C. 20240

Dear Secretary Salazar:

Great Expectations

"…we must do everything we can to stop the spread of WNS"

"…develop a cure for WNS."

- Expectations trigger action
- Appropriateness & effectiveness of action will depend on scientific information

We're in New Territory

Federal and state agencies have never faced a wildlife disease outbreak of this nature

- No trained crews for field epidemiology or ecological investigations
- Limited resources available: $ and staff
- Many unknowns

  - Disease, bats, ecological impacts….

In Closing

- Significant mortality and spreading
- Unknown ecological impacts
- Control presents biological and social challenges
- Multiple novel threats to bats
- 4 federally listed species vulnerable now
- Potential to impact 25 of 45 N. Am. bat species
- Science-based management solutions

Many of the Partners Involved

Federal Agencies/Sponsored
- DOI: USFWS, USGS, NPS, BLM
- USDA: USFS, APHIS
- DOD: ACOE, ARMY
- Smithsonian Institution, National Zoo
- National Institute for Mathematical and Biological Synthesis
- SE Cooperative Wildlife Disease Study

Academia
- Boston Univ.
- Bucknell Univ.
- Columbia Univ.
- Cornell Univ.
- Eastern Michigan Univ.
- Fordham Univ.
- Indiana State Univ.
- Missouri State Univ.
- Northern Kentucky Univ.
- Tufts University
- UC Davis
- University Hospitals Case Medical Center
- U. of Guelph
- U. of Tennessee
- U. of Winnipeg

State Agencies (47)
- AK, AL, AR, AZ, CA, CT, DE, FL, GA, IA, ID, IL, IN, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY

Non-Government Organizations
- Bat Conservation International
- National Speleological Society
- The Nature Conservancy
- Defenders of Wildlife
- Disney
- Bat World
- Am. Museum of Natural History
- Association of Zoos & Aquariums

International
- Canadian Provinces
- Canadian Coop. Wildlife Health Center
- European biologists
- IUCN

Tribal Agencies
- St. Regis Mohawk
- Wampanoag

http://www.fws.gov/WhiteNoseSyndrome.com

Alan Hicks

HOW WHITE-NOSE SYNDROME MAY AFFECT T&E SPECIES, THEIR RECOVERY, AND COAL MINING PERMITTING

Mike Armstrong
U.S. Fish & Wildlife Service
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Abstract

White nose-Syndrome (WNS) was first discovered in caves with hibernating bats in New York during the winter of 2006/2007. Since then, the disease has spread to at least eleven other states and has been responsible for the deaths of over one million bats, including endangered Indiana bats. In addition, bats testing positive for the fungus that leads to WNS (i.e., *Geomyces destructans*) have been found in two additional states. However, bats at these locations did not exhibit signs of the fungal infection characteristic of WNS-positive locations, nor was mortality or other visible signs of WNS detected at these locations. Since its discovery, colonies of hibernating bats have been reduced by as much as 81-97% at affected caves and mines near the original epicenter in New York. No one knows for certain how quickly or how far WNS will ultimately spread. The extent to which WNS results in the listing of more bat species as threatened and endangered would be expected to negatively impact permitting and operation of coal mines in the Eastern and Midwestern U.S. as eight coal mining states are already affected.

The emergence and spread of a pathogenic fungus (*Geomyces destructans*) that infects hibernating bats has the potential to undermine the basic survival strategy of more than half the bat species in the U.S. and all species of bats that occur in the higher latitudes of North America. With the exception of 4 species of migratory tree bats, the other bat species that occur above 40ºN in North America (roughly a line running from the top of California across Nebraska to Virginia) hibernate to survive the winter. Most species of bats that hibernate in the region are known to be affected and the endangered Indiana bat (*Myotis sodalis*) has been hit particularly hard. The sudden and widespread mortality associated with WNS is unprecedented in hibernating bats. If the spread of WNS is not slowed or halted, further losses could lead to the extinction of entire species and could more than quadruple those that are federally listed as endangered in the U.S.

White-Nose Syndrome

Origin of the Disease

White-nose Syndrome (WNS) was first discovered in caves with hibernating bats in New York during the winter of 2006/2007. Since then, the disease has spread to at least eleven other states (Virginia, West Virginia, Pennsylvania, Massachusetts, Vermont, New Hampshire, Connecticut, New Jersey, Tennessee, Maryland, and Delaware) and has been responsible for the deaths of over one million bats, including endangered Indiana bats.

In addition, bats testing positive for the fungus that leads to WNS (i.e., *Geomyces destructans*) have been found in 1 hibernaculum in western Pennsylvania, 3 hibernacula in Tennessee, 2 hibernacula in Missouri (northeast and southeast), 1 hibernaculum in northwestern Oklahoma, and 1 hibernaculum in Virginia. However, bats at these locations did not exhibit signs of the fungal infection characteristic of WNS positive locations, nor was mortality or other visible signs of WNS detected at these locations. A total of nine species have been confirmed positive for *Geomyces destructans* and/or the fungal infection. Six of these species have been documented to both have the fungus and suffer the fungal infection characteristic of WNS disease [i.e., little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), eastern small-footed bat (*Myotis leibii*), Indiana bat (*Myotis sadalis),* tricolored bat (*Pipistrellus subflavus*), and the big brown bat (*Eptesicus fuscus*)]. During the winter of 2010, three new species of bats were confirmed positive for the fungus through laboratory testing [i.e., the federally-endangered gray bat was confirmed positive in Missouri; the cave myotis (*Myotis velifer*) was documented positive in Oklahoma; and the southeastern bat (*Myotis austroriparius*) was positive in Virginia]. However, these species do not appear to have suffered the fungal infection that is characteristic of WNS disease in the northeastern U.S., as of the date of this paper.

To date, WNS has not been reported as affecting the federally-listed Gray bat, Virginia big-eared bat, or Ozark big-eared bat. During the winter of 2009/2010, WNS was documented in Hellhole Cave in West Virginia. Hellhole Cave is the most populated hibernaculum for Virginia big-eared bats. However, Virginia big-eared bats have not been documented to be affected by WNS within this cave. WNS is spreading within the range of the Virginia big-eared bat, but is not believed to have reached the range of the Ozark big-eared bat. Since its discovery, colonies of hibernating bats have been reduced by as much as 81-97% at the affected caves and mines that were surveyed near the original epicenter in New York (USGS[1]). White-nose Syndrome has been detected more than 700 kilometers (450 mi) away from the original site, and has infected bats in 9 surrounding states and 2 Canadian provinces. Furthermore, the fungus (*Geomyces* destructans) has been documented approximately 2,200 kilometers (1,350 miles) from the original site, and is now as close to the furthest western states as it is the original epicenter.

The sudden and widespread mortality associated with White-nose Syndrome is unprecedented in hibernating bats, which differ from most other small mammals in that their survival strategy involves a slow reproductive rate. Their life history adaptations include high rates of survival and low fecundity, resulting in low potential for population growth. Most of the affected species are long lived (~5-15 years or more) and have only one offspring per year. Subsequently, bat numbers do not fluctuate widely over time, and populations of bats affected by White-nose Syndrome will not recover quickly. Epizootic disease outbreaks have never been previously documented in hibernating bats (USGS[1]). A leading hypothesis is that the fungus is European in origin, new to North America, and bats species in this region show little or no resistance. The WNS outbreak will likely be similar to other introduced pathogens such as chestnut blight or dutch elm that spread rapidly and completely throughout the range of the host.

Characteristics of the Disease

The newly identified cold-loving fungus, *Geomyces destructans,* is now thought to be the primary causative agent of White-nose Syndrome (Gargas, A. et al. 2009). This fungus thrives in the darkness, low temperatures (5-10ºC; 40-50ºF), and high levels of humidity (>90%) characteristic of bat hibernacula. Unlike typical fungi, this species of *Geomyces* cannot grow above 20°C (68ºF), and therefore appears to be particularly adapted to persist in caves and mines and to colonize the skin of hibernating bats (USGS[1]). A consistent pattern of fungal skin penetration has been observed in over 90% of bats from the WNS-affected region that were submitted for disease investigation. Available evidence suggests the fungus establishes itself in the skin tissues of bats when their body temperatures are lowered during torpor (2-10ºC; 35-50ºF). Although life-threatening skin fungal infections of this sort are rare in warm-blooded birds and mammals, they occur more frequently in "cold-blooded" animals (e.g., *chytridiomycosis* in amphibians, and crayfish plague). The cold-loving fungus seems to be infecting bats when they reduce their body temperatures during hibernation to levels characteristic of "cold-blooded" animals. Fungal infiltration of the wing membranes of bats may be particularly problematic. Wing membranes represent about 85% of a bat's total surface area and play a critical role in balancing complex physiological processes. Healthy wing membranes are vital to bats, as they help regulate body temperature, blood pressure, water balance, and gas exchange—not to mention the ability to fly and to feed. Although White-nose Syndrome was named after the obvious sign of white noses on affected bats, bat wings may indeed be the most vulnerable point of infection (USGS[1]).

Impact of the Disease

A recent consensus by concerned scientists found that "White-nose syndrome is a devastating disease of hibernating bats that has caused the most precipitous decline of North American wildlife in recorded history. Since it was first discovered in 2006, WNS has infected six species of insect-eating bats in the northeastern and southern U.S., causing declines approaching 100% in some populations; estimated losses have exceeded one million bats over the past three years. It has the potential to impact all 25 of the hibernating bat species in North America. If the spread of WNS is not slowed or halted, further losses could lead to the extinction of entire species and could more than quadruple those that are federally listed as endangered in the U.S. Such losses alone are expected to have unprecedented consequences on ecosystem health throughout North America, with unknown economic consequences. Most bat species in North America feed on night-flying insects, of which many are pests of forests, agriculture, and garden crops or pose risks to human health. The number of insects consumed annually by one million bats is staggering—equivalent to 694 tons—emphasizing the extraordinary value of these bats to the normal function of both terrestrial and aquatic ecosystems (BCI)."

Endangered Bats

Six bats are currently listed as endangered including: Indiana bat, Gray bat, Virginia & Ozark big-eared bats, and Mexican & Lesser long-nosed bats. All of these bats roost in caves and/or mines during part of their life history. Four of these bats use caves/mines to hibernate during the winter including: Indiana bat, Gray bat, Virginia big-eared bat, and the Ozark big-eared bat (Figure 1). Three of these fours species (all but the Indiana bat) are cave obligate in that they roost in caves/mines in the summer and winter.

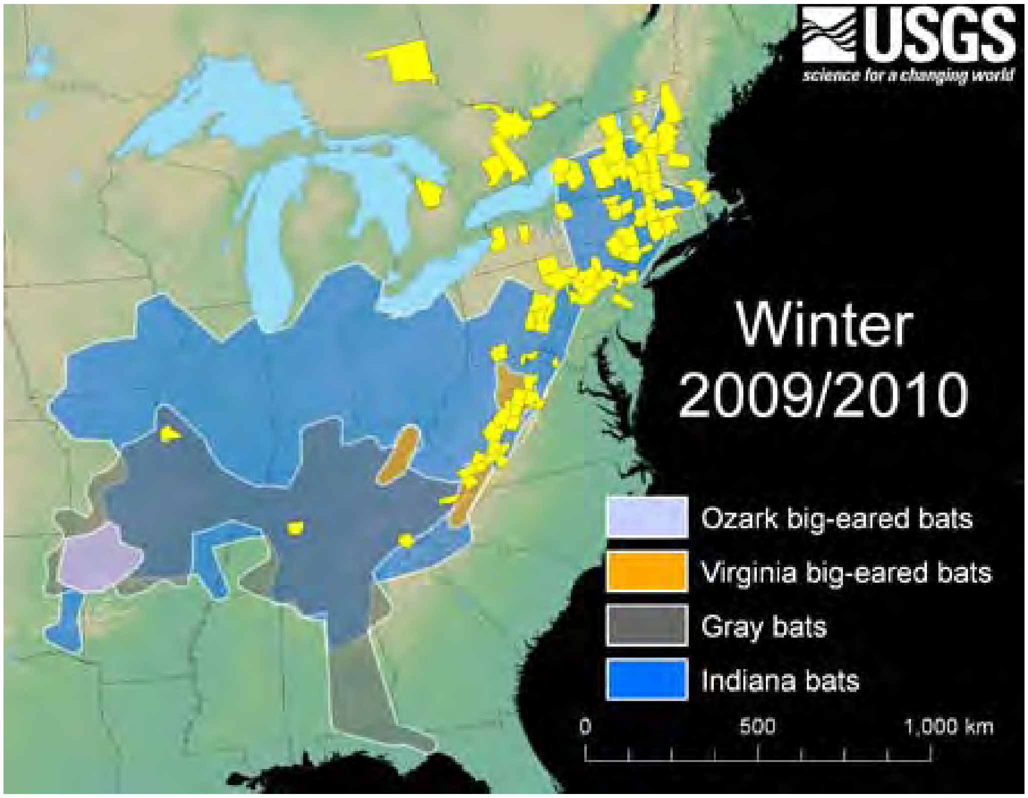

Figure 1. Range of the four endangered bats that hibernate in caves/mines.

All four endangered species and subspecies of hibernating bats in the U.S., which rely on undisturbed caves or mines for successful hibernation, are at risk from WNS. Three of these species are currently within the affected area, other species may be affected in the next few years, if not sooner. Thirteen additional hibernating bats are already federal species of concern (former Category 2 candidates for listing under the ESA).

Two migratory endangered bats use caves/mines as roosts and migrate south if necessary including: Lesser long-nosed bat (AZ and NM) and the Mexican long-nosed bat (TX and NM). We do not expect non-hibernating migrating bats to be at risk from WNS currently.

Indiana Bat

Indiana bats have and will continue to be negatively affected by WNS as it continues to spread throughout the Eastern and Midwestern U.S. Migrating Indiana bats may be a key contributor to the expansion of WNS into the upper Midwest over the next few years. The current status of WNS on the Indiana bat show that there are 44 hibernacula affected by WNS. These affected sites contained 55,488 individuals (14% of range-wide population) during the 2009 biennial counts. The next five (5) years should tell us much about the affect WNS has on recovery of the species. The potential for the spread of the disease to winter hibernacula in the eastern and Midwestern U.S. has been projected by Bat Conservation International on the map in Figure 2.

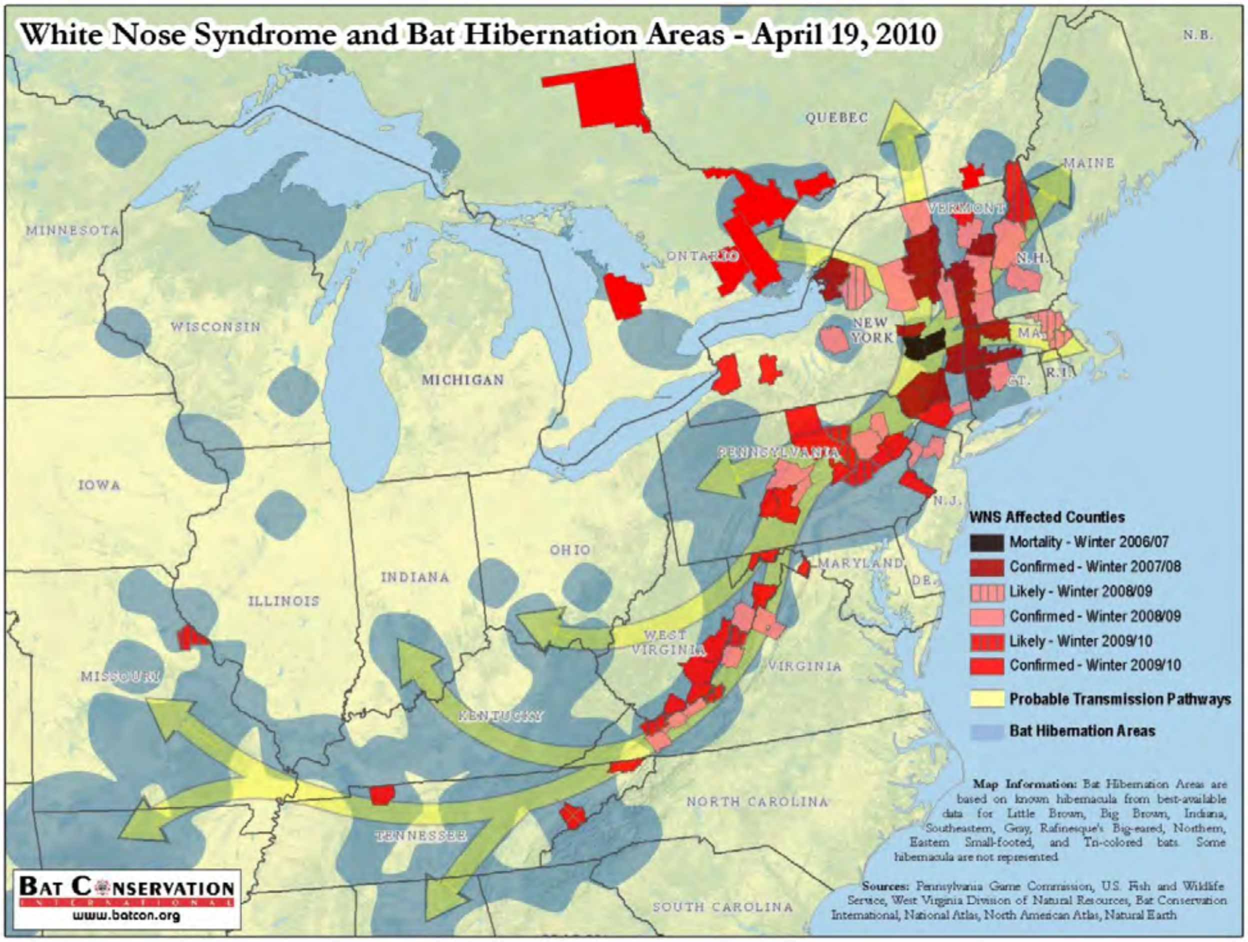

Figure 2. Spread of WNS in relation to Indiana bat hibernacula.

In New York, Indiana bat populations at 20 hibernacula have experienced a 61% decline in 3 years due to WNS. One hibernacula (Barton Hill Mine) appears to be maintaining its numbers despite being affected by WNS. This may be due to significantly lower humidity levels in the hibernacula but this site was only documented with WNS in 2008, so it is just as likely that mortality observed at other sites will be confirmed here as well. Although the Indiana bat has experienced significant declines, these declines have not been as great as some other species (e.g., little brown and tricolored bats). Currently, research in developing a population model for the little brown bat in the north-east U.S. shows a worst case scenario that predicts extinction in this part of their range (Frick et al., 2010). The USFWS, with the assistance of USGS, is developing a similar model for the Indiana bat.

Gray Bat

Prior to WNS, Gray bats were well on their way to recovery with an overall population increase of 104% from 1982 to 2007. Figure 3 shows the geographic distribution of the Gray bat in relation to the present outbreak of WNS. Medical tests from Gray bats in Missouri in May, 2010, were positive for the fungus believed responsible for WNS. These tests detected the genetic signature of *Geomyces destructans,* but the presentation on these bats was not typical of the way WNS has been observed in other bats in the eastern U.S. Gray bats did not show typical signs of infection such as infection and invasion into the wing tissue, muscle, and other soft tissue.

Concerns for the Gray bat related to WNS includes that the species: (1) is a member of the same genus *Myotis* as many of those currently affected; (2) is similar in size as other affected species; (3) migrates long distances between summer & winter roosts in caves/mines; (4) co-occurs at roosts with other species; and (5) may serve as a vector for WNS into the south and southern Midwest. The spread of WNS to Gray bats could be catastrophic, likely resulting in an immediate reversal of the recovery achieved to date.

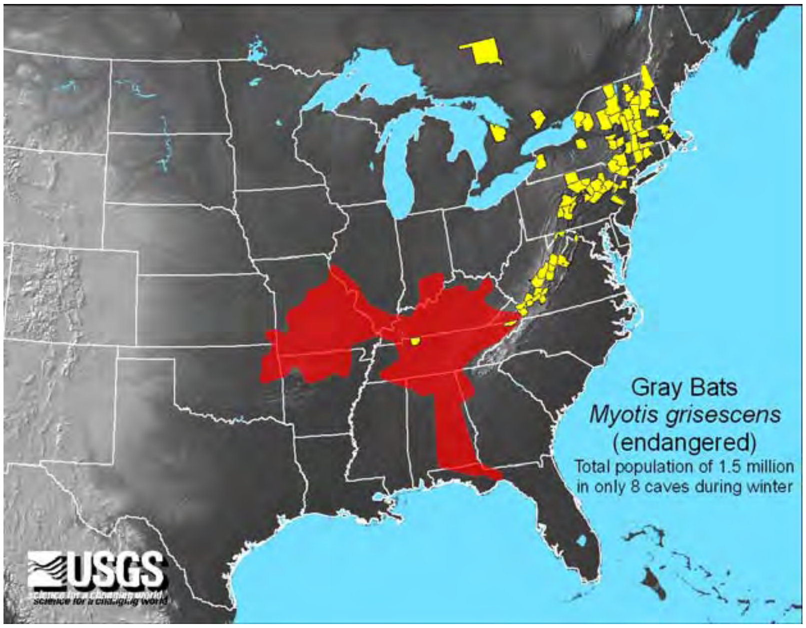

Figure 3. The distribution of the Gray bat in relation to the spread of WNS.

Virginia Big-Eared Bat

Figure 4 shows the geographic distribution of the Virginia big-eared bat in relation to the present outbreak of WNS. Concerns about the Virginia big eared bat and WNS are related to its small population of only 15,000 individuals with a distribution made up of 4 genetically distinct and isolated sub-populations. This combination makes it especially vulnerable to extinction. The largest sub-population has summer and winter roosts that exhibit signs of WNS. These infected sites are all in Pendleton County, West Virginia, where 91% of the subpopulation winter or summer. Currently, there has been no documentation of WNS impacts to the population. Potential reasons that they may not show typical symptoms of WNS is that the subspecies has a larger overall body size than most WNS infected species and they hibernate in colder and drier areas of the cave. Continued surveillance and monitoring of the four subpopulations over the next few years should assist greatly in understanding how this subspecies will fare.

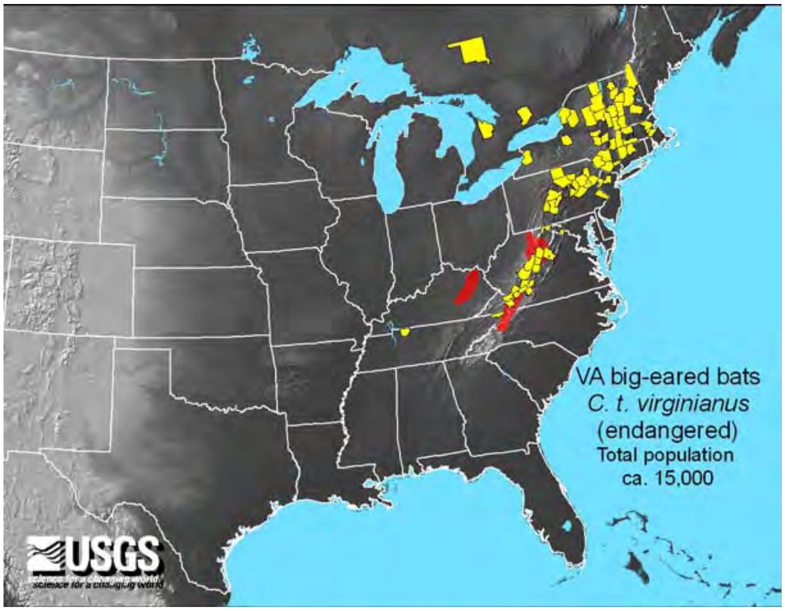

Figure 4. Distribution of Virginia big-eared bat in relation to the spread of WNS.

Ozark Big-Eared Bat

The Ozark big-eared bat is currently not affected by WNS. However, like the Virginia big-eared bat, its small population and limited geographic distribution (two states) make it especially vulnerable to extinction. There are only estimated to be 1,900 individuals in the wild. It has a similar life history to the Virginia big-eared bat which may suggest that the subspecies might react similarly to WNS.

Future Listings of Endangered Bats

With more than 1 million dead bats, WNS has had a catastrophic impact on many non-listed bat species including: Little brown bat; Northern long-eared bat; Tricolored bat; and the Eastern small-footed bat. Studies by Frick et al. have predicted that Little brown bat in the northeastern U.S. could be extinct in that part of its range within the next 20 years. The Center for Biological Diversity has petitioned the Service to list both the Northern long-eared and Eastern small-footed bats as of January 21, 2010.

Concerns for Bat Species in the Western U.S.

A current concern is that if the species thus far infected by WNS pass the disease through their populations to the west side of the Great Plains, then an additional 14 species of hibernating bats could be at risk. In fact, the cave *myotis* individual that tested positive for *Geomyces* destructans in western Oklahoma may prove to be the vector to these other species.

Potential Impacts of WNS on Coal Permitting

Areas for potential coal mining in the Eastern and Midwestern U.S. almost completely overlap the ranges of bats that are or will be potentially impacted by WNS in the same geographic area. If WNS continues to spread at the current rate, we may expect the following in relation to coal permitting activities: (1) additional future listings of hibernating bat species; (2) increased scrutiny over individual permits to ensure no jeopardy to the species; (3) increased scrutiny for impacts to bat roosting, sheltering, foraging habitats; and (4) that site-specific data will become more important as part of the permit application. If the rate of spread changes, we might see an increased need for regional differences in addressing consultations on listed species. Depending on differing mortality rates in different states that may impact the rate of loss to bat populations, this may require regional differences in management and permitting requirements.

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Bat Conservation International. *White Nose Syndrome*. <http://www.batcon.org/index.php/what-we-do/white-nose-syndrome.html>.

Frick, W.F., J.F. Polluck, A.C. Hicks, K.E. Langwig, D.S. Reynolds, G.T. Turner, C.M. Butchkoski, and T.H. Kunz.l. 2010. An emerging disease causes regional population collapse of a common North American bat species. Science. Vol. 329, pp. 679-682.

USGS[1] Fort Collins Science Center <http://www.fort.usgs.gov/WNS/>.

USFWS[3] 2009. Rangewide Population Estimate for the Indiana Bat (*Myotis sodalis*) by USFWS Region. Compiled by Andy King, USFWS Bloomington, IN.

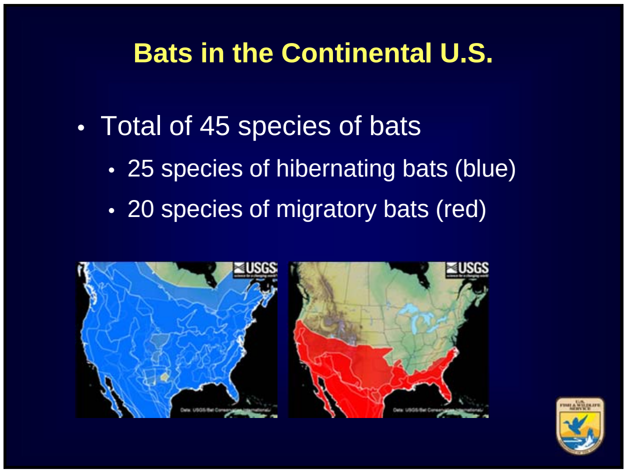
Mike Armstrong has been employed by the USFWS for 12 years. He has worked on coal mining issues in the Southwest and Southeast regions of the U.S. Mike currently serves as the Southeast Region's White-nose Syndrome and bat recovery coordinator working out of the Frankfort, KY, Ecological Services Field Office.

How WNS May Affect T&E Species, Recovery, & Coal Mining

Hicks - NYSDEC

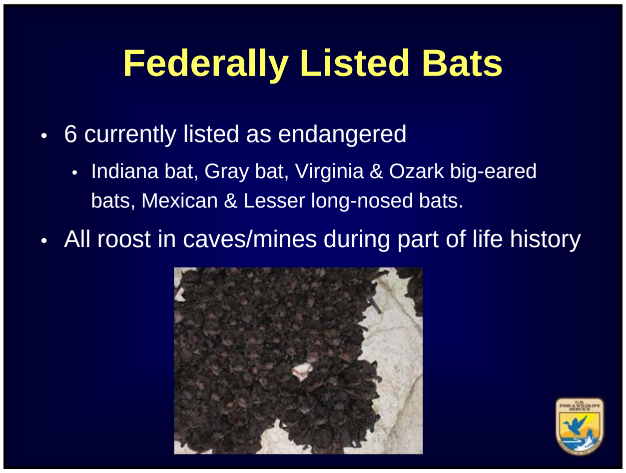
Mike Armstrong, US Fish & Wildlife Service

Protecting Threatened Bats at Coal Mines: a technical interactive forum
South Charleston, West Virginia
September 1, 2010



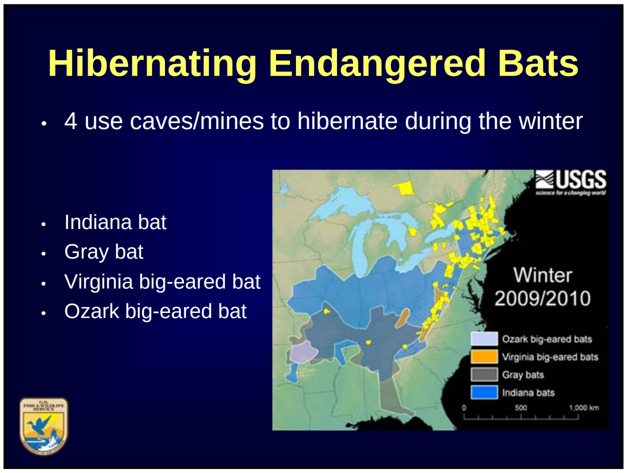
Bats in the Continental U.S.

- Total of 45 species of bats
  - 25 species of hibernating bats (blue)
  - 20 species of migratory bats (red)



Federally Listed Bats

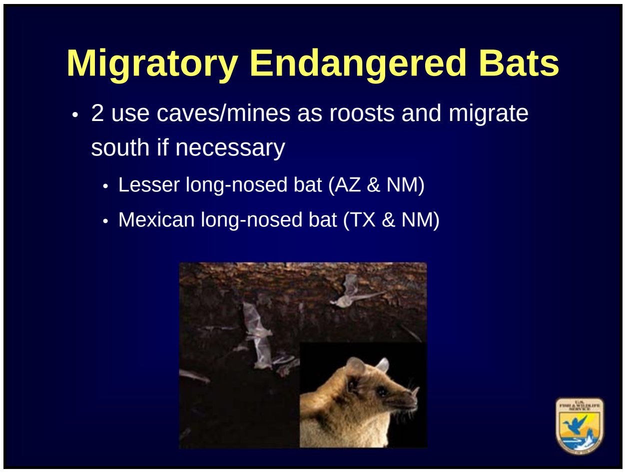
- 6 currently listed as endangered
  - Indiana bat, Gray bat, Virginia & Ozark big-eared bats, Mexican & Lesser long-nosed bats.
- All roost in caves/mines during part of life history



Hibernating Endangered Bats

- 4 use caves/mines to hibernate during the winter

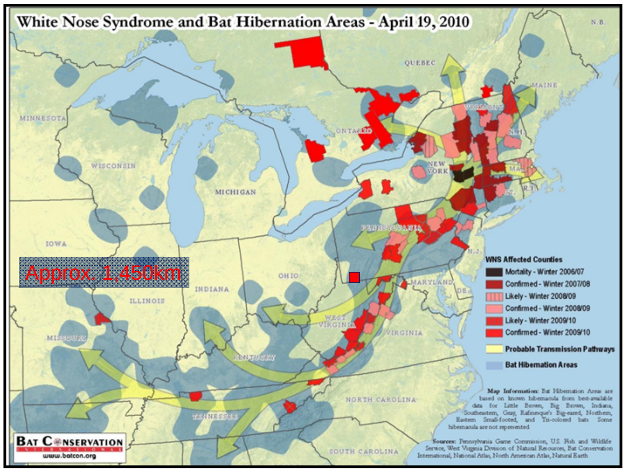
- Indiana bat
- Gray bat
- Virginia big-eared bat
- Ozark big-eared bat



Migratory Endangered Bats

- 2 use caves/mines as roosts and migrate south if necessary
  - Lesser long-nosed bat (AZ & NM)
  - Mexican long-nosed bat (TX & NM)

Indiana bat

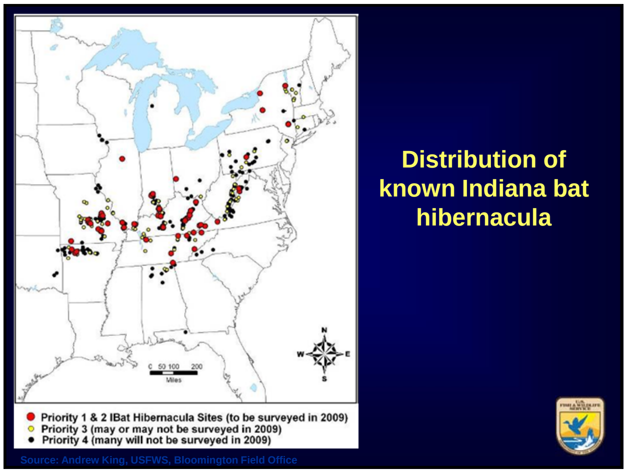


White Nose Syndrome and Bat Hibernation Areas - April 19, 2010

WNS Affected Counties
- Mortality - Winter 2006/07
- Confirmed - Winter 2007/08
- Likely - Winter 2008/09
- Confirmed - Winter 2008/09
- Likely - Winter 2009/10
- Confirmed - Winter 2009/10
- Probable Transmission Pathways
- Bat Hibernation Areas

Map Information: Bat Hibernation Areas are based on known hibernacula from best-available data for Little Brown, Big Brown, Indiana, Southeastern, Gray, Rafinesque's Big-eared, Northern, Eastern Small-footed, and Tri-colored bats. Some hibernacula are not represented.

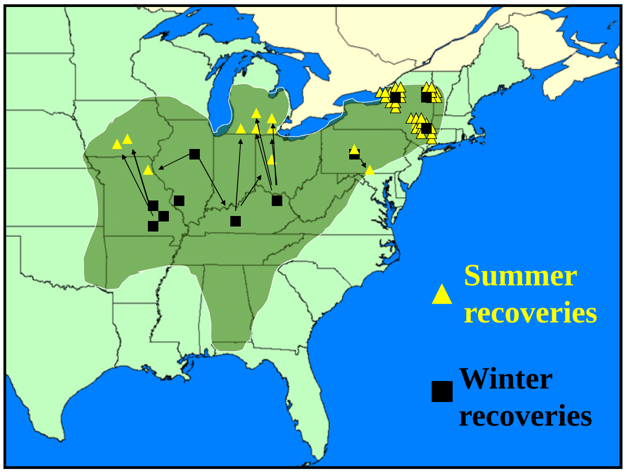
Sources: Pennsylvania Game Commission, U.S. Fish and Wildlife Service, West Virginia Division of Natural Resources, Bat Conservation International, National Atlas, North American Atlas, Natural Earth

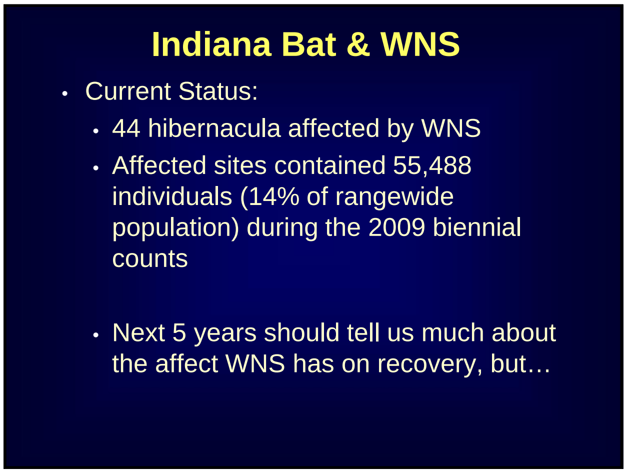


Distribution of known Indiana bat hibernacula

- ● Priority 1 & 2 IBat Hibernacula Sites (to be surveyed in 2009)
- ○ Priority 3 (may or may not be surveyed in 2009)
- ● Priority 4 (many will not be surveyed in 2009)

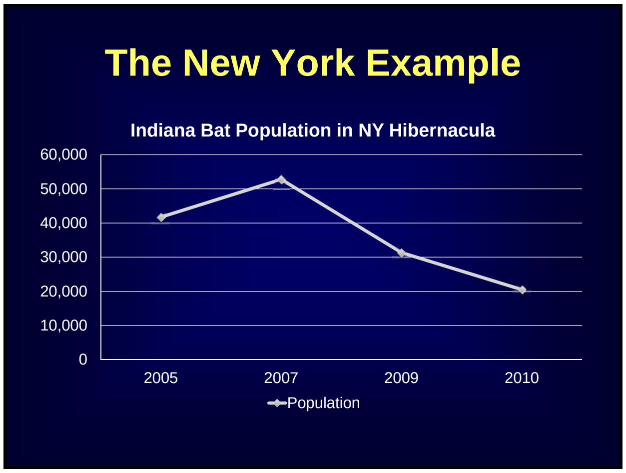
Source: Andrew King, USFWS, Bloomington Field Office





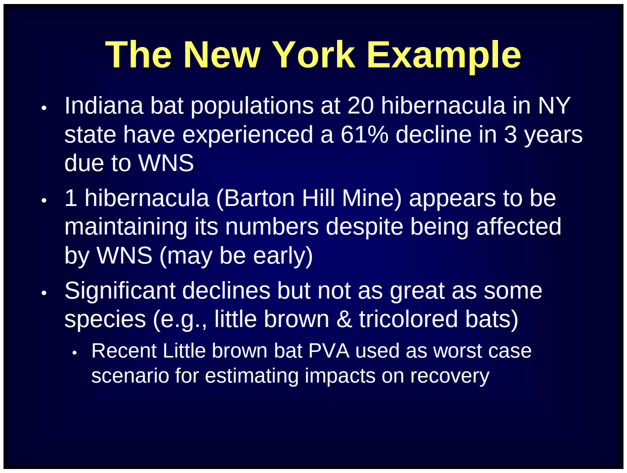
Indiana Bat & WNS

- Current Status:
  - 44 hibernacula affected by WNS
  - Affected sites contained 55,488 individuals (14% of rangewide population) during the 2009 biennial counts
  - Next 5 years should tell us much about the affect WNS has on recovery, but…



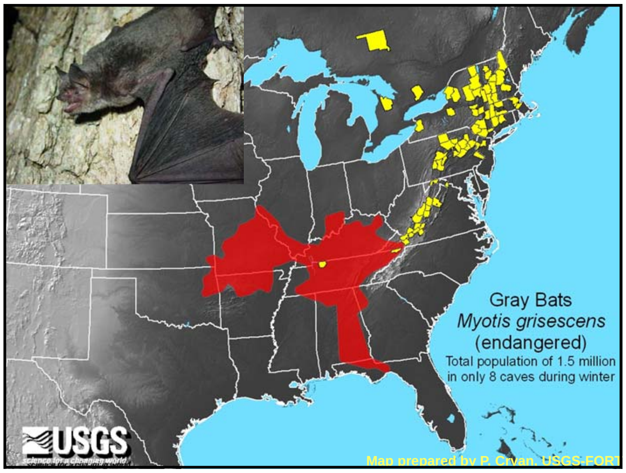
The New York Example

Indiana Bat Population in NY Hibernacula



The New York Example

- Indiana bat populations at 20 hibernacula in NY state have experienced a 61% decline in 3 years due to WNS
- 1 hibernacula (Barton Hill Mine) appears to be maintaining its numbers despite being affected by WNS (may be early)
- Significant declines but not as great as some species (e.g., little brown & tricolored bats)
  - Recent Little brown bat PVA used as worst case scenario for estimating impacts on recovery



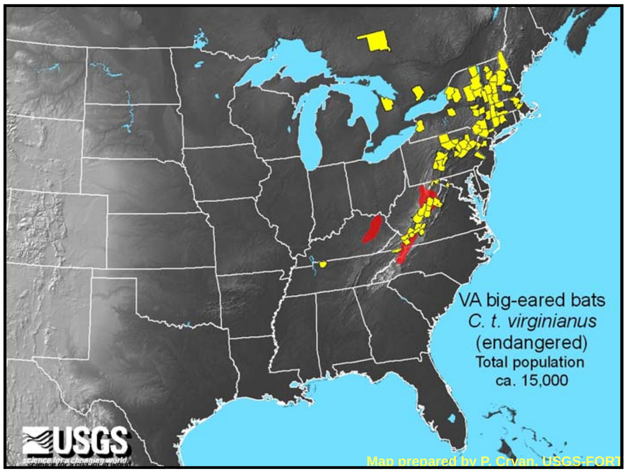
Map prepared by P. Cryan, USGS-FORT

Gray Bat

- Positive PCR test from gray bats emerging from a hibernacula in MO in May 2010
  - Test detected the genetic signature of *G. destructans* but the presentation on these bats was not typical of the way WNS has been observed in bats in the eastern U.S.
- Prior to WNS, gray bats were well on their way to recovery with an overall population increase of 104% from 1982 to 2007

Concern for Gray Bats

- Member of the genus *Myotis*
- Similar in size as other affected species
- Migrates long distances between summer & winter roosts (transmission vector)
- Co-occurs at roosts with other species
- Spread of WNS to gray bats could be catastrophic, likely resulting in an immediate reversal of the recovery achieved to date



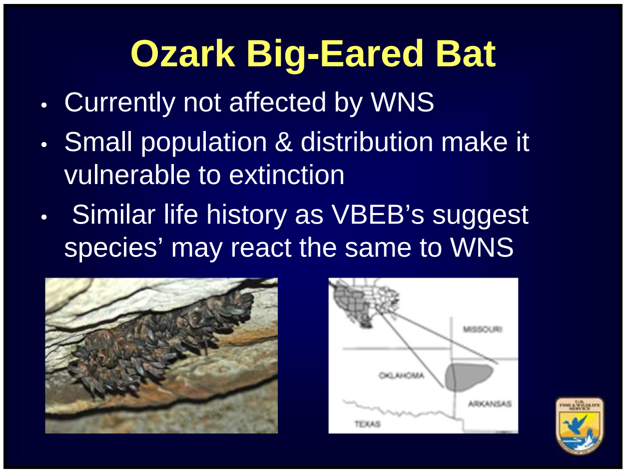
Map prepared by P. Cryan, USGS-FORT

Virginia Big-Eared Bats

- Small population & distribution made up of 4 genetically distinct & isolated sub-populations makes it vulnerable to extinction
- Largest sub-population has summer & winter roosts with WNS signs
- Sites in Pendleton Co. where 91% of WV VBEB winter or summer

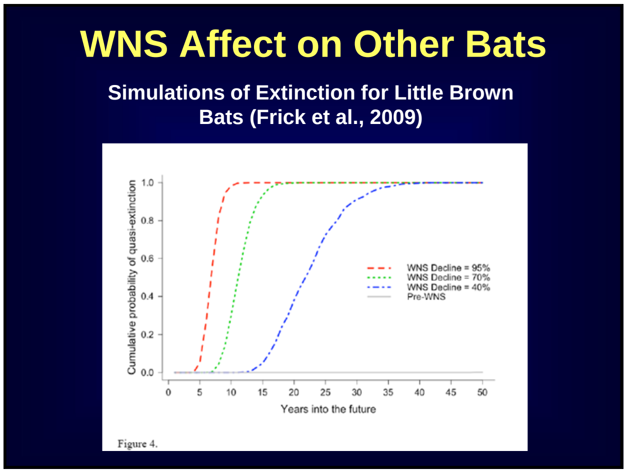
Virginia Big-eared Bats

- No documentation of impacts to VBEB yet
  - Larger overall body size
  - Hibernate in colder and drier areas of the cave
  - Other species specific reason?
- Time will tell for this species…



Ozark Big-Eared Bat

- Currently not affected by WNS
- Small population & distribution make it vulnerable to extinction
- Similar life history as VBEB's suggest species' may react the same to WNS

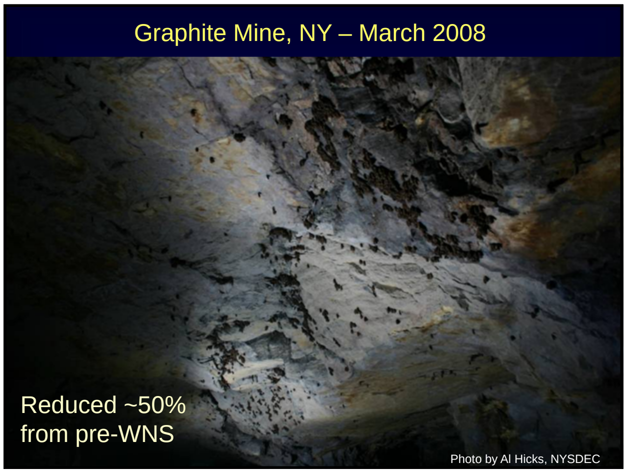


WNS Affect on Other Bats

Simulations of Extinction for Little Brown Bats (Frick et al., 2009)

Future Listings?

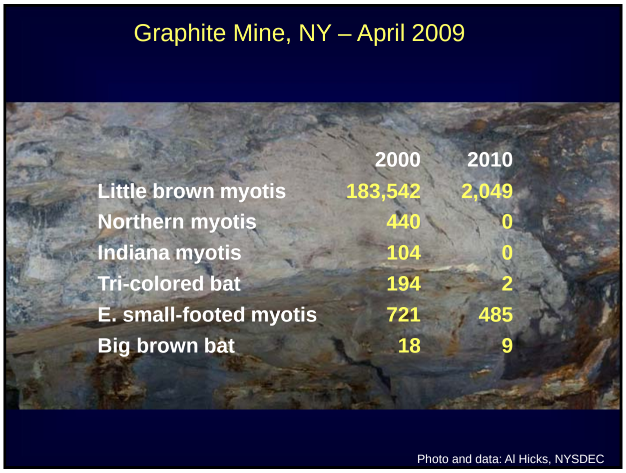
- With more than 1 million dead, WNS has had a catastrophic impact on many non-listed bat species
  - Little brown bat
  - Northern long-eared bat
  - Tricolored bat
  - Eastern small-footed bat
- CBD has petitioned the Service to list both the northern long-eared & Eastern small-footed bats (January 21, 2010)



Graphite Mine, NY – March 2008

Reduced ~50% from pre-WNS

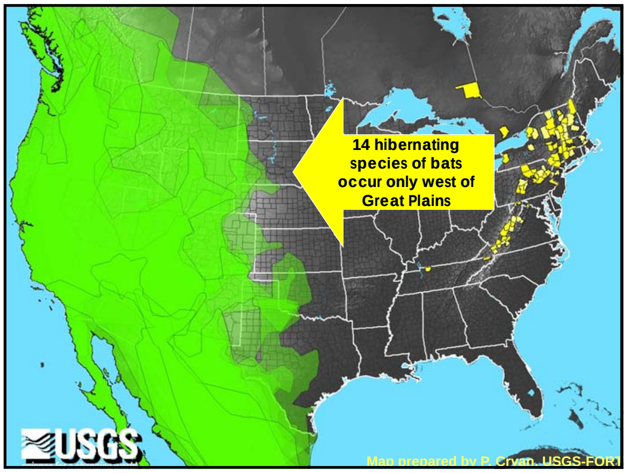
Photo by Al Hicks, NYSDEC



Graphite Mine, NY – April 2009

	2000	2010
Little brown myotis	183,542	2,049
Northern myotis	440	0
Indiana myotis	104	0
Tri-colored bat	194	2
E. small-footed myotis	721	485
Big brown bat	18	9

Photo and data: Al Hicks, NYSDEC

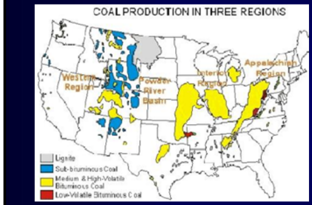


14 hibernating species of bats occur only west of Great Plains

Map prepared by P. Cryan, USGS-FORT

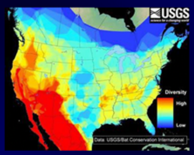
Impact on Coal Permitting

Coal



Bats

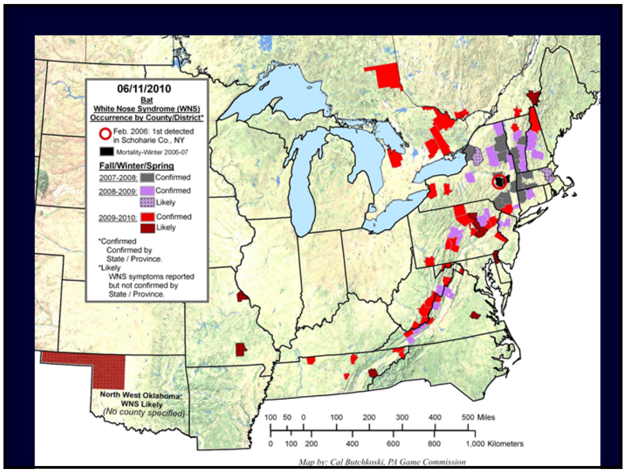
Bat species diversity in North America



Impact on Coal Permitting

- If WNS continues to spread at current rate, we would expect:
  - Future listings of hibernating bat species
  - Increased scrutiny over individual permits to ensure no jeopardy
    - Impact to bat roosting, sheltering, foraging habitats
    - Site-specific data will become important
- If the rate of spread changes, we might see:
  - Increased need for regional differences in addressing consultations on listed species.

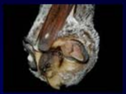
Thank You!
Questions?



Nine Bat Species in Northeast


Little brown bat (7-14g)


Indiana bat (6-9g)


Hoary bat (25-30g)


Big brown bat (14-21g)

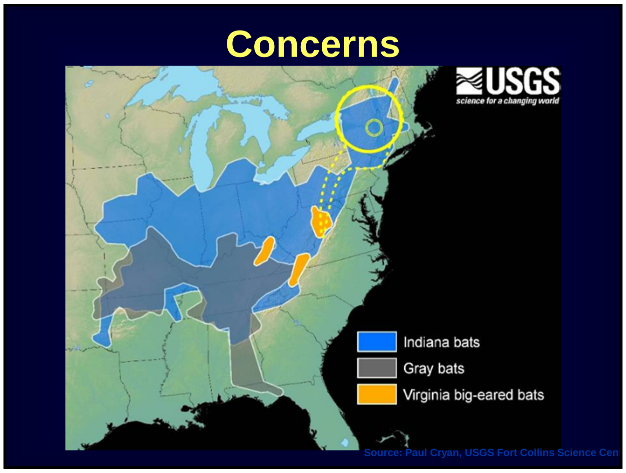

Tri-colored bat (6-8g)


Silver-haired bat (8-11g)


Small-footed bat (3-5g)

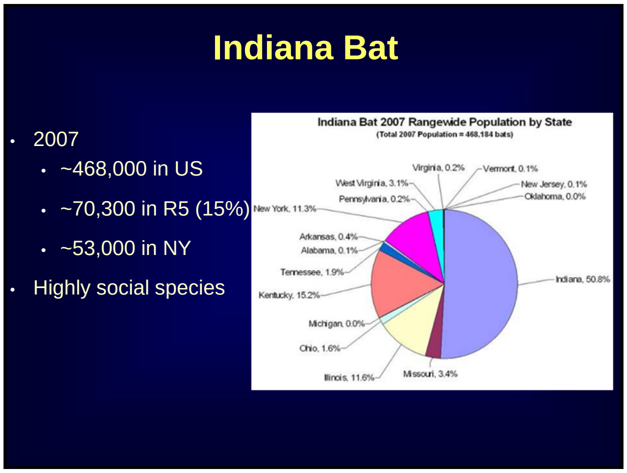

Northern long-eared bat (6-9g)


Eastern red bat (9-15g)



Concerns

Source: Paul Cryan, USGS Fort Collins Science Cen

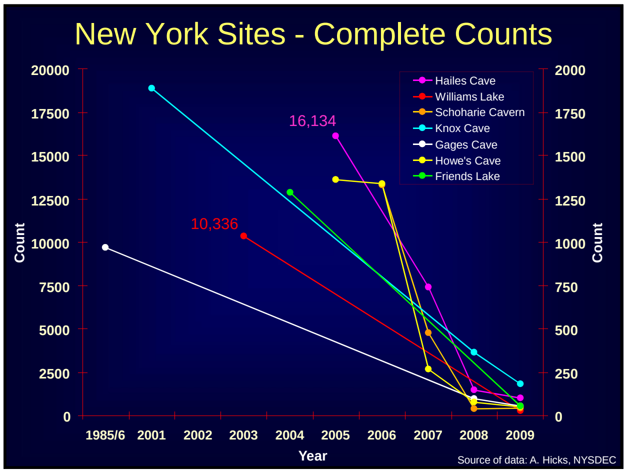


Indiana Bat

- 2007
  - ~468,000 in US
  - ~70,300 in R5 (15%)
  - ~53,000 in NY
- Highly social species

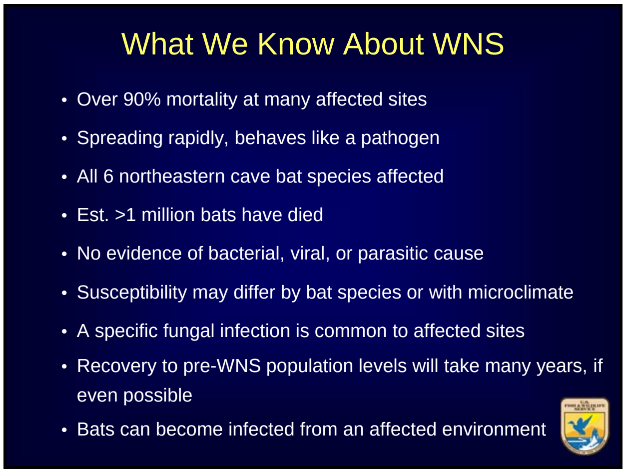
Glen Park, NY

Photos Courtesy of Ray Rainbolt, Fort Drum



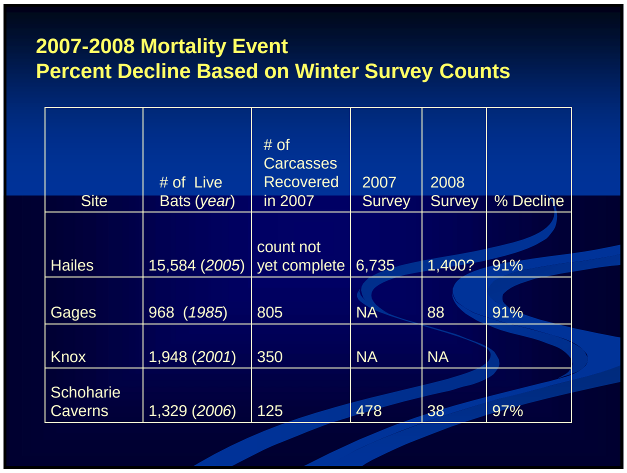
New York Sites - Complete Counts

Source of data: A. Hicks, NYSDEC



What We Know About WNS

- Over 90% mortality at many affected sites
- Spreading rapidly, behaves like a pathogen
- All 6 northeastern cave bat species affected
- Est. >1 million bats have died
- No evidence of bacterial, viral, or parasitic cause
- Susceptibility may differ by bat species or with microclimate
- A specific fungal infection is common to affected sites
- Recovery to pre-WNS population levels will take many years, if even possible
- Bats can become infected from an affected environment



2007-2008 Mortality Event
Percent Decline Based on Winter Survey Counts

Site	# of Live Bats (*year*)	# of Carcasses Recovered in 2007	2007 Survey	2008 Survey	% Decline
Hailes	15,584 (*2005*)	count not yet complete	6,735	1,400?	91%
Gages	968 (*1985*)	805	NA	88	91%
Knox	1,948 (*2001*)	350	NA	NA	
Schoharie Caverns	1,329 (*2006*)	125	478	38	97%

Simulations of Extinction for *Myotis lucifigus*

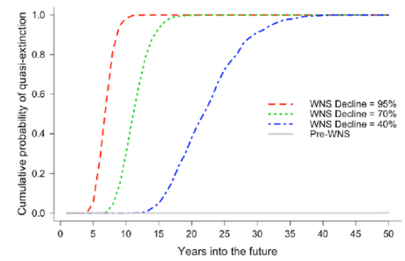


Figure 4.

Frick, Reynolds, Pollock, and Kunz - 2009

OPPORTUNITIES FOR EXPANDING EXISTING PROTECTION AND ENHANCEMENT GUIDELINES IN THE PROSPECT OF ADDITIONAL NORTH AMERICAN BAT SPECIES GAINING PROTECTION UNDER THE ENDANGERED SPECIES ACT

Brian Loges
Office of Surface Mining Reclamation and Enforcement
Alton, Illinois

Abstract

As White-nose Syndrome continues its rapid spread, populations of eastern cave-dwelling bat species are likely to decline to the point that additional bat species are likely to be listed under the endangered species act. The Office of Surface Mining will continue its active role in ensuring that coal mining, when properly implemented through Surface Mining Control and Reclamation Act (SMCRA), will not jeopardize the continued existence of any federally listed species. The recently developed *Range-wide Indiana Bat Protection and Enhancement Plan Guidelines* assist surface mining applicants and state coal mining regulatory agencies with portions of the permit review process addressing the Indiana bat (*Myotis sodalis*), ensuring its protection during coal mining operations authorized under SMCRA. The guidelines provide consistent and habitat based approaches for avoiding and minimizing any adverse effects of coal mining to hibernacula and summer habitats. Although the 2009 guidelines were developed specifically for the Indiana bat, the document is very broad in terms of geography and applicable habitats and could be easily modified to include other bat species with similar life histories.

Brian Loges is an Ecologist for the OSM Mid-Continent Region in Alton, Illinois. He has 15 years experience as a biologist working in both Missouri and Illinois. He has implemented efforts to protect crucial underground habitats through cave gate construction and enhance summer habitat while working in the Missouri Ozarks. Shortly after starting with OSM, he participated in the late stage reviews of the Range-wide Indiana Bat Protection and Enhancement Plan Guidelines. Brian has a BS in Environmental Biology from Eastern Illinois University and a MS in Biological Sciences from Southern Illinois University Carbondale.

KENTUCKY REPRESENTATIVE: MANAGEMENT OPPORTUNITIES FOR ADDRESSING WHITE-NOSE SYNDROME

Dr. Richard Wahrer
Kentucky Department of Natural Resources
Frankfort, Kentucky

Abstract

As of May, 2009, the Commonwealth of Kentucky has not recorded any occurrences of White-nose Syndrome in any bat species. Monitoring wintering bat populations will detect the presence of WNS early. The Kentucky Department for Fish and Wildlife resources and the U.S. Fish and Wildlife Service Frankfort Field Office have implemented a tiered approach to detection and prevention of White-nose Syndrome in winter habitats. Utilizing decontamination protocols, researchers conduct annual monitoring of scheduled hibernacula and spot checks of non-scheduled hibernacula. Additionally, entrance checks that will document bat activity on days normally too cold for activity will take place. Deployment of acoustic monitoring systems at selected hibernacula to determine activity level and baseline data on spring emergence of species present in the site is currently being conducted. The summer mist netting season has been delayed until June 1 with decontamination procedures required. The decision to close caves has been deferred to the owning/managing agency. The Daniel Boone National Forest has closed all of their caves.

Dr. Richard J. Wahrer is an Environmental Scientist in the Office of the Commissioner for the Kentucky Department for Natural Resources. He has been involved with the development of the regional Indiana Bat protection and enhancement guidelines and is a member of the Appalachian Regional Reforestation Initiative Core Team. He currently coordinates the Lands Unsuitable for Mining petition and Cumulative Hydrologic Impact Assessment programs. He is an instructor for the OSM/FWS Biological Opinion and Permit Findings classes. He holds a BS in Zoology and MS in Limnology from Stephen F. Austin University and a Ph.D. in Aquatic Biology from Texas A & M University.

WEST VIRGINIA REPRESENTATIVE: MANAGEMENT OPPORTUNITIES FOR ADDRESSING WHITE-NOSE SYNDROME

Ashley Carroll
WV DEP Division of Mining and Reclamation
Charleston, West Virginia

Abstract

Exhibiting a southward spreading trend from its initial 2006 documentation in New York, White-nose Syndrome (WNS) was first documented in West Virginia at four Pendleton County caves in the northern part of the state in January, 2009. In January, 2010, at the same county, it was confirmed at Hellhole Cave, the Mountain State's most important (and a Recovery Plan Priority II) hibernaculum. Later in winter 2010, it was also documented southward and adjacent into Pocahontas County and down into the southern counties of Greenbrier, Monroe and Mercer. Coal permitting program effects of WNS include the institution of strict sanitation procedures for qualified bat surveyors and the delay of mist netting season from May 15 to June 1 in 2009. WNS has halted a prior long-term improving population trend of the federally listed bat species in West Virginia.

Ashley Carroll reviews endangered species consultations for the West Virginia Department of Environmental Protection, Division of Mining and Reclamation. She began working full time for the Division of Mining and Reclamation in 2007. She began her career with WV DEP through the Governor's Internship Program in 2006 while completing her MS in Environmental Science from Marshall University, where she also holds a BS in Biology.

White Nose Syndrome Impacts on Bats and Mining West Virginia

White-Nose Syndrome

- Thought to be caused by a cold loving fungus, recently named *Geomyces destructans* – named so for its destructive nature
- Originated in upstate New York state in 2006 and has migrated south
- Has caused over a million bat deaths since 2006 – up to 100% mortality rates

White-Nose Syndrome

- Has been shown in 1/5 of all bat species in the United States including-
  - Little Brown Bat
  - Eastern Small-footed Bat
  - Northern Long-eared Bat
  - Tri-colored Bat
  - Big Brown Bat
  - Indiana Bat
  - Gray Bat
  - Cave Myotis
  - Southeastern Myotis

White-Nose Syndrome

- White-Nose Syndrome is killing bats by depleting the fat stored in winter and pulling bats out of hibernation too early
- Transmission is thought occur from bat to bat contact (via maternity colonies and hibernation) and human interaction through infected clothing
- Cave Closures
- Decontamination protocol is available on the FWS website

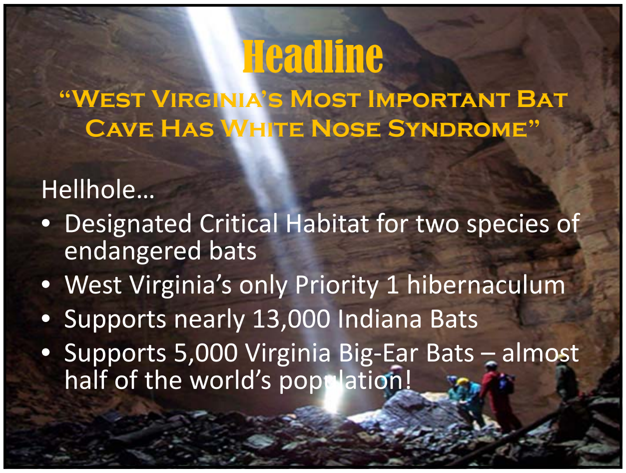
White-Nose Syndrome in West Virginia

- First observed in West Virginia in January 2009 in Pendleton county
- Bat caught in Fayette county in summer of 2009 with latent signs of WNS

White-Nose Syndrome

- Observed at Hell Hole cave in early 2010
- Bats have been found White Nose Positive in 2010 in several West Virginia counties including:

Greenbrier
Monroe
Pocahontas
Mercer
Pendleton



Headline

“WEST VIRGINIA’S MOST IMPORTANT BAT CAVE HAS WHITE NOSE SYNDROME”

Hellhole…

- Designated Critical Habitat for two species of endangered bats
- West Virginia’s only Priority 1 hibernaculum
- Supports nearly 13,000 Indiana Bats
- Supports 5,000 Virginia Big-Ear Bats – almost half of the world’s population!

Hellhole Cave

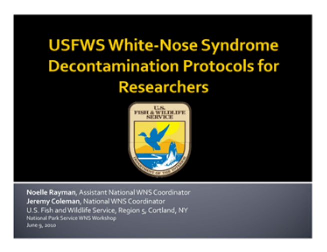
- West Virginia’s largest bat hibernaculum
- Bat counts February 2010 – USFWS, WVDNR and NSS
- Bats observed flying from entrance several weeks before and tested WNS positive
- WNS apparent in clusters of Indiana bats
- Little Brown bats
- Closed cave since 2007 – no human to bat transmission

How can we stop the spread of White-Nose Syndrome?

- Strict sanitation guidelines are being enforced
- Qualified bat surveyors
- Delay of Mist-netting season-: Mist-netting moved from May 15th to June 1st in response to WNS
- Recommendation of mist netting to all applicants with 40 or more forested acres

Disinfection Protocols

- USFWS – White Nose Syndrome Page
- http://www.fws.gov/WhiteNoseSyndrome/

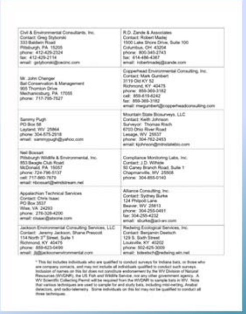


USFWS White-Nose Syndrome Decontamination Protocols for Researchers

Noelle Rayman, Assistant National WNS Coordinator
Jeremy Coleman, National WNS Coordinator
U.S. Fish and Wildlife Service, Region 5, Cortland, NY
National Park Service WNS Workshop
June 9, 2010

Qualified Bat Surveyors

Qualified Indiana Bat Surveyors*
(March 2010)



What about Caves?

- Bat friendly gates provide ideal additional habitat
- National Park Service

Any Questions?

Ashley E.L. Carroll
Ashely.e.Carroll@wv.gov
304-926-0499 ext. 1495

PENNSYLVANIA REPRESENTATIVE: MANAGEMENT OPPORTUNITIES FOR ADDRESSING WHITE-NOSE SYNDROME

Geoff Lincoln
Pennsylvania DEP Bureau of Mining and Reclamation
Harrisburg, Pennsylvania

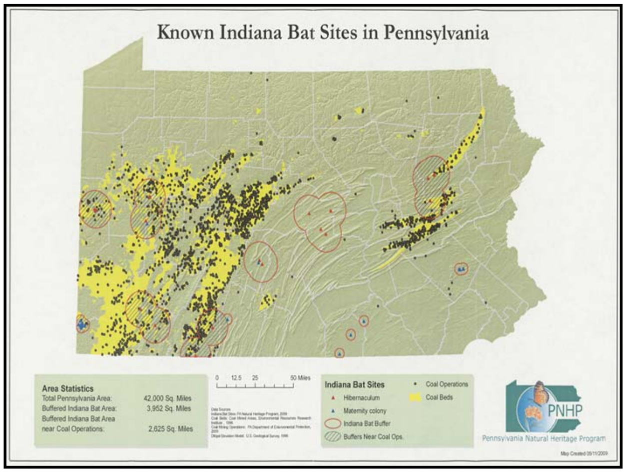
Abstract

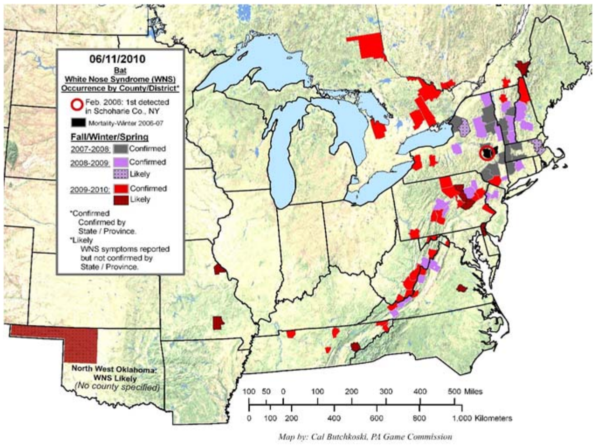
The mining of coal in Pennsylvania and its impact on Indiana bat habitat has collided with the heightened effort to protect bat habitat due to White-nose Syndrome. White-nose Syndrome is spreading across Pennsylvania starting in the northeast and spreading south and west devastating cave dwelling bat populations including the Indiana bat. In the past Pennsylvania mine operators and regulators have had limited dealings with Indiana bats and the protection of their habitat. Until recently the avoidance of known bat hibernacula and seasonal tree cutting restrictions were the only real impact bats and mining have had on each other. Pennsylvania has only 2-3% of the Indiana bat population with no P-1 and only one P-2 Indiana bat Hibernacula. In July 2009, the Range-wide Indiana Bat Protection and Enhancement Plan Guidelines were finalized laying the foundation for species and habitat protection. That same month the Pennsylvania Field Office of the U.S. Fish and Wildlife Service (USFWS) published the Indiana Bat Mitigation Guidance for Pennsylvania focusing on all land development and the impacts on Indiana bats and supporting habitat. In September, 2009, after meeting with the Office of Surface Mining and Pennsylvania Department of Environmental Protection the USFWS Pennsylvania field office published a sub section of the guidance titled Coal Mining Projects and Indiana Bats Species Specific Protective Measures. These protective measures specific to coal mining provided increased protection of the Indiana bat compared with the Range-Wide Guidance causing concern of many in the mining industry. First, the protective radius around hibernacula were increased from 5 to 10 mile radius for P-3 and P-4 hibernacula with the difference being an additional 235 square miles of protected habitat per hibernacula with a total impact of approximately 2.4 million acres of land. Second, the requirement of the PA Guidance to reforest the mine site at a 90% rate as opposed to the 70% rate in the Range- Wide Guidance leads to a considerable increase in habitat. Thirdly, areas of suitable habitat are now being protected in both guidance documents potentially impacting millions more acres all over the state (areas of forest with trees ≥5 inches diameter and greater than 40 acres). All of these measures, along with the off-site compensation option, have created an ever increasing amount of habitat protection for an ever decreasing number of Indiana bats. The results being an ever increasing cost to the mining industry with an ever decreasing amount of land in Pennsylvania available for mining operations.

Geoff Lincoln is the Chief of the Environmental Studies Section in the Bureau of Mining and Reclamation, Pennsylvania Department of Environmental Protection (DEP). Geoff has 25 years of experience in the environmental, health and safety fields working in the federal government, state government and private sector. He is an Environmental Science/Safety Officer in the Pennsylvania Army National Guard. He served for 5 years as an environmental planning officer for Fort Indiantown Gap, PA, managing Environmental Impact Studies (EIS) and developing natural resource management plans to include habitat management plans for threatened and endangered species. Currently, he is conducting statewide Indiana bat workshops with the U.S. Fish and Wildlife Service for DEP staff, consultants and mine operators. He has a MS and BA in Geoenvironmental Studies from Shippensburg University of Pennsylvania.

Indiana Bats and Coal Mining in Pennsylvania

From seasonal timber restrictions
to large tracts of land protected as
bat habitat in perpetuity





Map by: Cal Butchkoski, PA Game Commission

PEP – Long-term Habitat Needs

Protect and conserve habitat off-site to provide for long-term habitat needs of the Indiana bat

- Acquire habitat (fee simple or conservation easement) and place in conservation ownership
- Indiana bat conservation bank
- Indiana bat conservation fund (IBCF)
- Must result in permanent protection

IBCF Calculation Sheet

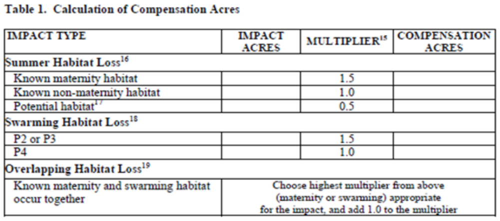


Table 1. Calculation of Compensation Acres

IMPACT TYPE	IMPACT ACRES	MULTIPLIER[15]	COMPENSATION ACRES
Summer Habitat Loss[16]			
Known maternity habitat		1.5	
Known non-maternity habitat		1.0	
Potential habitat[17]		0.5	
Swarming Habitat Loss[18]			
P2 or P3		1.5	
P4		1.0	
Overlapping Habitat Loss[19]			
Known maternity and swarming habitat occur together	Choose highest multiplier from above (maternity or swarming) appropriate for the impact, and add 1.0 to the multiplier		

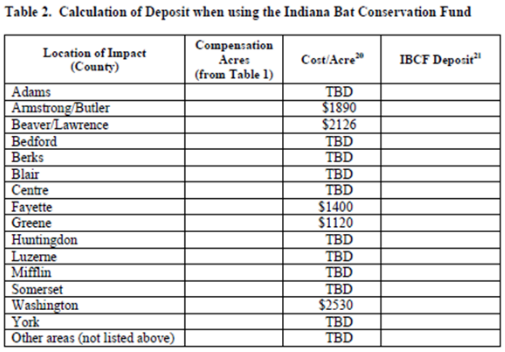


Table 2. Calculation of Deposit when using the Indiana Bat Conservation Fund

Location of Impact (County)	Compensation Acres (from Table 1)	Cost/Acre[20]	IBCF Deposit[21]
Adams		TBD	
Armstrong/Butler		$1890	
Beaver/Lawrence		$2126	
Bedford		TBD	
Berks		TBD	
Blair		TBD	
Centre		TBD	
Fayette		$1400	
Greene		$1120	
Huntingdon		TBD	
Luzerne		TBD	
Mifflin		TBD	
Somerset		TBD	
Washington		$2530	
York		TBD	
Other areas (not listed above)		TBD	


Questions?

Session 2

FEDERAL EFFORTS FOR THE RECOVERY OF THE INDIANA BAT

Session Chairperson:
T.J. Miller
U.S. Fish & Wildlife Service
Fort Snelling, Minnesota

Indiana Bat Recovery Plan Status
Scott Pruitt, U.S. Fish & Wildlife Service, Bloomington, Indiana

Indiana Bat Population Status and Trends
R. Andrew King, U.S. Fish & Wildlife Service, Bloomington Ecological Services Field Office, Endangered Species Program, Bloomington, Indiana

The Range-Wide Indiana Bat Protection and Enhancement Plan: Where We Were, Where We Are, and Where We Hope To Be
Carrie Lona, U.S. Fish & Wildlife Service, Kentucky Field Office, Frankfort, Kentucky

Everything You Wanted to Know About "Take" in the Endangered Species Act
Peg Romanik, U.S. DOI Solicitor's Office, Washington, D.C.

INDIANA BAT RECOVERY PLAN STATUS

Scott Pruitt
U.S. Fish & Wildlife Service
Bloomington, Indiana

Abstract

In April 2007, the U.S. Fish and Wildlife published a draft revision of the Indiana Bat Recovery Plan. With this revision we requested public comment and solicited peer review. We received hundreds comments from numerous government agencies, private organizations, and individuals. We also received several responses from peer reviewers. Since then, we have been working to review these comments and evaluating, adjusting, and improving the plan accordingly. For example, sections identified for further review include the recovery criteria and recovery actions. In addition, White-nose Syndrome is a new threat affecting nearly every aspect of recovery planning for this species that must be integrated into the recovery plan.

The speaker would not provide a paper for this talk.

Scott Pruitt has been with the U.S. Fish and Wildlife Service for 22 years and is currently the Field Supervisor of the Bloomington, Indiana, Field Office. The Bloomington Field Office has the national lead for recovery of the Indiana bat (*Myotis sodalis*). He has been involved with bat research for the past 13 years. He holds a BS in Wildlife Resources from the University of Idaho and a MS in Wildlife Biology from the Pennsylvania State University. He has also held positions with the Idaho Fish and Game Department, the Indiana Department of Natural Resources, and the Indiana University.

Indiana Bat Recovery Plan Status

presented by Scott Pruitt
USFWS - Bloomington, Indiana Field Office

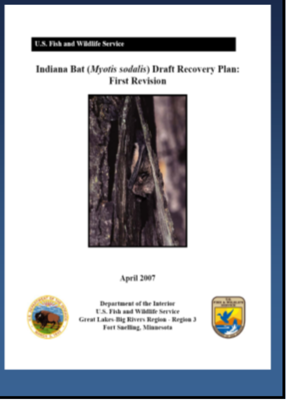
September 1, 2010

Recovery Plans

- Original Recovery Plan – 1983
- Agency Draft Revised RP – 1999
- Draft RP First Revision – 2007

90-day public comment period opened on April 16th and closed on July 16th 2007.

RP can be downloaded at http://www.fws.gov/midwest



U.S. Fish and Wildlife Service

Indiana Bat (*Myotis sodalis*) Draft Recovery Plan:
First Revision

April 2007

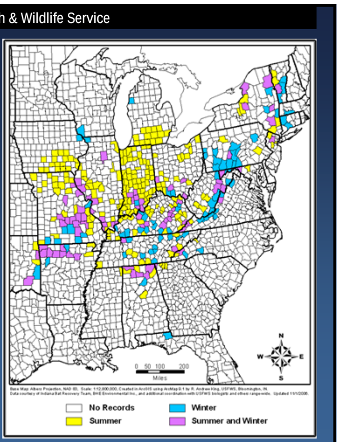
Department of the Interior
U.S. Fish and Wildlife Service
Great Lakes-Big Rivers Region - Region 3
Fort Snelling, Minnesota

Recovery Plan Outline

- Species Description, Distribution, Abundance
- Life History / Ecology
- Causes of Decline
- Recovery Program

Indiana bat (*Myotis sodalis*)

Composite Range of the Indiana Bat

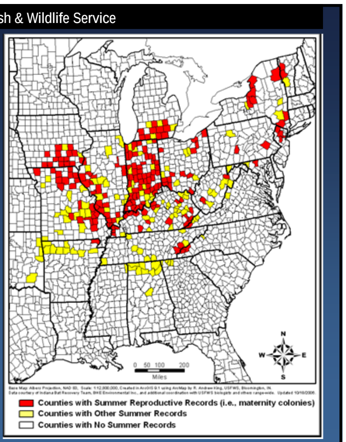


Base Map: Albers Projection, NAD 83, Scale: 1:12,000,000, Created in ArcGIS using ArcMap 9.1 by R. Andrew King, USFWS, Bloomington, IN.
Data courtesy of Indiana Bat Recovery Team, BHE Environmental Inc., and additional coordination with USFWS biologists and others range-wide. Updated 11/1/2006.

Map includes all known recent and historic records

Summer Records

269 Maternity colonies are currently considered to be locally extant in 16 States, which is approximately 6 - 9 % of assumed total number of colonies.



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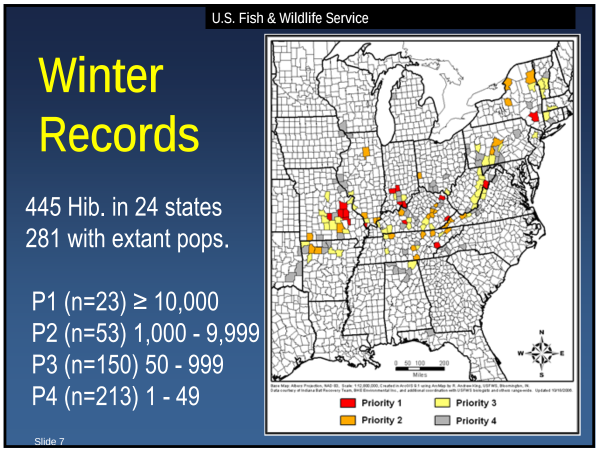
Data courtesy of Indiana Bat Recovery Team, BHE Environmental Inc., and additional coordination with USFWS biologists and others range-wide. Updated 10/18/2006.

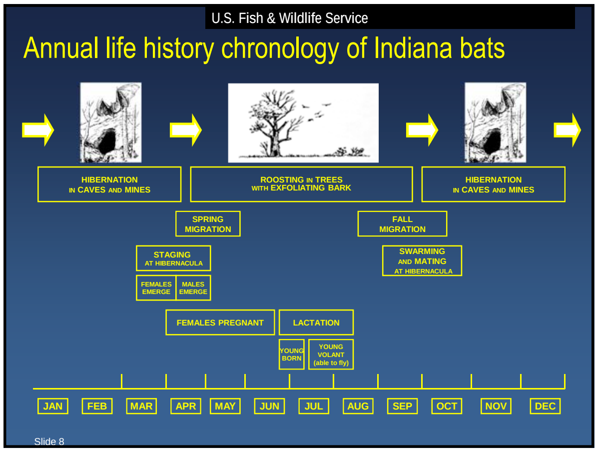

U.S. Fish & Wildlife Service

Winter Records

445 Hib. in 24 states
281 with extant pops.

P1 (n=23) ≥ 10,000
P2 (n=53) 1,000 - 9,999
P3 (n=150) 50 - 999
P4 (n=213) 1 - 49

Base Map: Albers Projection, NAD 83, Scale: 1:12,000,000, Created in ArcGIS 9.1 using ArcMap by R. Andrew King, USFWS, Bloomington, IN.
Data courtesy of Indiana Bat Recovery Team, BHE Environmental Inc., and additional coordination with USFWS biologists and others range-wide. Updated 10/10/2006.


U.S. Fish & Wildlife Service

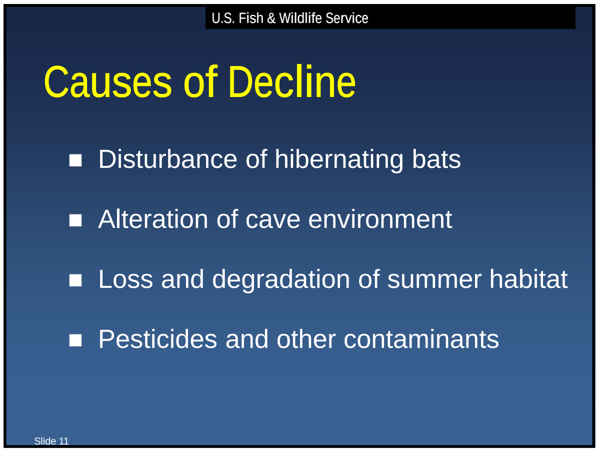
Annual life history chronology of Indiana bats

HIBERNATION IN CAVES AND MINES
ROOSTING IN TREES WITH EXFOLIATING BARK
HIBERNATION IN CAVES AND MINES
SPRING MIGRATION
FALL MIGRATION
STAGING AT HIBERNACULA
SWARMING AND MATING AT HIBERNACULA
FEMALES EMERGE
MALES EMERGE
FEMALES PREGNANT
LACTATION
YOUNG BORN
YOUNG VOLANT (able to fly)


U.S. Fish & Wildlife Service


U.S. Fish & Wildlife Service

In summer, Indiana bats typically roost under the loose bark of dead or dying trees.


U.S. Fish & Wildlife Service

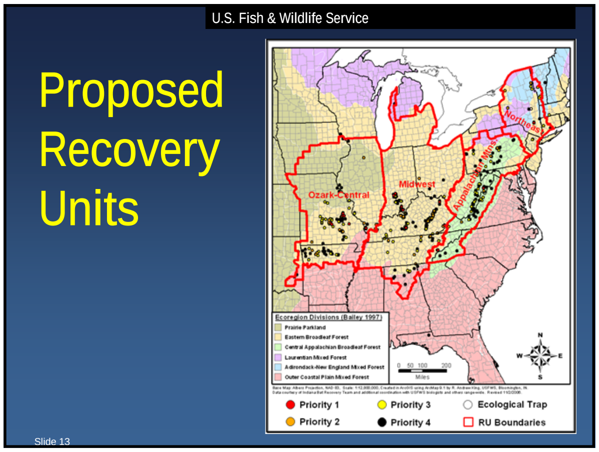
Causes of Decline

- Disturbance of hibernating bats
- Alteration of cave environment
- Loss and degradation of summer habitat
- Pesticides and other contaminants


U.S. Fish & Wildlife Service

Recovery Program

- **Goals**
- **Criteria**
- **Actions**



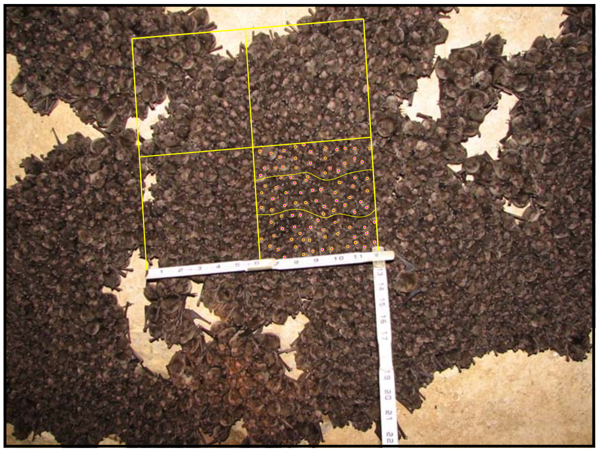
U.S. Fish & Wildlife Service

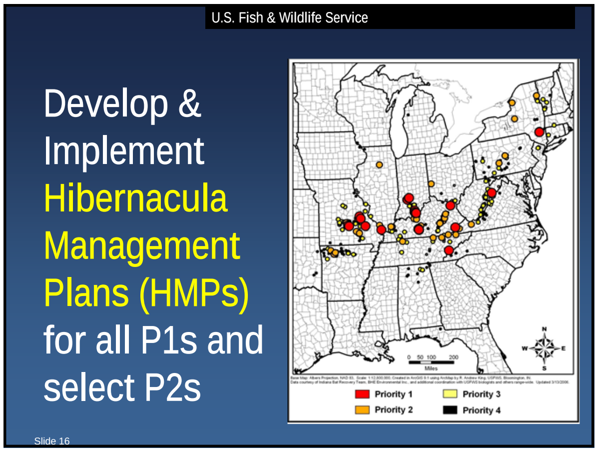
Proposed Recovery Units

U.S. Fish & Wildlife Service

Recovery Actions

- Population monitoring
- Conservation and management of habitat
- Research of species' requirements and threats
- Public outreach and education





U.S. Fish & Wildlife Service

Develop & Implement Hibernacula Management Plans (HMPs) for all P1s and select P2s

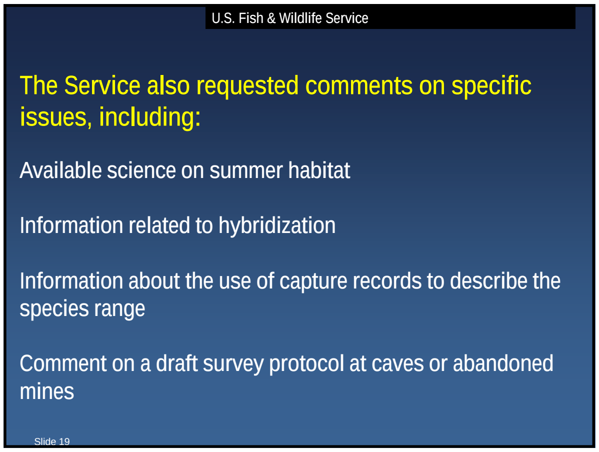
U.S. Fish & Wildlife Service

Information/Research Needs

Effects of Forest Management / Disturbance

U.S. Fish & Wildlife Service

Educational Outreach



U.S. Fish & Wildlife Service

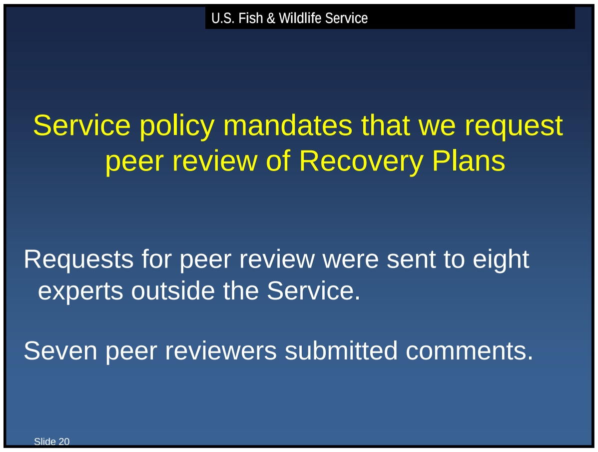
The Service also requested comments on specific issues, including:

Available science on summer habitat

Information related to hybridization

Information about the use of capture records to describe the species range

Comment on a draft survey protocol at caves or abandoned mines

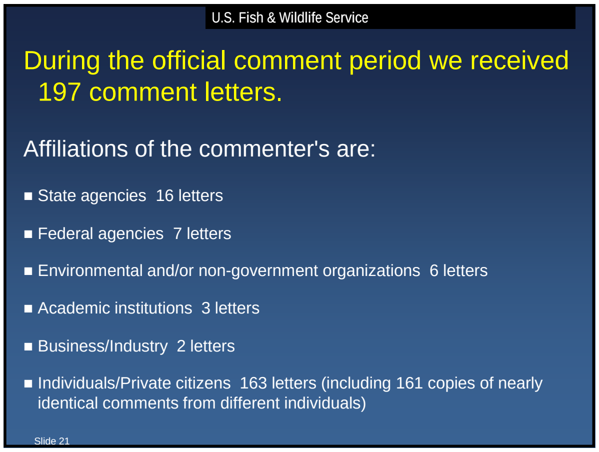


U.S. Fish & Wildlife Service

Service policy mandates that we request peer review of Recovery Plans

Requests for peer review were sent to eight experts outside the Service.

Seven peer reviewers submitted comments.



U.S. Fish & Wildlife Service

During the official comment period we received 197 comment letters.

Affiliations of the commenter's are:

- State agencies 16 letters
- Federal agencies 7 letters
- Environmental and/or non-government organizations 6 letters
- Academic institutions 3 letters
- Business/Industry 2 letters
- Individuals/Private citizens 163 letters (including 161 copies of nearly identical comments from different individuals)

INDIANA BAT POPULATION STATUS AND TRENDS

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Abstract

Over the past 30+ years, biologists across the bat's range have visited hundreds of hibernacula (i.e., caves and abandoned mines) every other winter to conduct standardized surveys of hibernating Indiana bats. The U.S. Fish and Wildlife Service (Service) helps coordinate the biennial winter surveys, collates the survey data from 17 states, and posts the resulting population estimates and trends on its Indiana bat website (http://www.fws.gov/midwest/Endangered/mammals/inba/index.html).

With an estimated rangewide population between 600,000 and 900,000 bats, the Indiana bat originally was listed as an endangered species on March 11, 1967, following establishment of the Endangered Species Preservation Act in 1966 and currently is listed as endangered under the Endangered Species Act of 1973, as amended. After being listed in 1967, the rangewide Indiana bat population continued to decrease precipitously and reached a low of about 329,000 bats in 2001 before an increasing population trend began in 2003 and continued through 2007. Through 2003, most of the overall population declines were attributed to declines at high-priority hibernacula in Kentucky and Missouri and to a lesser extent, Indiana. Bat populations in Missouri hibernacula declined drastically from 1980 through 1997 and have continued to decline at a slower rate from 1997 to present. In contrast, the recent 2003-2007 population increase was largely attributed to population growth at hibernacula in Illinois, Indiana, Kentucky, New York, and West Virginia. During the three intra-biennial survey periods from 2001-2003, 2003-2005 and 2005-2007, the rangewide population had increased by 10.8%, 16.9%, and 10.4%, respectively. In sharp contrast, from 2007 to 2009, the overall Indiana bat population declined by approximately 11.8% (a loss of approx. 55,458 bats). The 2009 Indiana bat rangewide population estimate was 414,031 bats with 99% of the bats hibernating in 8 states: Indiana (52%), Kentucky (14%), Illinois (13%), New York (8%), West Virginia (4%), Missouri (3%), Tennessee (3%), and Ohio (2%). This was the first observed overall decline since 2001. The negative influence of White-nose Syndrome (WNS) on Indiana bat population trends in affected states and recovery units is becoming more apparent especially in the Northeast Recovery Unit. In addition to ongoing WNS research, the Service and its partners are continuing to research and develop new survey techniques in an ongoing effort to improve both the accuracy and consistency of our Indiana bat population estimates.

Introduction

The Indiana bat (*Myotis sodalis*) was one the first species to become Federally listed as endangered on March 11, 1967. It is a migratory species that is found throughout much of the eastern United States. During winter, Indiana bats occupy suitable underground hibernacula (i.e., caves and mines). Biennial surveys of the hibernacula are the primary means by which Indiana bat populations are monitored. Indiana bats typically form dense clusters containing tens to thousands of individuals on cave and mine ceilings and walls each winter, which greatly facilitates biologists' efforts to enumerate them (USFWS 2007).

Prior to European settlement of the eastern United States, the rangewide Indiana bat population almost certainly exceeded a million bats and some individual caves were reported as having "millions" of hibernating bats many of which reasonably could be assumed to have been Indiana bats (Silliman 1887, Tuttle 1997, USFWS 2007). However, by the time bat biologists started conducting more-or-less standardized population surveys in the early 1980s, the rangewide population estimate was closer to half a million individuals.

In the original Recovery Plan (USFWS 1983), Indiana bat hibernacula were assigned priority numbers based on the number of Indiana bats they contained. For example, originally a Priority 1 (P1) hibernaculum was a site that had contained 30,000 or more Indiana bats since 1960. During a meeting of Recovery Team members and U.S. Fish and Wildlife Service (Service) biologists in November, 2005, it was decided that revisions to the existing hibernacula priority definitions were needed (USFWS 2007). With the end goal of achieving a wider and more even distribution of essential hibernation sites across the species' range, it was decided to lower the P1 population criterion from 30,000 bats to 10,000 and to omit the "since 1960" part of all the hibernacula definitions. These changes effectively increased the number of P1 hibernacula at that time from 11 sites in four states to 23 sites in seven states. The current hibernacula priorities are defined below.

Priority 1 (P1): Essential to recovery and long-term conservation of *M. sodalis*. Priority 1 hibernacula typically have (1) a current and/or historically observed winter population ≥ 10,000 Indiana bats and (2) currently have suitable and stable microclimates. Priority 1 hibernacula are further divided into one of two subcategories, "A" or "B," depending on their recent population sizes. Priority 1A (P1A) hibernacula are those that have held 5,000 or more Indiana bats during one or more winter surveys conducted during the past 10 years. In contrast, Priority 1B (P1B) hibernacula are those that have sheltered ≥ 10,000 Indiana bats at some point in their past, but have consistently contained fewer than 5,000 bats over the past 10 years.

Priority 2 (P2): Contribute to recovery and long-term conservation of *M. sodalis*. Priority 2 hibernacula have a current or observed historic population of 1,000 or greater but fewer than 10,000 and an appropriate microclimate.

Priority 3 (P3): Contribute less to recovery and long-term conservation of *M. sodalis*. Priority 3 hibernacula have current or observed historic populations of 50-1,000 bats.

Priority 4 (P4): Least important to recovery and long-term conservation of M. sodalis. Priority 4 hibernacula typically have current or observed historic populations of fewer than 50 bats.

Beginning in the 1980's, most P1 and P2 hibernacula were surveyed every other year (on the odd year) by one or more members of the Indiana Bat Recovery Team with assistance from state and Service biologists. The Recovery Team Leader, Rick Clawson, collated the population estimates from all known P1 and P2 hibernacula and assessed apparent population trends with data from those sites. In preparation for the "Indiana Bat: Biology and Management of an Endangered Species" symposium in Lexington, Kentucky in 2001, Clawson collated data from all known hibernacula (i.e., P1-P4) and published the first comprehensive population estimates and trends assessment for the species (Clawson 2002). Beginning in 2003, the Service's Bloomington Field Office (BFO) started collating rangewide population data and developing a comprehensive Indiana bat hibernacula database containing published and unpublished population estimates from all known hibernacula. Since 2005, the Service has helped coordinate the biennial winter surveys, collate the survey data from 17+ states, and post the resulting population estimates and trends on its Indiana bat website (http://www.fws.gov/midwest/Endangered/mammals/inba/index.html).

In 1995, the Indiana Bat Recovery Team requested distributional data in a letter sent to consultants, researchers, and authorities on endangered species in 28 states (Gardner and Cook 2002). From the responses received from this data request and other published and unpublished records, Gardner and Cook (2002) developed a rangewide database of county distributional records for the Indiana bat and used GIS software (ArcInfo® and ArcView®) to examine the bat's geographic distribution and to produce seasonal distribution maps. In June, 2005, the BFO e-mailed an Indiana bat hibernacula data request to over 75 individuals including Service biologists, Recovery Team members, bat researchers, state and Federal agency biologists, consultants, and other bat conservation partners in 27 states, who in turn forwarded the response to other colleagues. Hibernacula data were received from all 27 states. BFO biologists used the combined responses from the 1995 and 2005 data requests, existing Recovery Team records, and other published and unpublished records, to develop a GIS-based hibernacula database containing detailed information for all known (i.e., current and historic) hibernacula with one or more Indiana bat winter occurrence records. BFO has maintained the hibernacula database since 2005 and has continuously added new data as it becomes available. The most recent Indiana bat population data was collected during hibernacula surveys conducted throughout the species' range in January through early March, 2009, and is summarized below.

Results

Current Population Status

The Service currently (as of March 11, 2011) has records of one or more Indiana bats hibernating at 467 different hibernacula in 24 states between 1929 and the present (Table 1, Figure 1). Data entries for these 467 sites vary considerably with multiple sites with a single record of 1 bat to sites having had up to 123,800 bats at one point in time (e.g., Bat Cave, Shannon Co., MO in 1973) (USFWS, unpublished data). Of these 467 sites, 300 (64%) are considered to have an extant winter population (Table 1). Based on the 2009 or most recent population estimates, we have assigned each of the 467 sites a priority number which is tabulated in Table 1, and their rangewide distribution is depicted in Figure 1.

Table 1. Distribution and priority numbers of Indiana bat hibernacula by state and Recovery Unit (current as of Dec. 2010).

State	No. of Hibernacula by Priority Number[1] (No. with positive occurrence since 1999)						Total No. of Hibernacula with Any Winter Record	Total No. of Hibernacula with “Extant” Winter Populations (≥1 bat since 1999)
	P1A	P1B	P2A	P2B	P3	P4		
Alabama	-	-	-	-	4(2)	6(2)	10	4
Arkansas	-	-	2(2)	2(1)	12(9)	19(3)	35	15
Connecticut	-	-	-	-	1(0)	1(0)	2	0
Florida	-	-	-	-	-	1(0)	1	0
Georgia	-	-	-	-	-	2(0)	2	0
Illinois	1(1)	-	6(6)	-	7(6)	9(4)	23	17
Indiana	7(7)	-	3(3)	-	14(14)	13(10)	37	34
Iowa	-	-	-	-	-	2(0)	2	0
Kentucky	2(2)	3(3)	12(12)	4(3)	41(35)	54(25)	116	80
Maryland	-	-	-	-	-	4(0)	4	0
Massachusetts	-	-	-	-	1(0)	-	1	0
Michigan	-	-	-	-	-	1(1)	1	1
Missouri	1(1)	5(5)	5(5)	5(2)	25(19)	30(10)	71	42
New Jersey	-	-	-	-	2(2)	-	2	2
New York	3(3)	-	3(3)	-	4(4)	10(6)	20	16
North Carolina	-	-	-	-	-	4(1)	4	1
Ohio	-	-	1(1)	-	1(1)	5(0)	7	2
Oklahoma	-	-	-	-	-	3(2)	3	2
Pennsylvania	-	-	1(1)	1(0)	5(4)	20(12)	27	17
Tennessee	1(1)	-	2(2)	5(4)	15(13)	14(7)	37	27
Vermont	-	-	-	-	5(3)	1(0)	6	3
Virginia	-	-	-	2(2)	6(6)	8(3)	16	11
West Virginia	1(1)	-	-	1(1)	11(11)	26(13)	39	26
Wisconsin	-	-	-	-	-	1(0)	1	0
Total	**16**	**8**	**35**	**20**	**154**	**234**	**467**	**300**

[1] P1A: ≥10,000 bats at some point in time and ≥5000 bats at some point within past 10 yrs. P1B: ≥10,000 bats at some point in time, but <5,000 bats within past 10 yrs. P2A: 1,000-9,999 bats at some point in time and ≥500 bats at some point within past 10 yrs. P2B: 1,000-9,999 bats at some point in time, but <500 bats within past 10 yrs. P3: 50-999 bats at any point in time. P4: 1-49 bats at any point in time.

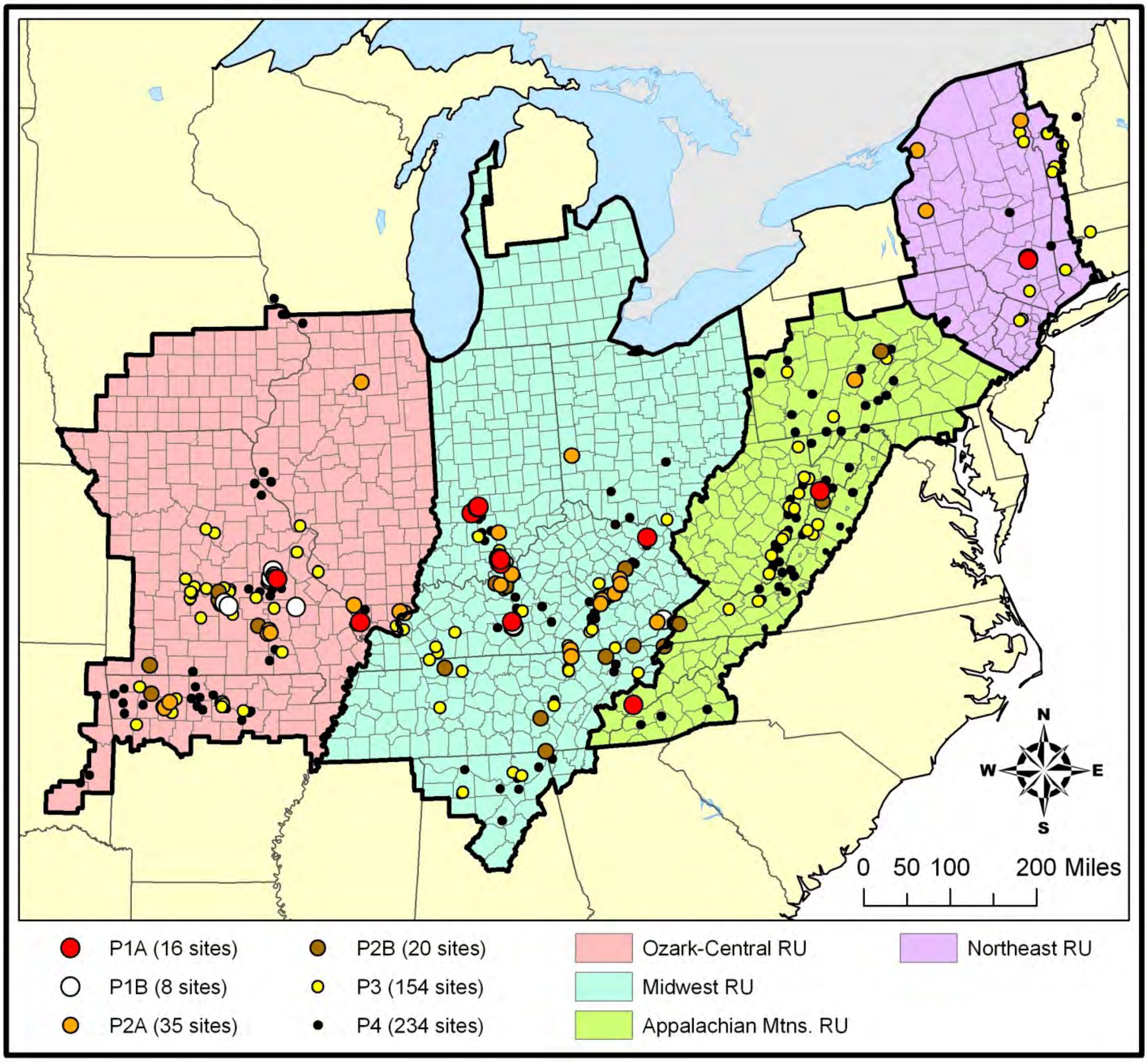

Figure 1. Location and priority number of known Indiana bat hibernacula within each Recovery Unit (RU boundaries depict currently assumed range limits of the species) (priority numbers were updated using 2009 population estimates) (all extant and historic sites are shown and all sites falling outside of a RU/the current range are historic).

Table 2 provides population estimates through time for each of the 23 current Priority 1 hibernacula (P1A=16, P1B=7).

Table 2. Winter population estimates through time for P1A (n=16) and P1B (n=7) Indiana bat hibernacula. All P1 hibernacula (n=24) have at some point in the recorded past had ≥10,000 hibernating Indiana bats and currently provide suitable winter habitat. P1A hibernacula have maintained a minimum of 5,000 Indiana bats during the last 10 years, whereas P1B hibernacula have not met this criterion in the last 10+ years.

State	Hibernaculum Name	Type	P1 Subcategory	Max. Pop. All-time	Max. Pop. Pre-1970	Max. Pop. 1970-79	Max. Pop. 1980-89	Max. Pop. 1990-99	Max. Pop. 2000-09	Most Recent Pop. Estimate (2009 or 2010)	Year G.d. and/or WNS was Confirmed
IN	Ray's	cave	A	77,687	3,200	9,233	28,581	62,464	77,687	59,250	-
IN	Wyandotte	cave	A	54,913	15,000	2,152	10,344	26,854	54,913	52,610	2011
IL	Magazine	mine	A	44,580	0	0	1,814	9,074	44,580	40,705	-
IN	Jug Hole	cave	A	46,664	Unk.	1,384	6,424	20,741	46,664	36,067	-
KY	Bat (Carter Co.)	cave	A	100,000	100,000	40,000	51,500	49,575	36,942	23,346	-
IN	Grotto	cave	A	16,190	200	2,193	4,198	4,361	19,197	19,197	2011
IN	Coon	cave	A	18,640	150	801	2,950	6,341	18,640	18,640	
IN	Twin Domes	cave	A	100,000	Unk.	100,000	98,250	87,350	50,325	18,484	
WV	Hellhole	cave	A	12,858	500	386	5,143	10,437	12,858	12,858	2010
NY	Barton Hill	mine	A	11,009	0	29	2,183	4,842	11,009	10,678	2008
NY	Williams Hotel	mine	A	24,317	0	0	236	7,553	24,317	8,152	2008
TN	White Oak Blowhole	cave	A	12,500	Unk.	12,000	12,500	7,259	7,983	7,983	2010
MO	Great Scott	cave	A	85,700	Unk.	81,800	85,700	32,125	8,250	4,670	-
IN	Batwing	cave	A	50,000	Unk.	50,000	29,960	13,150	9,350	4,222	2011
KY	Dixon	cave	A	16,550	4,000	9,525	16,550	9,150	3,670	2,432	-
KY	Line Fork	cave	B	10,000	10,000	9,536	8,379	3,297	1,877	1,877	-
MO	Pilot Knob	mine	B	100,000	100,000	100,000	88,923	33,538	1,678	1,678	-
KY	Long	cave	B	50,000	50,000	7,600	7,527	1,249	1,319	1,319	-
MO	Copper Hollow Sink	cave	B	21,000	Unk.	21,000	9,295	200	380	320	-
NY	Walter Wm. Preserve	mine	A	13,014	0	0	5,631	9,415	13,014	190	2008
MO	Onyx	cave	B	12,850	Unk.	12,850	8,994	1,275	180	120	-
MO	Brooks	cave	B	19,461	Unk.	19,461	11,850	2,700	235	20	-
MO	Ryden	cave	B	10,539	5,600	10,539	5,800	160	13	2	-
KY	Coach	cave	B	100,000	100,000	4,500	600	48	101	0	-

The 2009 Indiana bat rangewide population estimate was 414,031 bats with 99% of the bats hibernating at sites in 8 states: Indiana (52%), Kentucky (14%), Illinois (13%), New York (8%), West Virginia (4%), Missouri (3%), Tennessee (3%), and Ohio (2%) (Table 3, Figures 2 and 3) [Note: this is an updated 2009 estimate that significantly differs from the one that originally was posted on the Service's website in April 2010]. In 2009, the Midwest Recovery Unit (RU) contained two-thirds (68.6%) of the rangewide Indiana bat population followed by the Ozark-Central (16.5%), Northeast (8.2%) and Appalachian Mountains (6.6%) RUs.

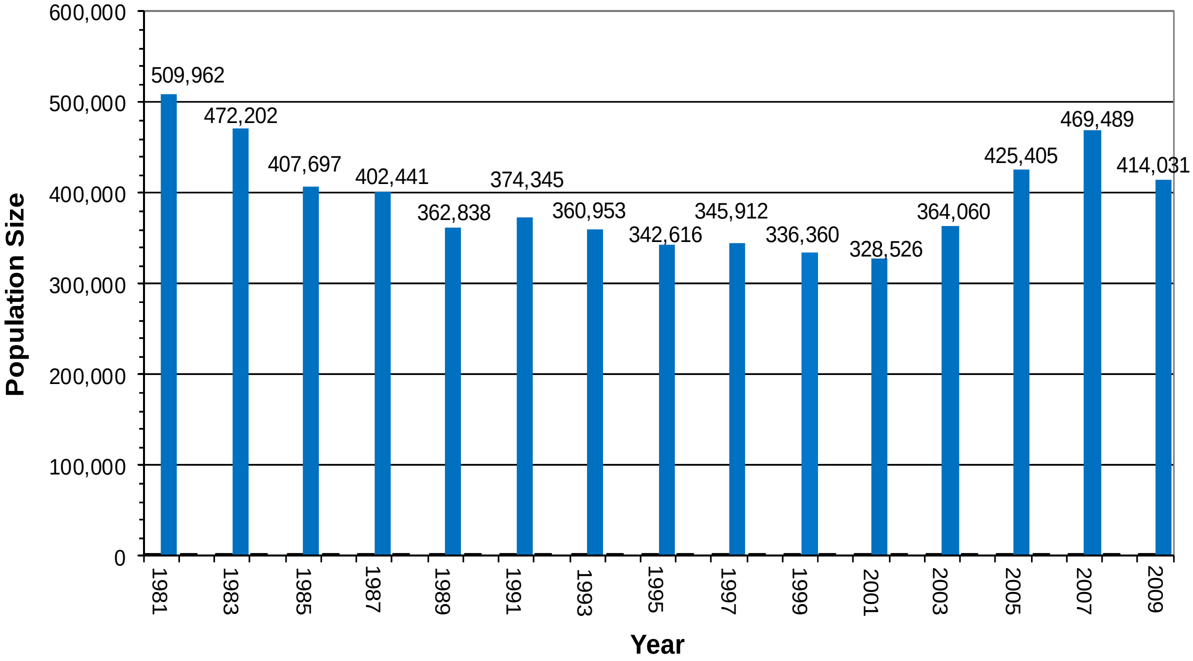

Figure 2. Indiana bat rangewide population estimates from 1981 – 2010 (USFWS unpublished data 2011).

Current WNS Status

As of March 11, 2011, biologists had confirmed White-nose Syndrome (WNS) and/or the fungus *Geomyces destructans* (*G.d.)* from bats/samples collected within at least 59 Indiana bat hibernacula in 11 states (IN=4, MA=1, MD=1, MO=1, NJ=2, NY=19, PA=10, TN=4, VA=4, VT=5, WV=7). Thirty-five of the 59 WNS/*G.d.*-affected sites sheltered one or more Indiana bats in 2009. In 2009, these 35 sites collectively contained approximately 134,770 bats or approximately 33% of the rangewide population. Table 2 provides the WNS/*G.d.* status for each of the 23 current P1 hibernacula.

Population Trends

After being listed in 1967, the rangewide Indiana bat population continued to decrease precipitously and reached a low of about 329,000 bats in 2001 before an increasing population trend began in 2003 and continued through 2007 (Table 3, Figure 2). Through 2003, most of the overall population declines were attributed to declines at high-priority hibernacula in Kentucky and Missouri and to a lesser extent, Indiana. Bat populations in Missouri hibernacula declined drastically from 1980 through 1997 and have continued to decline at a slower rate from 1997 to present. In contrast, the recent 2003-2007 population increase was largely attributed to population growth at hibernacula in Illinois, Indiana, Kentucky, New York, and West Virginia. During the three intra-biennial survey periods from 2001-2003, 2003-2005 and 2005-2007, the rangewide population had increased by 10.8%, 16.9%, and 10.4%, respectively. In sharp contrast, from 2007 to 2009, the overall Indiana bat population declined by approximately 11.8% (a loss of approx. 55,458 bats) with most of the apparent declines occurring in Indiana, Kentucky, and New York and to a lesser extent Missouri, and Illinois). This was the first observed overall population decline since 2001 (Figure 2).

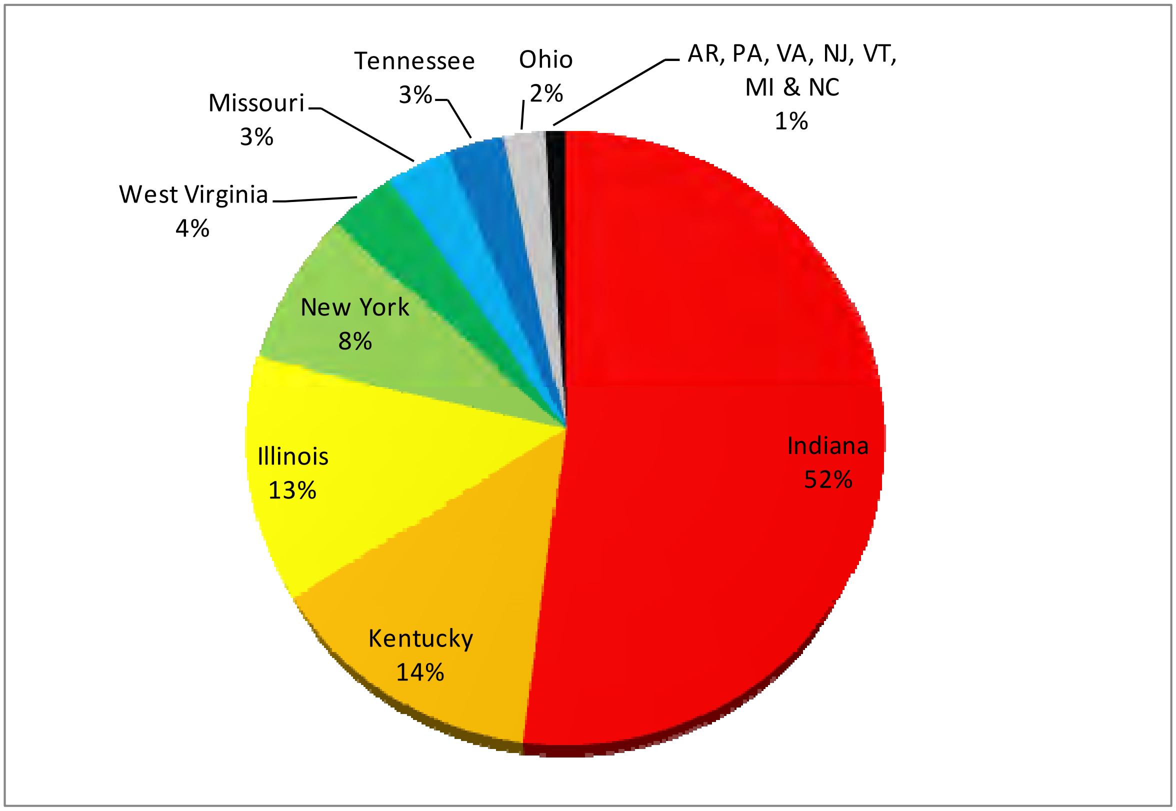

Figure 3. Pie chart of the 2009 Indiana bat rangewide population by state (USFWS, unpublished data, 2010) (total 2009 rangewide population estimate was 414,031 Indiana bats).

In 2009, the total Indiana bat population was estimated at approximately 414,000 bats, which represents a 35% decline from the 1971 population estimate of approximately 633,000 bats (Table 3). The overall population decline has not been uniformly distributed throughout the range of the species, however. Hibernating populations in the southern part of the range have declined by 71% in the past 40 years (since 1971), while those in the northern Midwest and Northeast had increased by up to 95% by 2007, prior to the onset of WNS and subsequent population declines in affected areas.

The population trends in the Indiana bat recovery units (RU) have not been uniform either (see Figure 1 for RU boundaries). Between 2001 and 2007, all four RUs had had a stable or upward trending population (Figure 4). However, in 2009 the Northeast and Midwest RUs both declined by 36.5% and 11.3% respectively. The overall decline in the Northeast RU primarily resulted from declines at several WNS-affected hibernacula in New York and the overall decline in the Midwest RU primarily stemmed from apparent declines at multiple P1 sites in Indiana and on P1 site in Kentucky (Figure 4). The Appalachian RU has shown a gradual increase between 2001 and 2009 and the Ozark-Central RU has remained relatively stable in recent years (2005-2009).

Table 3. Size and distribution of hibernating populations of the Indiana bat by region and state, based upon estimates nearest to the year indicated.[1]

	State	1971	1981	1991	2001	2007	2009
Southern Region	Alabama	300	276	216	173	258	253
	Arkansas	7,000	6,332	3,394	2,475	1,829	1,480
	S. Illinois	100	124	6,304	20,115	52,890	50,763
	Kentucky	100,000	93,935	80,765	51,053	71,250	57,325
	Missouri	346,000	232,911	87,138	18,999	15,895	13,674
	North Carolina	0	0	0	0	0	1
	Oklahoma	0	0	7	0	0	0
	Tennessee	15,500	18,998	8,598	9,564	8,906	12,721
	Virginia	1,300	1,121	1,599	969	723	730
	Subtotal	470,200	353,697	188,021	103,348	151,751	136,947
	% of Rangewide Total	74%	69%	50%	31%	32%	33%
Northern Region	N. Illinois (Blackball Mine)	100	20	621	1,562	2,513	2,513
	Indiana	157,000	151,676	162,714	173,111	238,026	215,277
	Michigan	0	0	0	20	20	20
	New Jersey	0	0	19	335	659	416
	New York	3,900	3,617	14,288	29,671	52,783	33,647
	Ohio	100	73	2,324	9,817	7,629	9,261
	Pennsylvania	800	440	262	702	1,038	1,031
	Vermont	0	2	8	246	325	64
	West Virginia	900	437	6,088	9,714	14,745	14,855
	Subtotal	162,800	156,265	186,284	225,178	317,738	277,084
	% of Rangewide Total	26%	31%	50%	69%	68%	67%
	Grand Total	633,000	509,962	374,345	328,526	469,489	414,031

[1] Not all surveys occurred exactly in the year portrayed in the table, particularly for the 1971 and 1981 columns. Population estimates for a particular period were based on the survey of that year or the nearest to the year indicated, either prior to or subsequent to that year.

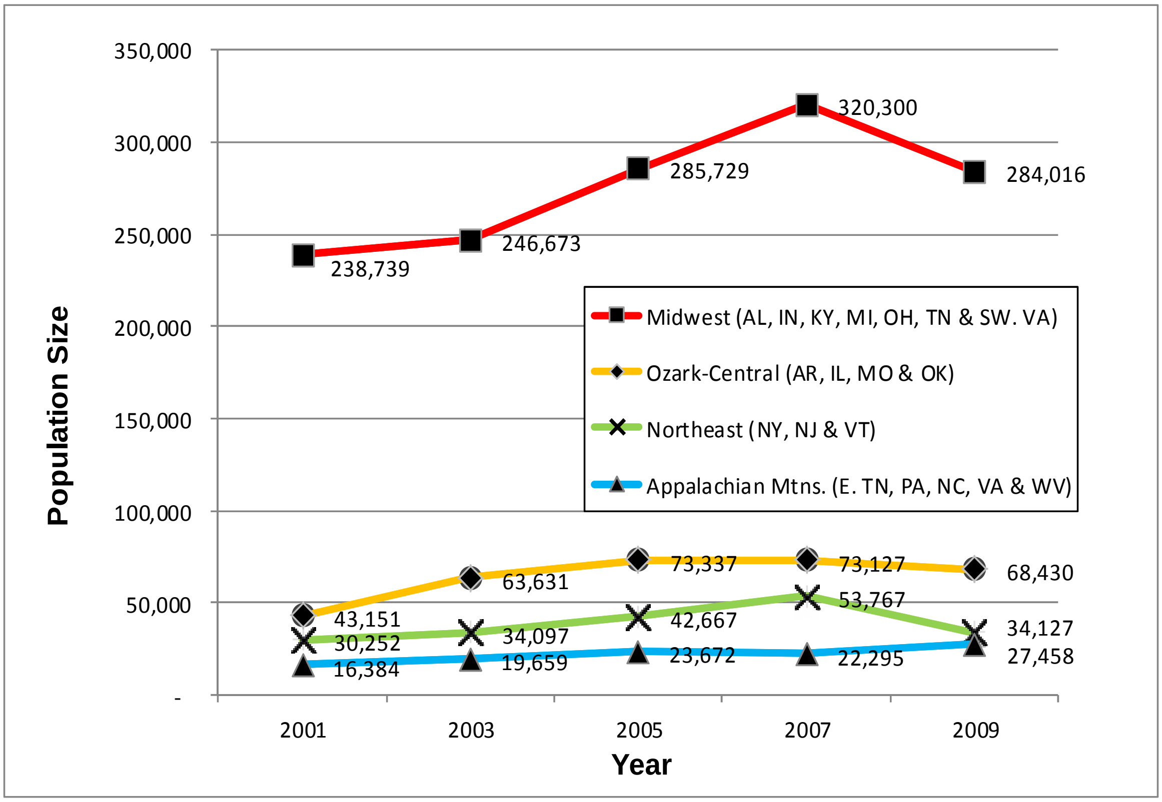

Figure 4. Most recent biennial Indiana bat population estimates by Recovery Unit.

Discussion

The Indiana bat population data in the Services' hibernacula database currently spans a period of 80+ years. Much effort and many resources have been expended over the decades by countless dedicated individuals (See Acknowledgements for a sampling) to obtain this data. Despite the Indiana bat's data set admittedly having some troublesome gaps (especially pre-1981; see USFWS 2007, Appendix 3) and including estimates derived from different survey techniques of variable accuracies (see Meretsky et al. 2010), to our knowledge, it remains unrivaled as the single most comprehensive and accurate population index available for any North American bat species and therefore is extremely valuable. Without such data, the Service would have few alternative means of monitoring and assessing population responses to threats and whether or not recovery goals are being achieved. Therefore, on behalf of the Service, I extend our sincere gratitude to all who have loaned us their hard-earned data over the many years.

The population numbers and trends presented in the text, tables, and figures more-or-less speak for themselves, but I will comment further on the following points.

- The Service recently reviewed existing population and threats data as part of a 5-Year Review for the Indiana Bat (King 2009). This review concluded that the population- and threats-based recovery criteria set forth in the draft recovery plan (USFWS 2007) had not yet been met and therefore the Indiana bat should remain listed as endangered. In 2007, WNS was not a known or recognized threat to the Indiana bat and therefore was not addressed in the draft recovery plan (USFWS 2007), but was included as an emerging threat in the 5-Year Review. In the year and a half since this review was completed, WNS has continued to threaten the species and *G.d.* has spread beyond the western boundary of the Indiana bat's range and to points north of this range. WNS has rapidly emerged as an unprecedented threat to numerous, perhaps all, hibernating bat species in North America (Blehert et al. 2009). The consensus of bat experts at a May, 2009 WNS meeting in Austin, Texas, was that "White-nose Syndrome is a devastating disease of hibernating bats that has caused the most precipitous decline of North American wildlife in recorded history." (http://www.batcon.org/, accessed 8-18-09). If the spread and current trends of mortality at affected sites continue, WNS threatens to drastically reduce the abundance of Indiana bats and other species of hibernating bats in major regions of North America in a remarkably short period of time (see Frick et al. 2010).

- The observed decline (-36.5%) within the Northeast RU between 2007 and 2009 (a net loss of approx. 19,640 bats) is presumably the result of bat mortality associated with the onset and spread of WNS. This decline may in reality be steeper than what we have calculated because some of the bats counted among the living during the winter hibernacula counts may have already been dead (yet still hanging on the ceiling/walls) and other WNS-affected bats likely died after the winter surveys were conducted. Therefore, the calculated decline should likely be considered a minimum.

- The overall population decline (-11.3%) within the Midwest RU between 2007 and 2009 (a net loss of approx. 36,284 bats) primarily resulted from large population declines at one P1 hibernaculum in KY (Bat Cave in Carter Co) and three P1 hibernacula in Indiana (Ray's, Jug Hole, and Twin Domes caves). WNS was not detected at these sites in 2009 (nor 2010) and no WNS-associated mortality was observed elsewhere in this RU that year. The Service and its partners are investigating potential causes that may have contributed to the apparent population declines at these sites. One plausible explanation for the apparent decline at Bat Cave in Kentucky was that the Indiana bats appeared to be utilizing cracks in the cave ceiling more so in 2009 than had been observed in previous years, which may have obscured some unknown portion of the bats from the surveyors view (Mike Armstrong, USFWS, pers. comm., 2011). Potential causes of the apparent declines at the Indiana sites are still being explored.

- Over the past 5+ years, the Service and its partners have invested a significant amount of staff time and resources into researching, developing, and field testing new and improved population survey techniques for the Indiana bat (Hamilton et al. 2009, Meretsky et al. 2010) and have tackled a few problematic survey sites as well (e.g., Elliott and Kennedy 2008). The importance of these actions was recognized by the Service and they were included as priority tasks needing to be completed in the draft recovery plan (USFWS 2007). As a result of our own exploratory efforts and those of a few pioneers (e.g., Al Hicks and Carl Herzog), digital photography has emerged as an efficient and highly accurate survey tool in many hibernacula settings and an excellent means for conducting WNS surveillance as well. Therefore, the Service has been encouraging the use of digital cameras during winter surveys of *M. sodalis* and will continue to research and develop new survey techniques in an ongoing effort to improve both the accuracy and consistency of our bat population estimates.

Acknowledgements

I wish to thank the many individuals responsible for collecting and collating hibernacula survey data of Indiana bats over the many past decades: T. Aley, M. Armstrong, W. W. Baker, J. Belwood, C. Benson, S. Bosworth, A. Boynton, V. Brack, A. Breisch, E. Britzke, J. Brown, S. Brown, C. Butchkoski, T. Carter, J. Chenger, R. Clawson, S. Cochran, C. Collins, S. Collins, G. Conner, D. Corgiat, J. B. Cope, T. Counts, D. Crane, R. Currie, D. Dalton, G. Dalton, S. Darling, W. Davis, J. Dickson, R. Dubos, J. Duffey, K. Dunlap, B. Elliott, T. Elliot, D. Feller, H. Garland, J. Garner, J. E. Gates, J. C. Fisher, J. Gardner, B. Glass, J. Godwin, D. Good, J. Gore, G. O. Graening, G. Graeter, J. Hajenga, J. S. Hall, J. Hargis, S. Harriss, M. J. Harvey, N. Heaslip, R. Heidorn, T. Hemberger, A. Henry, H. Henry, S. Hensley, A. Hicks, C. Herzog, J. Hofmann, D. Howell, K. Hudson, S. Humphrey, S. Johnson, J. Kath, J. Kennedy, E. King, M. King, J. Kiser, K. Knight, A. Kurta, M. Lacki, R. LaVal, J. Leffler, B. Lindsay, B. Loges, J. MacGregor, B. Madje, B. Marsh, C. McGrath, R. McClanahan, V. Meretsky, L. Merhoff, C. Mohr, E. Mortenson, R. Mumford, R. Myers, D. Newman, R. Niver, P. Novak, R. Olson, J. Ozier, B. Palmer-Ball, D. Pelren, M. Phipps, L. Pruitt, S. Pruitt, B. Puckette, S. Rapaski, D. Ray, R. Reynolds, N. Rogers, S. Samoray, C. Sanders, B. Sasse, P. Savoie, D. Saugey, A. Scherer, J. Schwierjohann, J. Sealander, J. Shimp, G. Sievert, B. S. Silliman, B. Slack, R. Slack, T. Sollman, R. Stark, B. Steffen, C. Stihler, M. Sutton, D. Swanson, D. Tecic, S. Thomas, G. Turner, M. Tuttle, M. Valent, S. vonOettingen, J. Wallace, J. Whitaker, S. Widowski and dozens of others that have assisted and I have inadvertently omitted.

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Andrew King is an endangered species biologist in the U.S. Fish and Wildlife Service's Ecological Services Field Office in Bloomington, Indiana. He began working with bats 20 years ago as an environmental consultant and conducted many surveys and radio-telemetry studies of Indiana bats and gray bats in 10 states. Since joining the USFWS in 2001, he has conducted/developed Section 7 consultations, Habitat Conservation Plans, NEPA analyses, and a wide variety of ESA recovery planning and implementation efforts. In 2007, he wrote the sections of the *Indiana Bat Draft Recovery Plan: First Revision* pertaining to population distribution, abundance, and trends and recently completed a 5-Year Review for the Indiana bat. He coordinates the biennial Indiana bat winter population surveys and maintains the Service’s Indiana Bat Hibernacula Database, which he created in 2005. He holds a BS in Wildlife Science from Purdue University and a MS in Raptor Biology from Boise State University.

Indiana Bat Population Status and Trends

presented by
Andy King
U.S. Fish and Wildlife Service
Bloomington Field Office, Indiana

September 1 , 2010

Federal Status of the Indiana Bat

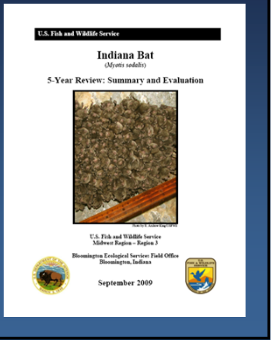
- *Myotis sodalis* was originally listed as being in danger of extinction under the Endangered Species Preservation Act of 1966 (32 FR 4001, March 11, 1967),
- Overall population was approx. 883,000 bats at time of original listing.
- Currently listed as "endangered" under the Endangered Species Act (ESA) of 1973, as amended.

Factors contributing to population declines

- Winter populations in caves and mines were vulnerable to human disturbance, vandalism, and natural hazards,
- Improper cave gates and structures physically blocked bat ingress/egress and/or restricted airflow leading to altered/unsuitable micro-climates within hibernacula,
- Changing land-uses (e.g., forest clearing and fragmentation), and
- Chemical contamination.

5-Year Review

- completed in 2009
- evaluated progress towards achieving recovery criteria laid out in the 2007 draft recovery plan
- **Bottom-Line:** the Indiana bat still remains "endangered."



U.S. Fish and Wildlife Service

Indiana Bat
(Myotis sodalis)

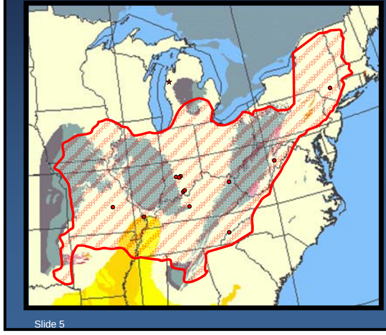
5-Year Review: Summary and Evaluation

U.S. Fish and Wildlife Service
Midwest Region – Region 3

Bloomington Ecological Services Field Office
Bloomington, Indiana

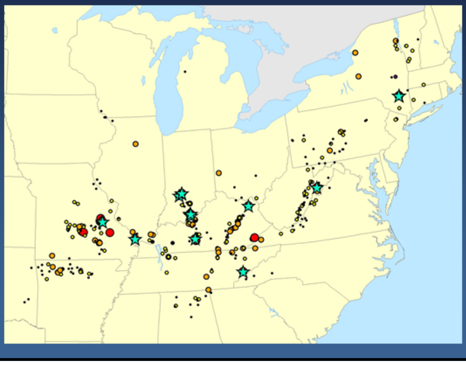
September 2009

Range of the Indiana Bat in relation to Eastern U.S. Coal Fields



- Approximate Indiana Bat Composite Range (summer and winter)
- ★ Isolated Record
- ● Priority IA Hibernacula (>10,000 bats since 1999)
- 🟧 Anthracite (potentially minable)
- 🟨 Lignite (potentially minable)
- ▨ Low Volatile Bituminous (potentially minable)
- ▨ Medium and High Volatile Bituminous (potentially minable)
- ■ Medium and High Volatile Bituminous (other uses)

Indiana Bat Hibernacula



Priority 1 (P1): ≥ 10,000 Indiana bats.
P1A ≥ 5,000 bats over the past 10 years.
P1B < 5,000 bats over the past 10 years.

Priority 2 (P2): 1,000 to 9,999 bats.

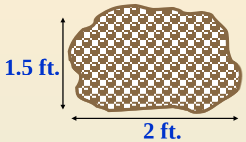
Priority 3 (P3): 50 to 999 bats.

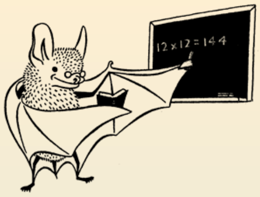
Priority 4 (P4): < 50 bats.

Packing densities of large clusters of *M. s.* reported between 194 – 500+ bats/ft.^{2}

LaVal and LaVal 1980
Hicks and Novak 2002
Tuttle 2003
Elliot and Kennedy 2008

Math

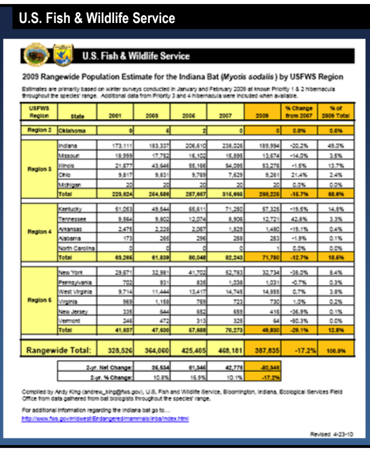




Using the dimensions of the cluster above and the packing densities below, calculate the estimated number of Indiana bats within the cluster.

If 300 bats/ft.^{2}, then total # of bats = 900
If 400 bats/ft.^{2}, then total # of bats = 1200

In 2009, we compiled data from 16 states with extant winter populations



U.S. Fish & Wildlife Service

2009 Rangewide Population Estimate for the Indiana Bat (*Myotis sodalis*) by USFWS Region

Estimates are primarily based on winter surveys conducted in January and February 2009 at known Priority 1 & 2 hibernacula throughout the species' range. Additional data from Priority 3 and 4 hibernacula were included when available.

USFWS Region	State	2001	2003	2005	2007	2009	% Change from 2007	% of 2009 Total
Region 2	Oklahoma	0	6	2	0	0	0.0%	0.0%
Region 3	Indiana	173,111	183,337	206,610	238,026	189,994	-20.2%	49.0%
	Missouri	18,999	17,752	16,102	15,895	13,674	-14.0%	3.5%
	Illinois	21,677	43,646	55,166	54,095	53,276	-1.5%	13.7%
	Ohio	9,817	9,831	9,769	7,629	9,261	21.4%	2.4%
	Michigan	20	20	20	20	20	0.0%	0.0%
	Total	223,624	254,586	287,667	315,665	266,225	-15.7%	68.6%
Region 4	Kentucky	57,053	49,544	65,611	71,250	57,325	-19.6%	14.8%
	Tennessee	9,564	9,802	12,074	8,906	12,721	42.8%	3.3%
	Arkansas	2,475	2,228	2,067	1,829	1,480	-19.1%	0.4%
	Alabama	173	265	296	258	253	-1.9%	0.1%
	North Carolina	0	0	0	0	1	0.0%	0.0%
	Total	69,266	61,839	80,048	82,243	71,780	-12.7%	18.5%
Region 5	New York	29,671	32,981	41,702	52,783	32,734	-38.0%	8.4%
	Pennsylvania	702	931	836	1,038	1,031	-0.7%	0.3%
	West Virginia	9,714	11,444	13,417	14,745	14,855	0.7%	3.8%
	Virginia	969	1,158	769	723	730	1.0%	0.2%
	New Jersey	335	644	652	659	416	-36.9%	0.1%
	Vermont	246	472	313	326	64	-80.3%	0.0%
	Total	41,637	47,630	57,688	70,273	49,830	-29.1%	12.8%
Rangewide Total:		328,526	364,060	425,405	468,181	387,835	-17.2%	100.0%

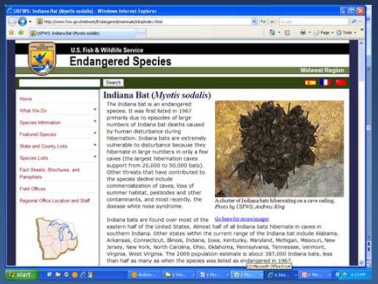
2-yr. Net Change:	35,534	61,345	42,776	-80,346
2-yr. % Change:	10.8%	16.9%	10.1%	-17.2%

Compiled by Andy King (andrew_king@fws.gov), U.S. Fish and Wildlife Service, Bloomington, Indiana, Ecological Services Field Office from data gathered from bat biologists throughout the species' range.

For additional information regarding the Indiana bat go to...
http://www.fws.gov/midwest/Endangered/mammals/inba/index.html

Revised 4-23-10

2009 population data are posted on the Region 3 Indiana bat website



Indiana Bat (*Myotis sodalis*)

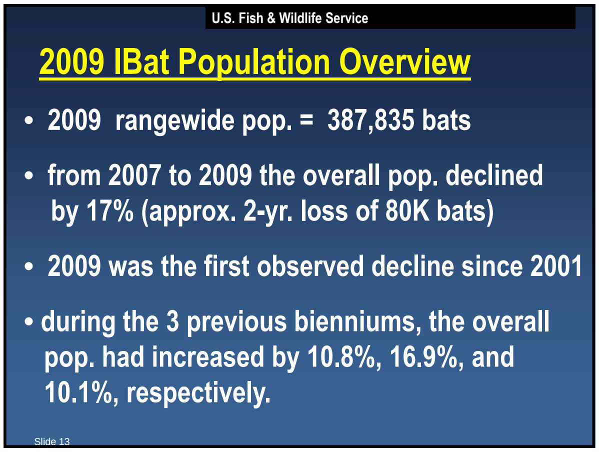
The Indiana bat is an endangered species. It was first listed in 1967 primarily due to episodes of large numbers of Indiana bat deaths caused by human disturbance during hibernation. Indiana bats are extremely vulnerable to disturbance because they hibernate in large numbers in only a few caves (the largest hibernation caves support from 20,000 to 50,000 bats). Other threats that have contributed to the species decline include commercialization of caves, loss of summer habitat, pesticides and other contaminants, and most recently, the disease white nose syndrome.

A cluster of Indiana bats hibernating on a cave ceiling. *Photo by USFWS; Andrew King*

Go here for more images

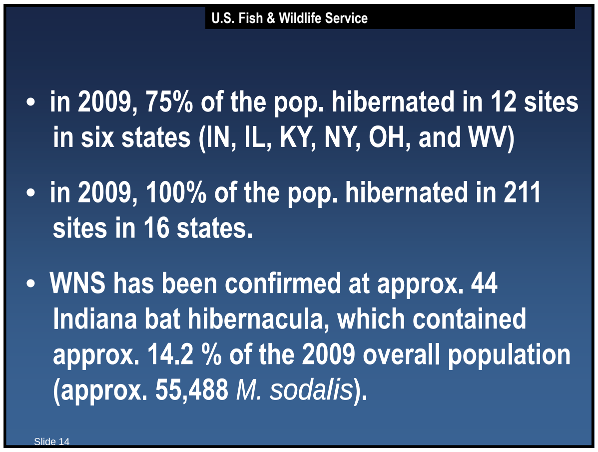
Indiana bats are found over most of the eastern half of the United States. Almost half of all Indiana bats hibernate in caves in southern Indiana. Other states within the current range of the Indiana bat include Alabama, Arkansas, Connecticut, Illinois, Indiana, Iowa, Kentucky, Maryland, Michigan, Missouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia. The 2009 population estimate is about 387,000 Indiana bats, less than half as many as when the species was listed as endangered in 1967.

http://www.fws.gov/midwest/Endangered/mammals/inba/index.html

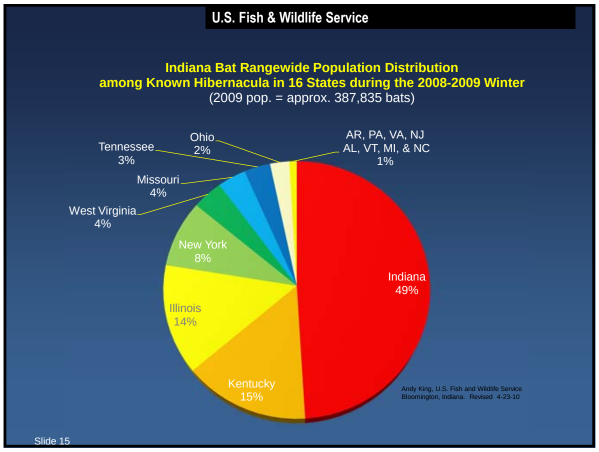


2009 IBat Population Overview

- 2009 rangewide pop. = 387,835 bats
- from 2007 to 2009 the overall pop. declined by 17% (approx. 2-yr. loss of 80K bats)
- 2009 was the first observed decline since 2001
- during the 3 previous bienniums, the overall pop. had increased by 10.8%, 16.9%, and 10.1%, respectively.



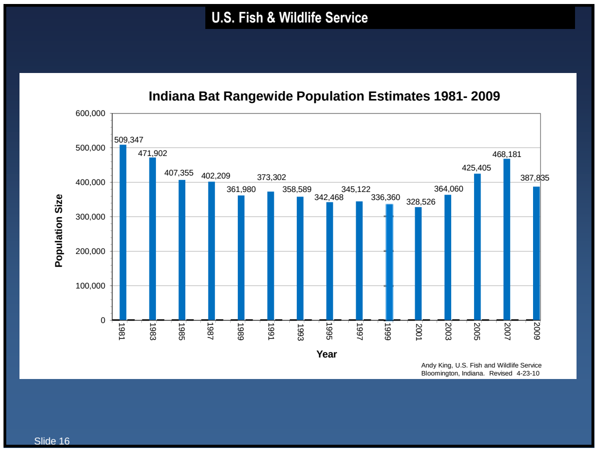
- in 2009, 75% of the pop. hibernated in 12 sites in six states (IN, IL, KY, NY, OH, and WV)
- in 2009, 100% of the pop. hibernated in 211 sites in 16 states.
- WNS has been confirmed at approx. 44 Indiana bat hibernacula, which contained approx. 14.2 % of the 2009 overall population (approx. 55,488 *M. sodalis*).



Indiana Bat Rangewide Population Distribution among Known Hibernacula in 16 States during the 2008-2009 Winter

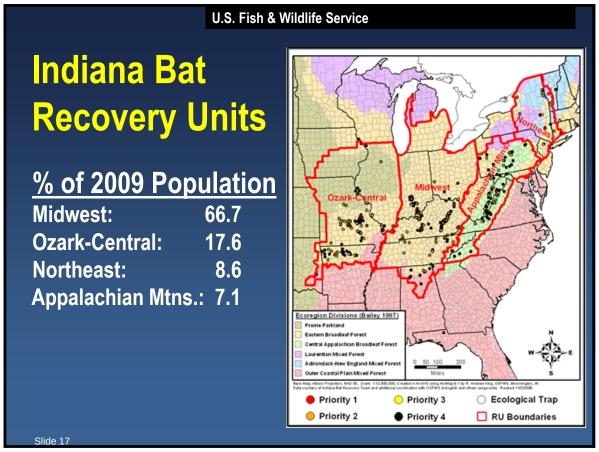
(2009 pop. = approx. 387,835 bats)

Andy King, U.S. Fish and Wildlife Service Bloomington, Indiana. Revised 4-23-10



Indiana Bat Rangewide Population Estimates 1981- 2009

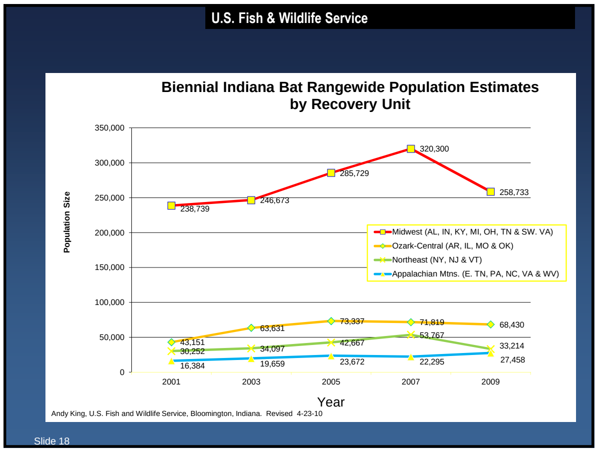
Andy King, U.S. Fish and Wildlife Service Bloomington, Indiana. Revised 4-23-10



Indiana Bat Recovery Units

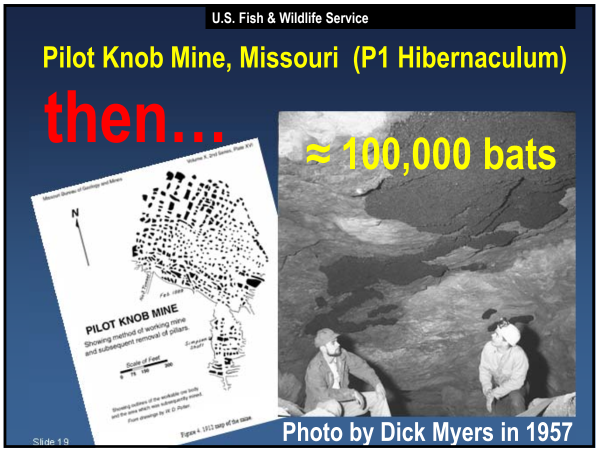
% of 2009 Population

Midwest:	66.7
Ozark-Central:	17.6
Northeast:	8.6
Appalachian Mtns.:	7.1



Biennial Indiana Bat Rangewide Population Estimates by Recovery Unit

Andy King, U.S. Fish and Wildlife Service, Bloomington, Indiana. Revised 4-23-10



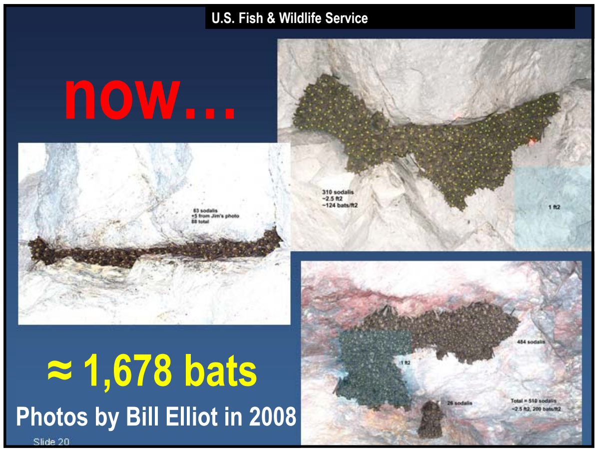
U.S. Fish & Wildlife Service

Pilot Knob Mine, Missouri (P1 Hibernaculum)

then…

≈ 100,000 bats

Photo by Dick Myers in 1957

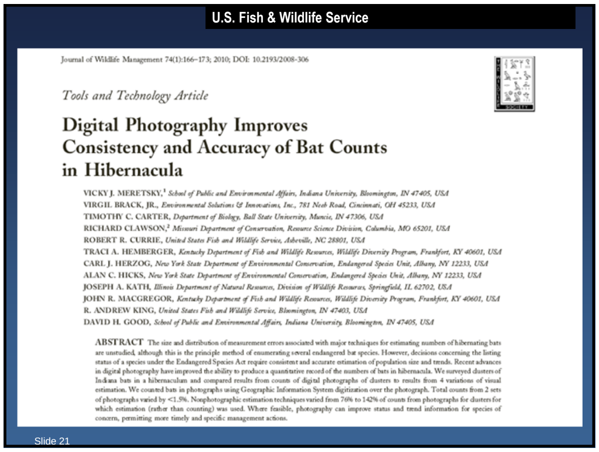


U.S. Fish & Wildlife Service

now…

≈ 1,678 bats

Photos by Bill Elliot in 2008



U.S. Fish & Wildlife Service

Journal of Wildlife Management 74(1):166–173; 2010; DOI: 10.2193/2008-306

Tools and Technology Article

Digital Photography Improves Consistency and Accuracy of Bat Counts in Hibernacula

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DAVID H. GOOD, *School of Public and Environmental Affairs, Indiana University, Bloomington, IN 47405, USA*

ABSTRACT The size and distribution of measurement errors associated with major techniques for estimating numbers of hibernating bats are unstudied, although this is the principle method of enumerating several endangered bat species. However, decisions concerning the listing status of a species under the Endangered Species Act require consistent and accurate estimation of population size and trends. Recent advances in digital photography have improved the ability to produce a quantitative record of the numbers of bats in hibernacula. We surveyed clusters of Indiana bats in a hibernaculum and compared results from counts of digital photographs of clusters to results from 4 variations of visual estimation. We counted bats in photographs using Geographic Information System digitization over the photograph. Total counts from 2 sets of photographs varied by <1.5%. Nonphotographic estimation techniques varied from 76% to 142% of counts from photographs for clusters for which estimation (rather than counting) was used. Where feasible, photography can improve status and trend information for species of concern, permitting more timely and specific management actions.

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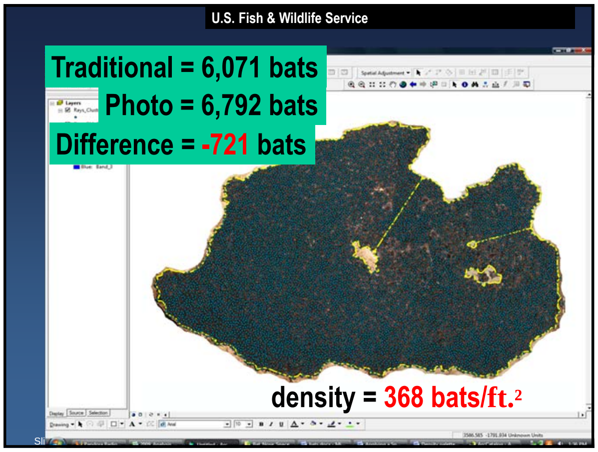
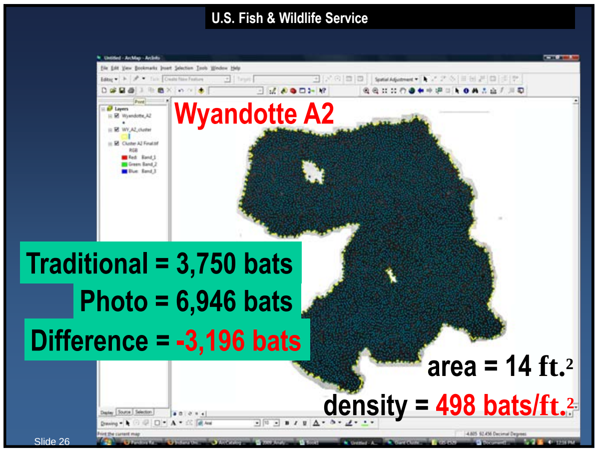


U.S. Fish & Wildlife Service

Traditional = 6,071 bats
Photo = 6,792 bats
Difference = -721 bats

density = 368 bats/ft.²


U.S. Fish & Wildlife Service


U.S. Fish & Wildlife Service

Traditional = 3,750 bats
Photo = 6,946 bats
Difference = -3,196 bats

area = 14 ft.^{2}
density = 498 bats/ft.^{2}


U.S. Fish & Wildlife Service

Pilot study using image-recognition software

Hamilton et al. 2009


U.S. Fish & Wildlife Service

Figure 9—Feature Analyst produced polygons encircling bat muzzles. Errors of commission and omission are shown in the inset. The number of polygons delineated by Feature Analyst for this cluster was 3 percent lower than the manually interpreted count of 242. Photo courtesy of Alan C. Hicks.


U.S. Fish & Wildlife Service

Thank You

THE RANGE-WIDE INDIANA BAT PROTECTION AND ENHANCEMENT PLAN: WHERE WE WERE, WHERE WE ARE, AND WHERE WE HOPE TO BE

Carrie L. Lona
U.S. Fish & Wildlife Service
Kentucky Field Office
Frankfort, Kentucky

Abstract

In 1996, a Biological Opinion (BO) was issued to the Office of Surface Mining (OSM) by the U.S. Fish and Wildlife Service (FWS) for surface mining and reclamation operations under the Surface Mining Control and Reclamation Act of 1977. The BO serves as an overall framework for OSM's compliance with the Endangered Species Act (ESA). In particular, the 1996 BO: (a) evaluated SMCRA's potential effects on federally listed species, (b) determined that implementation of SMCRA would not jeopardize the continued existence of any federally listed species, and (c) identified several reasonable and prudent measures that must be met in order for SMCRA-authorized coal mining programs to maintain compliance with the ESA. A key condition of the 1996 BO required each state to 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." For the federally endangered bat (*Myotis sodalis*), this proved to be a difficult and complicated condition to meet. Ideas concerning protective measures varied widely between local FWS offices and state regulatory authorities and were inconsistent across the species' range. These conflicts and inconsistencies often led to separate ESA requirements within different permitting programs for the same project and a delay in permit review and issuance.

Due to concerns that agencies were not consistently implementing the 1996 BO, a team facilitated by OSM, representing three FWS regions, and including state coal mining regulatory programs, met in 2009 and developed guidelines to provide habitat protection and avoidance measures for the Indiana bat that could be used in coal mining states across the species' range. State participation on the team and peer review of the guidelines was coordinated by the Interstate Mining Compact Commission (IMCC), a multi-state organization representing the natural resource interests of its member states. The team developed the *Range-wide Indiana Bat Protection and Enhancement Plan* (PEP) *Guidelines* to assist surface mining applicants and state coal mining regulatory agencies (RA) with the process and ensure protection of this species during coal mining operations. Based on the best scientific information available and current mining practices, the PEP guidelines identify species-specific protective measures for the Indiana bat and outline many of the options that are available for applicants to satisfy these requirements. States began implementing the new guidelines in the fall of 2009 with a goal of providing recommendations to promote consistency in PEP's among states/regions within the range of the Indiana bat.

Range-wide Indiana Bat Protection and Enhancement Plan (PEP) Guidelines

The guidelines are intended to cover the applicant and the RA under the ESA for the Indiana Bat. The guidelines are a *minimum* set of requirements/recommendations; state RA's and local FWS offices may require additional measures. If the guidelines are not implemented, the RA and/or applicant may not be covered under the ESA.

Implementation of the guidelines has led to several questions and a need for clarification on some issues:

1. <u>Do the guidelines need to be followed by all mining states within the Indiana bat's range?</u>
   Following the guidelines ensures that the applicant and RA will be covered under the ESA for the Indiana bat. If the applicant and/or RA cannot follow the guidelines, they should coordinate with the local FWS office to achieve compliance.

2. <u>If these are "guidelines" why are some measures "required"?</u>
   Required measures are those elements that the development team acknowledged as critical to achieving compliance with the "No Jeopardy" determination of the Biological Opinion. Recommended measures are desired because of their benefits to Indiana bats, but are not critical.

3. Is it permissible to cut trees in the summer?
   Removing trees during the summer may be permissible if the RA and/or FWS determine that the forested habitat within the project area is not suitable for Indiana bats (i.e- contains no trees greater than or equal to 5 inches in diameter at breast height (dbh) with exfoliating bark) or on a case-by-case, project-specific basis and if approved by the local FWS office.

4. Why is selective tree clearing no longer allowed?
   Selective tree clearing allowed the removal of all suitable roost trees within a project area during the winter, when Indiana bats would not be present. A permitted biologist would walk the site, marking all potential roost trees to be removed. Once all suitable roost trees had been removed, the remaining forested habitat, not considered suitable for Indiana bat utilization, could be removed during any time of the year.

   Observations by state regulatory authority biologists showed that suitable roost trees/snags were being missed, especially within large permit areas, and it was determined that is was not feasible for a permitted biologist to mark every possible roost tree/snag within an area. In addition, there were instances where selectively removing roost trees actually created more Indiana bat roosting habitat. This occurred because the felling of selected trees killed or injured live trees and created snags (i.e. the operation produced trees that were once unsuitable were now suitable Indiana bat roost trees). In other instances, natural events (e.g., ice storms, wind-throw, etc.) could create suitable habitat after selective tree clearing had occurred, so, collectively, these factors showed that selective tree clearing was problematic and should be avoided. After several discussions within the development team, it was determined that risks associated with selective tree clearing outweighed the benefits to Indiana bats. In some cases, the RA and local FWS may agree that selective tree clearing is appropriate, but this would only be on very small parcels where it could be clearly demonstrated that all suitable trees could be marked and removed without creating additional habitat.

Since the initial implementation of the guidelines, several future improvements have been identified, which include:

- Applicants should submit a thorough habitat assessment with the application or preliminary application to better assist the RA/USFWS in making a habitat determination;
- Applicants should only submit PEPs that, at a minimum, follow the guidelines;
- Applicants should consider early coordination if a project will not be able to follow the guidelines; and
- There is a need for continual outreach and communication among the RA's, local FWS offices, applicants, and the mining industry.

Conclusion

Overall, the implementation of the guidelines appears successful. The majority of RA's, local FWS offices, and applicants have stated that they are benefitting from a clear, concise guide for protecting the Indiana bat on coal mining projects.

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EVERYTHING YOU WANTED TO KNOW ABOUT “TAKE”
IN THE ENDANGERED SPECIES ACT

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Abstract

“Take” is a powerful component of the Endangered Species Act (ESA). The ESA wields a strong hammer when the potential for take of listed species occurs – there are civil and criminal penalties for prohibited take. If an action is likely to “take” listed species then both the government and private parties must seek an exception for prohibited take either in the form of an incidental take statement under section 7 or an incidental take permit under section 10 of the ESA.

The definition of “take,” therefore, is a core component in the analysis of any action that may affect listed species. The ESA offers a broad definition of “take,” which has been further defined by regulations promulgated by the U.S. Fish and Wildlife Service. Under these regulations, the subcomponents “harm” and “harass,” as a form of “take,” are defined. The Supreme Court upheld the Service’s right to promulgate those definitions. This discussion will focus on the statutory and regulatory prohibitions against take, the definitions of take and its various components, as well as court decisions that offer further guidance on take.

Take Under the Endangered Species Act

The stated purposes of the Endangered Species Act (ESA) of 1973 are to provide a means to protect the ecosystems of endangered and threatened species, to provide a program for the conservation of threatened and endangered species, and to promote steps to achieve the purposes of certain specified treaties and conventions set out in the ESA.[1] Section 4 of ESA sets out procedures to qualify a plant or wildlife species to become “listed” as a species protected under the ESA. Once a plant or wildlife species has been “listed” under the ESA, as either a “threatened” or “endangered” species, certain specific protections under the ESA are triggered.[2]

Definition of “Take”

Generally, the ESA prohibits the “taking” of listed fish and wildlife species.[3] Specifically, the ESA states that it is unlawful for any person to “take any such species within the United States or territorial sea of the United States.” The term “take” is defined in the ESA as “to harass, harm, pursue, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.” [4] Most of the terms listed as prohibited acts in the definition of “take” are self-evident and relate to acts like deliberate hunting that, traditionally, have been subject to government regulation. Some of the prohibited acts (e.g. harass, harm) in the definition, however, are broader in scope and were not found in traditional conservation laws.

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[1] 16 U.S.C. § 1531(b).

[2] This paper represents only a broad discussion of “take” under the ESA. In addition to the prohibition against the taking of listed species, the ESA provides multiple tools for the conservation of species.

[3] 16 U.S.C. § 1538. For fish and wildlife species under the jurisdiction of the Fish and Wildlife Service, generally, take is prohibited for both threatened and endangered wildlife unless there is a special 4(d) rule for that species. Under the ESA, there is no prohibition for the take of listed plants. There are, however, prohibitions against jeopardizing listed plant species, removing plants from areas under Federal jurisdiction, maliciously damaging or destroying plants from areas under Federal jurisdiction, or removing, cutting, digging up, damaging, or destroying plants in any area in knowing violation of State laws. 16 U.S.C. §1538(a)(2)(B).

[4] 16 U.S.C. § 1532 (19).

In 1981, the United States Fish and Wildlife Service (the "Service") and the National Marine Fisheries Service ("NMFS") finalized regulations to define the terms "harm" and "harass." The term "harm" was defined as:

> an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter. 50 C.F.R. §17.3

The term "harass" was defined as:

> An intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering.[5] 50 C.F.R §17.3.

These definitions were not without controversy. Most of the controversy surrounded the potential consequences for "take" could be caused by an underlying action's habitat modification. Some landowners and land managers, in particular, were concerned that this definition could include actions that, in the past, were not considered to trigger the prohibition against take under the ESA. Specifically, under these new definitions, where changes to habitat could result in illegal "take," certain land activities such as logging, grazing, or mining now had the potential to trigger criminal and civil penalties under section 9 of the ESA. For example, after promulgation of these definitions, a mining company would have to consider whether any habitat modification that occurred because of their actions would kill or injure a listed species by significantly impairing "essential behavioral patterns" rather than just whether their activity would directly kill or injure a listed species.

Like most matters involving the ESA, the controversy of the proper definition of "harm" eventually was tested in the courts. Two decades after the definition of "harm" was proposed, litigation over the definition managed to work its way all the way to the Supreme Court. The case before the Supreme Court involved an attack on the validity of the rule itself, not the application of that rule. That is, the Respondents[6] (a group of small landowners, logging companies and private individuals) argued that the regulatory definition of "harm" was not supported by the congressional legislative history and that section 5 of the ESA, which allows for the Secretary to buy land, was the exclusive check on habitat degradation for listed species. In short, the Respondents argued that the definition of "harm" went too far by including the potential for take liability from habitat modification.

The majority of the Supreme Court disagreed with Respondent's arguments and concluded that the regulatory definition of "harm" was valid as it "rested on a permissible construction of the ESA."[7] The Court concluded that the ordinary meaning of the word "harm" does not duplicate any of the other descriptive actions in the statutory definition of "take"; that the broad purpose of the ESA supports the concept of protecting the "precise harm" of habitat degradation; and, the language of the ESA indicates that Congress understood that section 9 prohibition against take would apply to "indirect takings" as well as direct takings.[8] The definition of "harass" has been the focus of very limited litigation and the regulatory definition noted above stands.

Penalties

Section 11 of the ESA provides for criminal, civil, and administrative penalties for violations of its "take" prohibitions.[9] In addition, in certain circumstances, injunctive relief can also be pursued. The level of criminal sanctions depends on the listing status of the species. Anyone who knowingly violates the ESA's take prohibitions with respect to endangered species

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[5] The definition of "harass" also sets out three exceptions related to the care of captive wildlife.

[6] The "Respondents" before the Supreme Court, were the plaintiffs at the District Court level. The District Court found against them. The Court of Appeals, after initially affirming the judgment of the lower court, ultimately reversed the lower court's ruling. The government, therefore, petitioned the Supreme Court to hear this matter.

[7] *Babbitt v. Sweet Home Chapter of Communities for a Great Oregon*, 110 S.Ct. 2401(1995).

[8] The Court issued a majority opinion, a concurring opinion, and a dissenting opinion in this matter. The issues of "indirect effects" and causation were a significant part of the focus in the concurring and dissenting opinions.

[9] 16 U.S.C. §1540.

can be imprisoned for up to one year and fined up to $50,000 or both.[10] With respect to take of a threatened species, the penalty can be up to six months imprisonment and a $25,000 fine or both. Civil penalties may attach as well – up to $25,000 for each violation of an endangered species and $12,500 for a take of a threatened species. Federal agencies also have the authority to take administrative actions such as revoking leases, licenses, or permits for violations of the ESA's take prohibitions. Further, the ESA contains an all-encompassing forfeiture clause, which could result in the forfeiture of essentially all objects (including guns, equipment, vessels, aircraft, etc) used "to aid the taking." Finally, courts have the power to enjoin actions that unlawfully take listed species.

Unlike many other wildlife statutes, the ESA provides for citizen suits against anyone for the violation of any provision of the ESA.[11] That is, a private individual or group can file suit to enjoin the actions of an individual or a government agency for violations under the ESA. This is a very powerful tool for a private individuals or groups as it allows them to focus a court's attention on activities that may impact listed species even if the Federal government is not aware of the violation or has chosen not to act on the violation.

Exceptions to the Prohibitions on Take

The ESA provides some exceptions to the prohibition on take of listed species of fish and wildlife. The two most common exceptions are the take authorizations that are granted under section 7 and section 10 of the ESA. Under either of these sections, if certain procedures are followed and certain required findings are made, take can be authorized.

Consultation under section 7 of the ESA is the mechanism federal agencies can use to acquire authorization for take of listed species.[12] Section 7 of the ESA, and its implementing regulations, require federal agencies to consult with the Fish and Wildlife Service (the Service) to determine if any discretionary agency action they take may affect a listed species.[13] If that action is likely to adversely affect a listed species, the action agency must engage in formal consultation with the Service. The Service ultimately issues a biological opinion that determines whether the agency's action is likely to jeopardize the continued existence of a listed species or adversely modify designated critical habitat. If the Service determines that the action is not likely to jeopardize the continued existence of a listed species, the Service is required to produce an Incidental Take Statement (ITS). The ITS is the mechanism that "authorizes" the take. The ESA, however, requires that the ITS contain "reasonable and prudent" measures that minimize the impact of the action on listed species. The action agency (or applicant) must comply with the RPM's and any terms and conditions associated with the RPM's in order to receive the exemption from liability for take.

Individuals or actors other than the Federal Government can receive a permit for the incidental take of listed species under the procedures set forth in section 10 of the ESA.[14] In order to receive the permit, first an applicant is required to submit a "conservation plan," more commonly called a "conservation habitat plan" or "HCP." Section 10 requires that the plan include measures to mitigate for any take that is likely to occur because of the underlying action. Further, the ESA requires that the impacts of any incidental taking will be "minimized and mitigated" to the "maximum extent practicable."[15] Finally, the Service must determine that the take that results from the underlying action will not "appreciably reduce the likelihood of the survival and recovery of the species in the wild." If all the requirements of section 10 are met, an incidental take permit is issued.

Conclusion

Congress enacted the ESA because they found that various species of fish, wildlife and plants were extinct and that other species were in danger of extinction. Congress declared that those species are of "esthetic, ecological, educational, historical,

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[10] In 1978, Congress lowered the standard from "willful" to "knowing". "Knowing" does not mean that the person had to know the species being taken was a listed species but rather simply that the person "knowing" took the action that resulted in the take. For example, a hunter does not have to "know" that he shot a listed bird as long as he knowingly shot his gun.

[11] 16 U.S.C. §1540(g).

[12] 16 U.S.C. §1536.

[13] If the action may affect a listed species under the jurisdiction of the National Marine Fisheries Service (NMFS), the action agency consults with that agency. NMFS is governed by the same consultation regulations as is the Service. These regulations are set out in 15 C.F.R. Part 402.

[14] 16 U.S.C. §1539.

[15] There are other procedural requirements – including proof of funding – not discussed here. See, also,

recreational, and scientific value" to this country.[16] The ESA, therefore, contains powerful prohibitions against the take of species listed under the provisions of the ESA. Those who knowingly violate the take provisions, without first receiving an ITS under section 7 of the ESA or an incidental take permit under section 10 of the ESA, face the potential for civil, criminal, and injunctive actions taken against them.

Peg Romanik is a senior attorney with the Division of Parks and Wildlife, Office of Solicitor, U.S. Department of the Interior. Peg's focus is primarily on section 7 of the ESA. She coordinates national level legal issues across the country. She works with regional and field office attorneys in the Solicitor's Office as well as with other Federal agencies' ESA attorneys. Peg works with FWS biologists both in DC as well as in regional and field offices when vexing section 7 issues arise. She frequently helps teach the section 7 classes at the National Conservation Training Center. Peg also coordinates with various U.S. Attorney offices and the Department of Justice on cases involving the Fish and Wildlife Service. Peg graduated from the University of Notre Dame law school and Michigan State University.

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[16] 16 U.S.C. §1531(3).

Range-Wide Indiana Bat Protection and Enhancement Guidelines: Where We Were, Where We Are, and Where We Hope to Be

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Important Things That Would Not Exist If It Weren't For Bats:

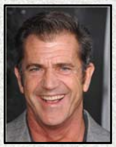
Batman

Grandpa Munster

Minor League Baseball Teams

Meatloaf

"Blind as a bat!"

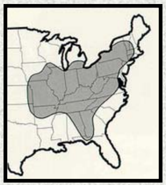


"Batty"

Halloween

The Count

Summer Roost



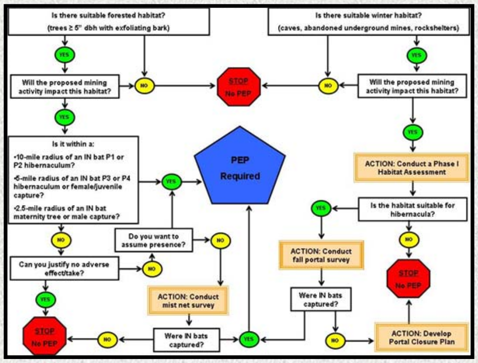
Range of the Indiana Bat

Indiana Bat Roost Tree

Where We Were:

- In 1996 the USFWS issued a Biological Opinion for OSM that stated that impacts from surface mining would not jeopardize federally listed species as long as the State agencies and local USFWS offices worked together to create Protection and Enhancement measures for each species.
- Good idea in theory, but most states and local USFWS offices couldn't agree on protective measures.
- The Indiana bat was by far the species with the most "issues" across it's range. It was decided that one Protection and Enhancement Plan (PEP) could be developed to cover surface mining throughout the species' range.
- The guidelines are the product of State and Federal government collaboration and partnerships among three USFWS Regions and their field offices; 13 state coal mining regulatory agencies, and the Interstate Mining Compact Commission (representing those states); and two OSM Regions and their field offices.

Range-Wide Indiana Bat Protection and Enhancement Guidelines



Where We Are:

- At this time, the guidelines have been implemented in most states where applicable
- The Guidelines set the ***MINIMUM*** standards for development of the species-specific protective measures.
- The goal is to provide consistent, predictable in the SMCRA permitting process across the Indiana bat's range.

Where We Are:

- If the guidelines are implemented, the applicant and RA are covered under the ESA for the Indiana Bat.
- State RA's and local FWS offices may require additional measures—remember the guidelines are the *MINIMUM* standard.
- If the guidelines are not implemented—

YOU MAY NOT BE COVERED!!!

Frequently Asked Questions

1. **Do we have to follow the guidelines:** Yes, if you want to be covered under the ESA. Otherwise, you need to work with the local FWS office to ensure compliance.
2. **If these are "guidelines" why are some measures "required":** Required measures are elements that the development team felt were critical to achieving compliance with the "No Jeopardy" determination of the Biological Opinion. Recommended measures are desired, but not critical.
3. **Can we ever cut trees in the summer?** Yes-if the RA and/or FWS determine that the forested habitat within the project area is not suitable for Indiana bats (i.e- contains no trees > or = 5"dbh with exfoliating bark) or on a case-by-case project-specific basis (if approved).

Frequently Asked Questions

4. **Why is selective tree clearing no longer allowed?**

Selective tree clearing allowed the removal of all suitable roost trees within a project area during the winter, when bats would not be present. Once all suitable roost trees had been removed, the remaining forested habitat could be removed during any time of the year because no habitat=no bats.

However, personal observations showed that suitable roost trees/snags were being missed and it was determined that it's unfeasible for a permitted biologist to mark every possible roost tree/snag within an area, especially when the permit area is large. Further, there is the risk that selectively removing roost trees actually created more habitat by killing live trees and creating snags (i.e. trees that were once unsuitable were now suitable) or natural events (ice storms, etc.) could create suitable habitat after selective tree clearing had occurred.

In the end, it was determined that that risks to Indiana bats associated with selective tree clearing outweighed the benefits. In some cases, the RA and local FWS may agree that selective tree clearing is appropriate—but this would only be on very small parcels where it could be clearly demonstrated that all suitable trees could be marked and removed without creating additional habitat.

Where We Hope to Be:

- Applicants submitting a thorough habitat assessment with the application or preliminary application to better assist the RA/USFWS in making a habitat determination.
- The submittal of PEP's that, at a minimum, follow the guidelines.
- Early coordination for projects that are not able to follow the guidelines.
- Continual outreach between the RA's, USFWS, and Industry.

Questions?

Session 3

STATUS OF STATE PERMITTING/RECOVERY/MITIGATION/ IMPLEMENTATION STRATEGIES

Session Chairperson:
Dr. Richard Wahrer
Kentucky DNR
Frankfort, Kentucky

A Comparison of Indiana Bat Population and Coal Mining Trends
Kimery C. Vories, U.S. DOI Office of Surface Mining, Alton, Illinois

Industry Perspective on Indiana Bat Protection Efforts
Bernard Rottman, Peabody Energy, Evansville, Indiana

State Survey of Indiana Bat Protection and Enhancement Measures and Interactive Panel Discussion on State-Specific Bat Protection Strategies at Coal Mines
Gregory E. Conrad, Interstate Mining Compact Commission, Herndon, Virginia

INTERACTIVE PANEL DISCUSSION: State- Specific Bat Protection Strategies
Panel Moderator: Gregory E. Conrad, Interstate Mining Compact Commission, Herndon, Virginia
Pennsylvania Representative: State-Specific Bat Protection Strategies at Coal Mines
Geoff Lincoln, Pennsylvania DEP Bureau of Mining and Reclamation, Harrisburg, Pennsylvania

Virginia Representative: Indiana Bats and the Coal Mining Industry in Virginia
John Lawson, Virginia Division of Mined Land Reclamation, Big Stone Gap, Virginia

Ohio Representative: State-Specific Bat Protection Strategies at Coal Mines
Scott Stiteler, Ohio DNR Division of Mineral Resources Management, Columbus, Ohio

West Virginia Representative: State-Specific Bat Protection Strategies at Coal Mines
Bob Fala, West Virginia DEP, Division of Mining and Reclamation, Charleston, West Virginia

Session 3—Continued

Indiana Representative: State-Specific Bat Protection Strategies at Coal Mines

Ramona Briggeman, Indiana Division of Fish and Wildlife, Jasonville, Indiana

Kentucky Representative: State-Specific Bat Protection Strategies at Coal Mines

Dr. Richard Wahrer, Kentucky Department of Natural Resources, Frankfort, Kentucky

A COMPARISON OF INDIANA BAT POPULATION AND COAL MINING TRENDS

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Abstract

Bat population census information shows a dramatic decline in the number of Indiana bats (*Mysotis sodalis*) since 1965 nationwide. On a regional basis, however, the populations have been increasing in the northern States and decreasing in the southern States. Indiana bat population data from 2001-2007 show that the population had been steadily increasing prior to the outbreak of White-nose Syndrome (WNS). This report compares the data on changes in populations of the Indiana Bat prior to the outbreak of WNS with data representing coal production from the same States and over the same time period. The result of this comparison indicates there are no data that would suggest a correlation between the Indiana Bat population trends and: (1) total coal production, (2) rate of growth or decline in coal mining as indicated by percent change in coal production, or (3) surface mining or underground mining methods. This conclusion would be supported by a comparison of the data from the Forest Service that there are 384 million acres of forest cover in the eastern U.S. with the 3.07 million acres of total permitted acreage of surface coal mines in the 14 States within the Indiana bat habitat (OSM 2004), that results in a maximum of 0.8% of the eastern forest cover that could be impacted by surface coal mining.

Although the regional changes in bat population may be suggestive of changes in climate (a uniform increase in the temperature in winter hibernacula could make hibernacula in southern States too hot and in northern States more suitable), the most likely reason for the decline of the species is tied to human disturbance of their underground winter habitat during hibernation. The current emphasis of the U.S. Fish and Wildlife Service (USFWS) on mitigation of impacts due to coal mining is to protect and enhance summer habitat. This may not be effective when the limiting factor in sustaining a healthy Indiana bat population is having an adequate supply of suitable winter hibernacula.

Investigations are needed to determine what, if any, impact coal mining and reclamation is having on the bat populations and what mitigation activities are appropriate and effective. The challenge before the States, USFWS, OSM, the coal mining industry, and bat conservationists is to coordinate these concerns in a way that is both protective of the species and appropriately efficient in terms of mitigation requirements that bring proven positive results for this species.

Trends in Indiana Bat (*Mysotis sodalis*) Populations

Richard Clawson of the Missouri Department of Conservation elaborated on the trends in population decline over the last 40 years for the Indiana bat as follows.

> *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 (Table 1). 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%. Cumulatively, the total population of Indiana bats has declined by 56% since regular surveys began (Figures 1 and 2).* (Clawson, 2004)
>
> *<u>Known and Suspected Causes of Decline</u>*
>
> *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 may also 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. (Clawson, 2004)

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. (Clawson, 2004)

Table 1. The size of hibernating populations of the Indiana bat by Region and State, based upon estimates nearest to the year indicated (Clawson, 2007).

	State	1965	1980	1990	2001	2007
Southern Region	Alabama	350	350	350	250	250
	Arkansas	15,000	15,000	4,500	2,500	1,800
	Illinois South	14,700	14,700	14,500	19,500	40,000
	Kentucky	248,100	102,200	78,700	50,050	68,800
	Missouri	399,000	342,000	150,100	73,000	65,550
	Oklahoma	0	0	0	5	5
	Tennessee	20,100	20,100	16,400	10,200	8,400
	Virginia	3,100	2,500	1,900	850	750
	Subtotal	700,350	496,850	266,450	156,355	185,555
Northern Region	Illinois North	100	100	400	1,550	1,800
	Indiana	160,300	155,200	163,500	173,100	238,200
	Michigan	0	0	0	20	20
	New Jersey	0	0	0	100	650
	New York	20,200	21,100	26,800	29,750	54,000
	Ohio	150	3,600	9,500	9,800	7,600
	Pennsylvania	700	700	400	700	750
	Vermont	0	0	0	150	300
	West Virginia	1,500	1,200	6,500	9,750	14,600
	Subtotal	182,950	181,900	207,100	224,920	317,920
	Grand total	883,300	678,750	473,550	381,275	503,475

Information provided by Clawson (2004) showed a dramatic decline in the number of Indiana bats from 1965-2001 nationwide. However, on a State-specific basis populations are increasing in the northern States and decreasing in the southern States (Figures 1 and 2). Information provided by Clawson (2007) during the Indiana Bat and Coal Mining Revised Recovery Plan workshop showed a steady increase in the Indiana bat population from 2001-2007 nationwide.

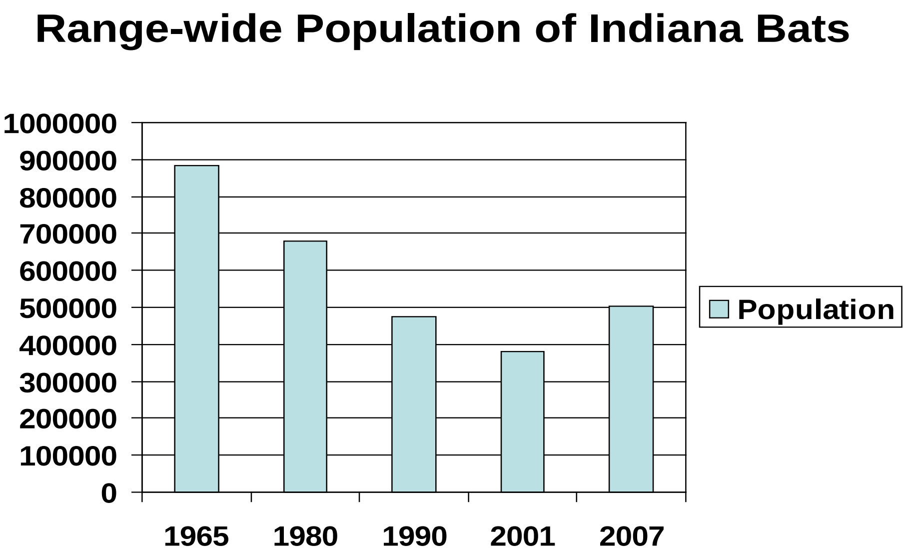


Figure 1. Range Wide Population Trends based on estimates and surveys from 1965 to2007 for the Indiana Bat (Clawson, 2007).

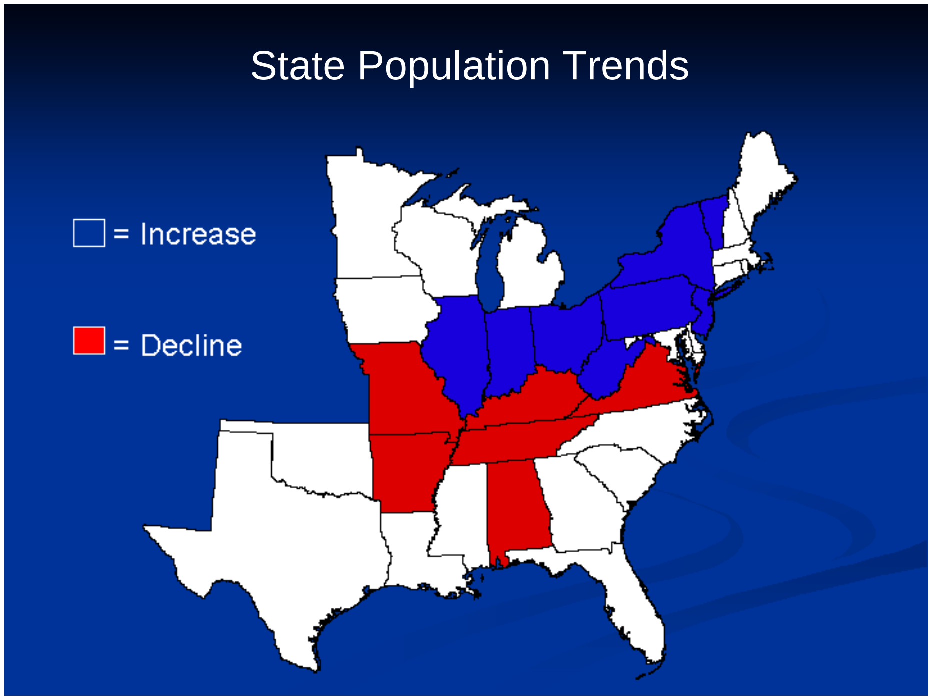
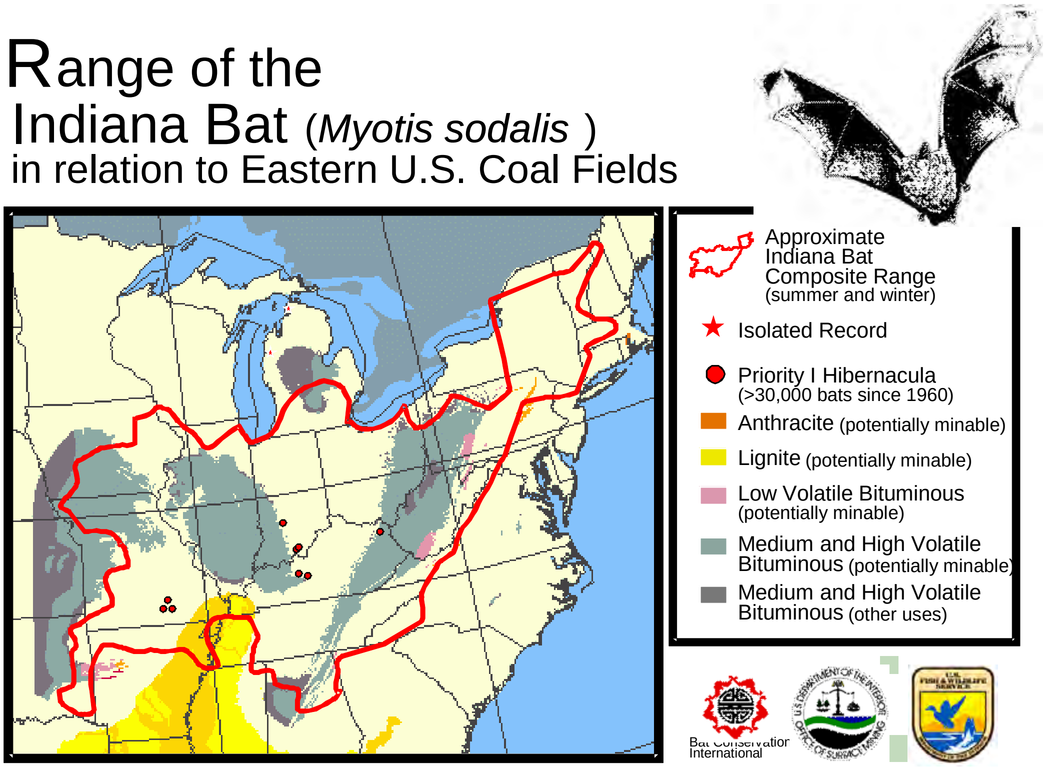


Figure 2. State Population Trends for the Indiana bat from 1960 to 2003 (Clawson, 2004).

Overlap of the Eastern Coal Fields with Indiana Bat Habitat

Figure 3 illustrates the range overlap of Indiana Bat habitat with coal fields in the Eastern United States. Of the fourteen States included in either the summer or winter range of the Indiana Bat, twelve are actively involved in coal mining including: Alabama, Arkansas, Illinois, Indiana, Kentucky, Missouri, Ohio, Oklahoma, Pennsylvania, Tennessee, Virginia, and West Virginia. The State of Iowa is involved with reclamation of abandoned coal mines but no longer has active coal mining.



Coal field and Indiana bat range (based on data compiled by Bat Conservation International) boundaries were accessed via The National Atlas of the United States (http://nationalatlas.gov). Map prepared by Andrew King, Bloomington, Indiana Field Office, U.S. Fish and Wildlife Service.

Figure 3. Coal Field and Indiana Bat range (based on data compiled by Bat Conservation International). Boundaries were accessed via “The National Atlas of the United States” (http://nationalatlas.gov). Map prepared by Andrew King, Bloomington, Indiana Field Office, U.S. Fish and Wildlife Service.

Coal Production Data and Trends

In order to better understand the relationship between Indiana Bat populations and coal mining activity in the eastern United States, coal production data were obtained from the U.S. Department of Energy, Energy Information Administration Website at www.eia.doe.gov/fuelcoal.html. The coal production data from 1970, 1980, 1990, and 2006 (U.S. Department of Energy(a)) was determined from the States where Indiana Bat populations and coal reserves overlap (Figure 3). These data were then compared to trends in the Indiana Bat populations presented by Clawson (2007). The total coal production in millions of tons (Table 2) for each decade from 1970 to 1990 and then from 2006 was the most recent data available and was as comparable as possible to the data from Clawson. The southern States where the Indiana Bat populations are declining are shown first in capital red letters followed by the northern States where the Indiana Bat populations are increasing in lower case blue letters. The percent change in coal production for this time period is obtained by calculating the difference in total coal production from 1970 to 2006 and dividing it by coal production in 1970 resulting in either a positive or negative change in coal production for that time period. The data in Table 3 compares the positive or negative change in bat population with the positive of negative percent change in coal production for the same time period.

Table 2. Coal Production Trends in States
with Changing Populations of Indiana Bats.

State	Coal Production in Millions of tons*				
	1970	1980	1990	2006	% Change
ALABAMA	15.5	21	19	21	+35%
ARKANSAS	0.35	0.4	0.15	0.01	-97%
KENTUCKY	100	140	175	127	+27%
MISSOURI	3.3	5	2.5	0.6	-82%
OKLAHOMA	1.0	5.0	1.8	2.3	+130%
TENNESSEE	No data	No data	2.6	2.6	0%
VIRGINIA	35	35	46	31.6	-10%
Illinois	64	60	60	32	-50%
Indiana	18	27	33	36	+100%
Ohio	51	38	35	25	-51%
Pennsylvania	85	90	70	68	-20%
West Virginia	135	120	155	159	+17%

(*www.eia.doe.gov/fuelcoal.html) (Southern States with Declining Populations of Indiana Bat in are shown in Red Capital Letters; Northern States with Increasing Populations of Indiana Bat in are shown in Lower Case Blue Letters).

Table 3. Comparison of Changes in
Indiana Bat Populations with Changes in Coal Production.

State	Total Change in Indiana Bat Population 1965-2007	% Change in Coal Production 1970-2006
ALABAMA	-100	+35%
ARKANSAS	-13,200	-97%
KENTUCKY	-179,300	+27%
MISSOURI	-333,450	-82%
OKLAHOMA	+5	+130%
TENNESSEE	-11,700	0%
VIRGINIA	-2,350	-10%
Illinois	+27,000	-50%
Indiana	+77,900	+100%
Ohio	+7,450	-51%
Pennsylvania	+50	-20%
West Virginia	+13,100	+17%

(Southern States with Declining Populations of Indiana Bat in are shown in Red Capital Letters; Northern States with Increasing Populations of Indiana Bat in are shown in Lower Case Blue Letters)

Comparison of Bat Population Trends with Growth or Decline of Coal Mining Activity in a State

The author assumes that if coal mining activity had a negative impact on Indiana bat populations, then you would expect a correlation between declines in bat populations associated with an increase in coal production or vice versa. The data in Figure 4 illustrates a comparison of the positive or negative change in bat populations with the positive or negative changes in percent coal production. Actual bat population changes are shown in green and actual coal production changes are shown in blue. Figure 4 is arranged from left to right by the State of Missouri with the greatest total decline in bat population to the State of Indiana with the greatest increase in bat population. The blue arrows indicate the expected direction of percent change in coal production assuming that increasing coal production was having a negative impact on the Indiana bat population. The red dashed line would be the expected trend line in coal production if a positive percent change in coal production had a negative impact on bat population. The red line is an arbitrarily projected line that would be expected to mirror image the bat population trends where a large percent increase in coal production would result in a large decrease in bat population and large decrease in coal production would result in a corresponding large increase in bat population.

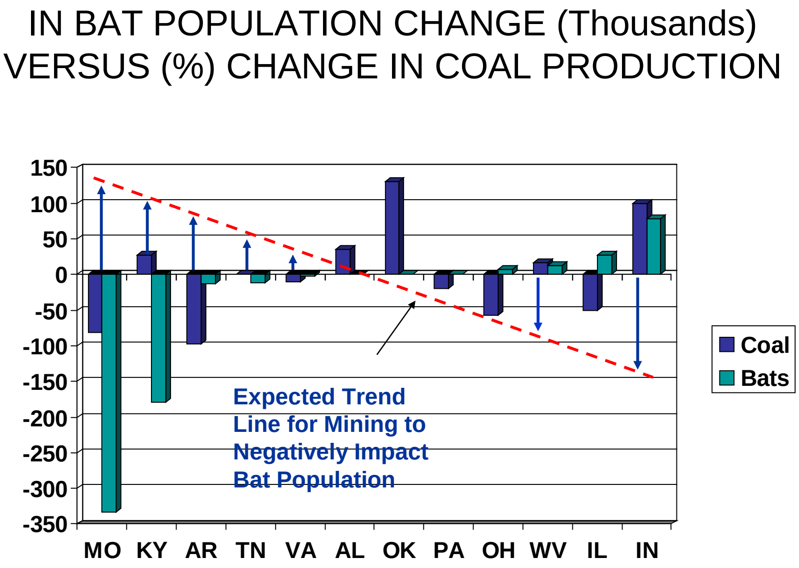

IN BAT POPULATION CHANGE (Thousands)
VERSUS (%) CHANGE IN COAL PRODUCTION

Figure 4. Indiana Bat population change versus Percent Change in Coal Production.

Indiana Bat Populations with Significant Population Decline

Missouri is the State with the greatest percent decrease in Indiana bat population from 399,000 in 1965 to 65,550 in 2007. This population decline of 333,450 represents an 84% reduction. If there was a correlation with coal mining, then you would expect to see a significant increase in coal production during the same time period. Instead, Missouri has experienced a dramatic decline in coal production (negative 82%). The current total coal production in Missouri (0.6 million tons per year) is so small that it cannot be a contributing factor to the bat population trend. A similar case could be made for Arkansas. The population has decreased from 15,000 in 1965 to 1,800 in 2007. This population decline of 13,200 represents an 88% reduction in numbers of Indiana bat. Yet during the same time period, Arkansas has experienced a 97% decrease in coal production resulting in a total current coal production of 0.01 million tons per year which again is so small that it is cannot be a contributing factor to the bat population trend.

The State with the second largest decrease in bat population is Kentucky from 248,100 in 1965 to 68,800 in 2007. This population decline of 179,300 represents a 72 % reduction. In the case of Kentucky, there has been a significant increase in coal production (positive 27%). Coal mining in Kentucky, unlike mining in Missouri and Arkansas, is largely by underground mining (61%) and the increase in coal production has been largely due to an increase in underground mining. Although the reduction in bat populations in Kentucky is substantial, there seems to be little mechanism for an increase in impact to summer habitat due to mining when the increase has been largely due to underground mining. The data also shows that the bat population in Kentucky has increased from 50,050 in 2001 to 68,800 in 2007 even though it is a Southern State where populations have been generally in decline.

Indiana Bat Populations with Significant Population Increases

Indiana is the State that has the largest increase in Indiana bat population from 160,300 in 1966 to 238,200 in 2007. This population increase of 77,900 represents a 49% increase. If there was a negative correlation with coal mining, then you would expect to see a significant decrease in coal production during the same time period. Instead, Indiana has experienced a substantial increase in coal production (positive 100%). This is especially significant since the predominant mining method in Indiana is by surface mining (67.5%) that would be assumed to have the greatest impact on bat populations and summer habitat.

The State of West Virginia has experienced an 873% increase in its Indiana Bat population while its coal production has also grown by 17%.

The State of Oklahoma has experienced a 130% increase in coal production while the bat population has increased from 0 to 5 over the same time period.

In conclusion, if changes in the rate of coal production were correlated with changes in corresponding increases or decreases in bat population then a pattern should be evident in Figure 4 as indicated by the dashed red line. Instead, trends in bat populations appear to be totally independent of changes in coal production rather than in any way related to them.

Comparison of Trend in Indiana Bat Populations with the Size of the Coal Mining Industry in a State

The author examined the possible correlation between trends in bat populations as compared to the overall size of the coal industry in a State, the theory being that there may be some threshold for the size of the coal mining industry to have an impact on bat populations. Figure 5 provides data for a visual comparison of total coal production in 2006 with the positive or negative change in bat population from 1965 to 2007. Actual bat population changes are shown in green and total coal production is shown in blue. The figure is arranged from left to right with West Virginia being the State with the greatest total coal production to Arkansas with the least. The States are divided into three sizes of coal mining industries. These categories include a large coal industry (WV, KY, PA), medium size coal industry (IN,VA, IL,OH, AL), and a small size coal industry (TN, MO, AR). The green arrows indicate the expected direction of bat population increase or decrease if there were a large negative population decrease with a large coal mining industry, a smaller negative population decrease with a medium sized coal industry, and a positive population increase with a coal industry too small to have any negative influence on the bat population. The red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a large size coal industry would result in a large decrease in bat population, a medium size coal industry would result in a smaller decrease in bat population and, a small coal industry would result in a corresponding increase in bat population.

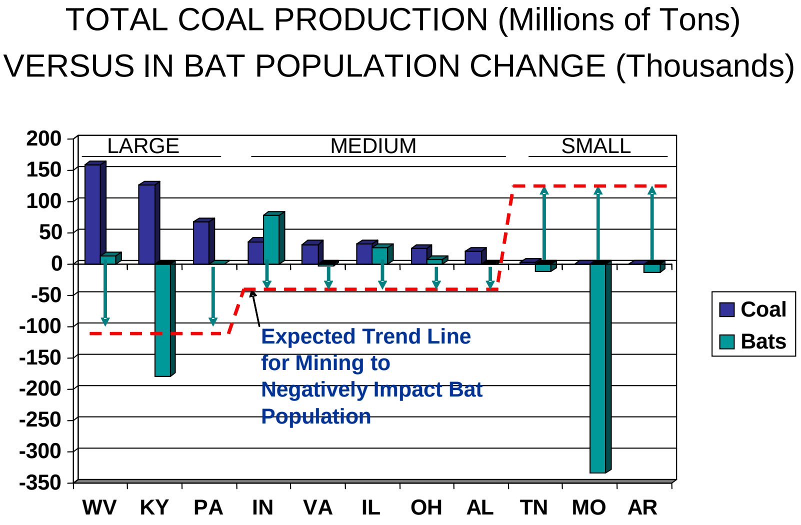

TOTAL COAL PRODUCTION (Millions of Tons)
VERSUS IN BAT POPULATION CHANGE (Thousands)

Figure 5. Total Coal Production by State Compared with Change in Indiana Bat Population.

The three States with greatest coal production showed two States, West Virginia and Pennsylvania had gains in bat populations while Kentucky had a substantial decrease in bat population. Of the five States with a medium sized coal industry, three States, Indiana, Illinois, and Ohio, had substantial increases in bat populations while two States had small declines in bat populations. Of the three States that have a total coal production that is too small to have any impact on bat populations, Tennessee, Missouri, and Arkansas, all had substantial decreases in bat populations with Missouri having the greatest decline. These results would suggest that the size of the coal mining industry in a State does not appear to be related to changes in bat population.

Correlation of Bat Population Data with Coal Production Data Associated with either Surface Mining or Underground Mining Methods

The author also examined trends in bat populations as compared to the predominant mining method for the State. If over 60 percent of the coal was produced by surface mining methods in 2005 then the State was categorized as a surface coal mining State. If over 60 percent of the coal was produced by underground mining methods in 2005 then the State was categorized as an underground coal mining State. Table 4 contains the coal production figures for the predominately surface mined States and shows the coal production figures for the predominately underground mined States (U.S. Department of Energy (b) summarized in Table 5). These tables illustrate that with the exception of the State of Indiana, the major coal producing States within the range of the Indiana Bat are predominately underground mining States.

Table 4. Total Coal Production in Thousands of Tons for States where the Predominant Mining Method was Surface Mining in 2005.

State	Total Coal Production in thousands of tons	Surface Mined	Underground Mined	% Surface Mined
Totals	40,134	27,251	12,878	
ARKANSAS	3	1	0	100
MISSOURI	598	598	0	100
OKLAHOMA	1,858	1,391	465	74.9
TENNESSEE	3,218	1,993	1,224	61.9
Indiana	34,457	23,268	11,189	67.5

(Southern States with Declining Populations of Indiana Bat in Red Capital Letters; Northern States with Increasing Populations of Indiana Bat in Lower Case Blue Letters)

Table 5. Total Coal Production in Thousands of Tons for States where the Predominant Mining Method was Underground Mining in 2005.

State	Total Coal Production in thousands of tons	Underground Mined	Surface Mined	% Underground Mined
Totals	436,606	291,744	144,864	
ALABAMA	21,339	13,295	8,044	62.3
KENTUCKY	119,734	73,702	46,032	61.5
VIRGINIA	31,596	21,225	10,371	67.2
Illinois	32,014	26,343	5,671	82.2
Ohio	24,718	15,823	8,896	64.0
Pennsylvania	67,494	54,563	12,931	80.8
West Virginia	139,711	86,793	52,919	62.1

(Southern States with Declining Populations of Indiana Bat in Red Capital Letters; Northern States with Increasing Populations of Indiana Bat in Lower Case Blue Letters)

Correlation of Coal Production Data with Indiana Bat Population Data from Predominately Surface Mined States

Table 6 indicates the percent change in coal production compared to changes in Indiana bat populations from 1965 to 2007 for Predominately Surface Mining States.

Table 6. Percent Change in Coal Production from 1970 to 2006 for Predominately Surface Mining States.

Surface Coal Mining State	Total Change in IN Bat Population	% Change in Coal Production
ARKANSAS	-13,200	-97%
MISSOURI	-333,450	-82%
OKLAHOMA	+5	+130%
TENNESSEE	-11,700	0%
Indiana	+77,900	+100%

Correlation of Percent Change in Surface Mined Coal Production with Change in Indiana Bat Population

In Figure 6, the percent changes in coal production are compared with bat population trends for States that are predominately mined by surface mining methods. Actual bat population changes are shown in green and percent change in coal production is shown in blue. The figure is arranged from left to right by the State of Missouri with the greatest total decline in bat population to the State of Indiana with the greatest increase in bat population. The blue arrows indicate the expected direction of percent change in coal production assuming that increasing coal production was having a negative impact on the Indiana bat population. The dashed red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a high percent change in coal production would result in a large decrease in bat population and small percent change in coal production would result in a corresponding large increase in bat population.

The data from Missouri and Arkansas show a dramatic reduction in surface coal mining that is occurring at the same time as the population of Indiana bats are dramatically decreasing. The data from Oklahoma shows a substantial increase in surface coal mining with a very small increase in Indiana bat population. The Indiana data illustrates a substantial increase in bat populations occurring at the same time as a substantial increase in surface mining activity. The author could not find data to support any connection between the level of surface coal mining activity with trends in the Indiana bat population.

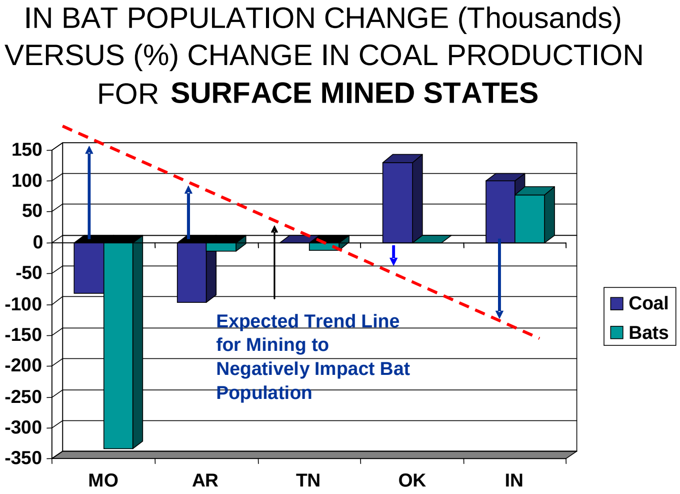


Figure 6. Change in the Population of Indiana Bats versus the percent Change in Coal Production for Surface Mined States.

Correlation of Total Coal Production in States with Surface Mining as the Predominant Mining Method with Change in Indiana Bat Population

In Figure 7 the total coal production is compared with bat population trends for States that are mined predominately by surface mining methods. Actual bat population changes are shown in green and total coal production is shown in blue. The figure is arranged from left to right by the State of Indiana with a medium sized coal industry with the other four states with a coal industry too small to be of any significant influence on bat populations. The green arrows indicate the expected direction of bat population increase or decrease if there were a negative correlation with the size of the coal industry in the State. The red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a medium sized total coal production level would result in a moderate decrease in bat population and small total coal production would result in a corresponding large increase in bat population.

These data suggest that Indiana, with a medium-sized coal production where the bat population has substantially increased in comparison to Missouri, Arkansas, Oklahoma, and Tennessee with very small coal production and yet the bat populations in Missouri and Arkansas still decreasing dramatically. The trend in data does not support a connection between levels of surface coal mining activity with trends in the Indiana bat population.

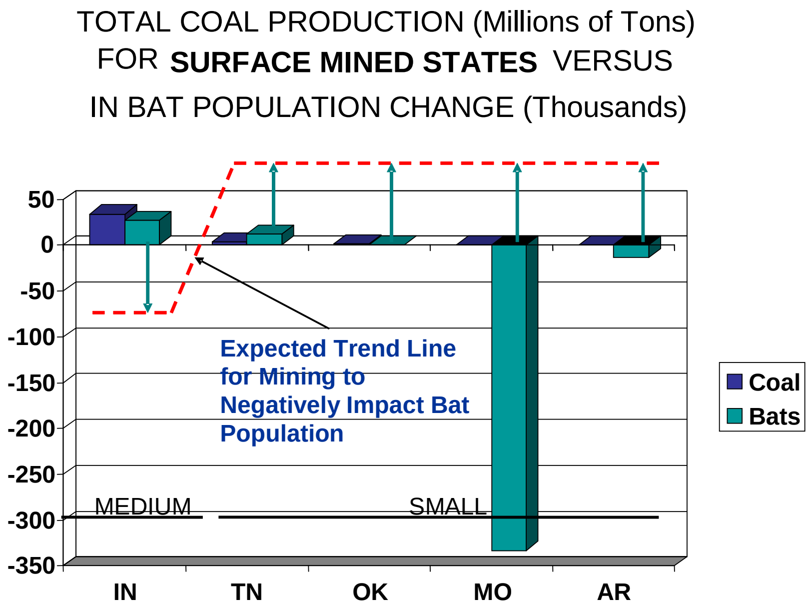


Figure 7. The Indiana Bat Population Change versus the Total Coal Production for Surface Mined States.

Correlation of Coal Production Data from Predominately Underground Mining States with Indiana Bat Population Data

The percent change in coal production from 1970 to 2006 for Predominately Underground Mining States is summarized in Table 7. Kentucky has the most dramatic decrease in bat population whereas Illinois shows the most significant increase in bat population that occurred at the same time as a 52 percent decrease in coal production.

Table 7. Percent Change in Coal Production for Predominately Underground Mining States.

Underground Coal Mining State	Total Change in IN Bat Population	% Change in Coal Production
KENTUCKY	-179,300	+27%
VIRGINIA	-2,350	-10%
ALABAMA	-100	+35%
Pennsylvania	+50	-20%
Ohio	+7,450	-51%
West Virginia	+13,100	+17%
Illinois	+27,000	-50%

In Figure 8, the percent change in coal production is compared with bat population trends for States where coal is mined predominately by underground mining. Actual bat population changes are shown in green and percent change in coal production is shown in blue. The figure is arranged from left to right by the State of Kentucky, with the greatest total decline in bat population to the State of Illinois, with the greatest increase in bat population. The blue arrows indicate the expected direction of percent change in coal production assuming that increasing coal production was having a negative impact on the Indiana bat population. The dashed red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a high percent change in coal production would result in a large decrease in bat population and small percent change in coal production would result in a corresponding large increase in bat population.

In this case, five of the seven underground mining States KY, AL, PA, OH, and IL would seem to support the expected trend if increased coal mining activity resulted in a decrease in bat populations. The data from Virginia and West Virginia would contradict this trend because Virginia has a decreasing coal production along with a decrease in bat population while West Virginia has an increase in coal production along with an increase in bat population. In addition, since the majority of mining is underground, increases in coal production would not be expected to affect surface habitat of the bat.

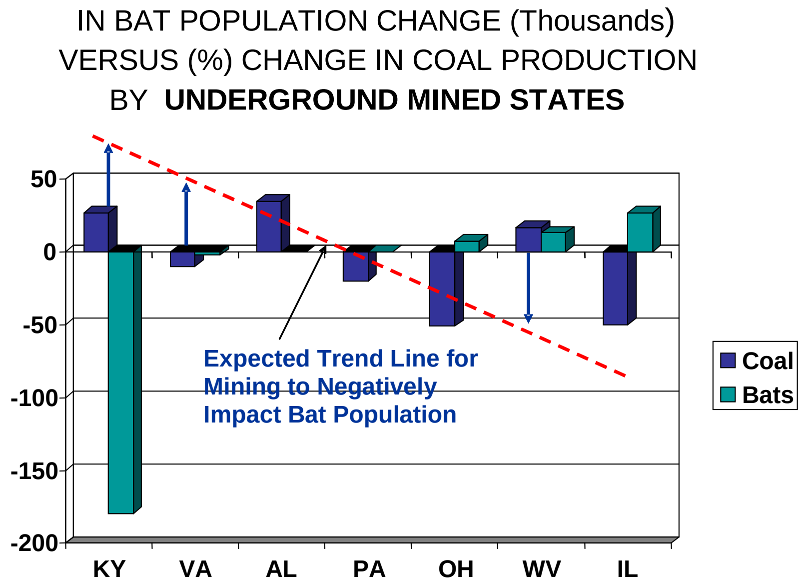


Figure 8. Indiana Bat Population Change versus the Percent Change in Coal Production for Underground Mined States.

The data in Figure 9 compares the total coal production data with bat population trends for States that are mined predominately by underground mining methods. Actual bat population changes are shown in green and total coal production is shown in blue. The figure is arranged from left to right by the State of West Virginia with the greatest total coal production to the State of Alabama with the least. The States of West Virginia, Kentucky, and Pennsylvania would be classed as having a large sized coal industry while the other States Virginia, Illinois, Ohio, and Alabama would be classes as having a medium sized coal industry. The green arrows indicate the expected direction of bat population increase or decrease if there were a negative correlation with total coal production levels. The red line is an arbitrarily projected line that would be an expected mirror image of the bat population trends where a State with a large coal industry should result in a large decrease in bat population and State with a medium sized coal industry would be expected to result in a smaller decrease in bat population.

Of the States with a large coal industry, the State with the highest total coal production is West Virginia that had an increase in bat population. The State with the second highest total coal production was Kentucky that had a substantial decrease in bat population. Of the States with a medium coal industry, three showed a significant increase in bat population with one a very small decrease. Based on these data, there does not appear to be any trend to support a connection between levels of underground coal mining activity with trends in the Indiana bat population.

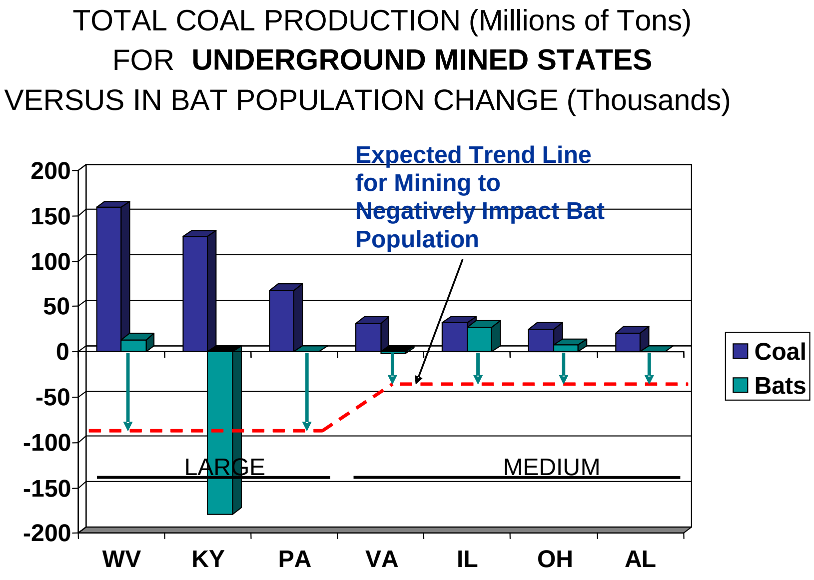

TOTAL COAL PRODUCTION (Millions of Tons)
FOR **UNDERGROUND MINED STATES**
VERSUS IN BAT POPULATION CHANGE (Thousands)

Figure 9. Indiana Bat Population Changes versus Changes in Total Coal Production for Underground Mined States.

Conclusion

Information provided by Clawson (2004) during the Indiana Bat and Coal Mining forum showed a dramatic decline in the number of Indiana bats from 1965-2003 nationwide. Information provided by Clawson (2007) during the Indiana Bat and Coal Mining Revised Recovery Plan workshop showed a steady increase in the Indiana bat population from 2001-2007 nationwide. Coal production data from 1970, 1980, 1990, and 2006 (U.S. Department of Energy(a) and (b)) was determined from the States where Indiana Bat populations and coal reserves overlap.

Over the time period from 1970-2006, coal mining activity in these States has ranged from a negative 97% in Arkansas to a positive 100% in Indiana and 130% in Oklahoma. Total coal production ranges from 10,000 tons/year in Arkansas to 159 million tons/year in West Virginia. They include five States where surface mining methods predominate and seven States where underground mining methods predominate. Coal production has increased significantly in the States of Alabama, Indiana, Kentucky, Oklahoma, and West Virginia.

Over the time period from 1965-2007, bat populations are decreasing in the six coal mining States of Alabama, Arkansas, Kentucky, Missouri, Tennessee, and Virginia and increased in the six coal mining States of Illinois, Indiana, Ohio, Oklahoma, Pennsylvania, and West Virginia. More recently from 2001 to 2007, bat populations have been increasing in seven of the coal mining States including Alabama, Illinois, Indiana, Kentucky, Oklahoma, Pennsylvania, and West Virginia.

There does not appear to be any consistent pattern or trend in data between coal mining and bat population related to changes in levels of coal mining activity, total coal production (size of the mining industry), or mining method (surface versus underground). This conclusion would be supported by a comparison of the data from the Forest Service that there are 384 million acres of forest cover in the eastern U.S. with the 3.07 million acres of total permitted acreage of surface coal mines in the 14 States within the Indiana bat habitat (OSM 2004), that results in a maximum of 0.8% of the eastern forest cover that could be impacted by surface coal mining.

> *While total forest area has been relatively stable for the last 100 years (currently about 747 million acres), there have been significant regional shifts in the area and composition of the nation's forests. Reversion of marginal farmland in the east, large scale planting in the South, and fire suppression have contributed to increases in forest area. Urbanization, conversion to agriculture, reservoir construction, and natural disasters have been major factors contributing to loss of forests. Eastern forests cover about 384 million acres and are predominantly broadleaf (74%), with the exception of extensive coniferous forests and plantations in the southern coastal region. These are largely in private ownership (83%)(Smith, W. B. et al.1997).*

Although some of the changes in bat population are suggestive of changes in climate (a uniform increase in the temperature of winter hibernacula could make hibernacula in southern States too hot and in northern States more suitable), the most likely reason for the decline of the species is tied to human disturbance of their underground winter habitat during hibernation. Active coal mining operations do not have any impact on underground winter habitat of the species. The current emphasis of the U.S. Fish and Wildlife Service on mitigation of impacts due to coal mining is to protect and enhance summer habitat. This may not be effective when the limiting factor in sustaining a healthy Indiana bat population is having an adequate supply of suitable winter hibernacula.

Investigations need to be undertaken to determine what, if any, impact coal mining and reclamation is having on the bat populations and what mitigation activities are appropriate and effective. The challenge before the States, USFWS, OSM, the coal mining industry, and bat conservationists is to coordinate these concerns in a way that is both protective of the species and appropriately efficient in terms of mitigation requirements that bring proven positive results for this species.

> *The recovery of the species will depend upon our ability to detect, restore, and protect key caves and mines that provide adequate and suitable winter hibernacula (Tuttle, 2007).*

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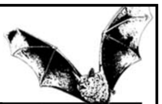
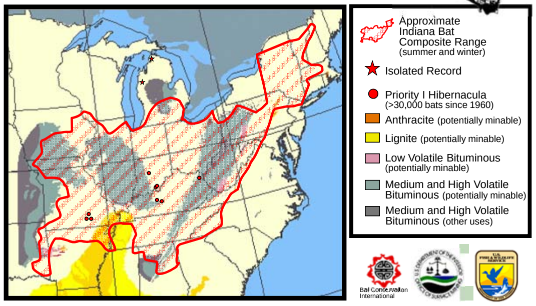
COAL MINING & INDIANA BAT POPULATION TRENDS

KIMERY VORIES
OSM
ALTON, IL

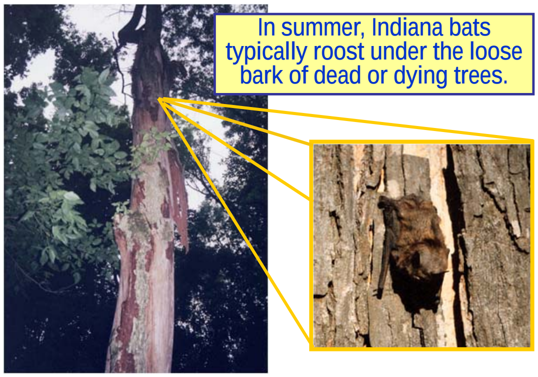
Range of the Indiana Bat (*Myotis sodalis*) in relation to Eastern U.S. Coal Fields





Coal field and Indiana bat range (based on data compiled by Bat Conservation International) boundaries were accessed via The National Atlas of the United States (http://nationalatlas.gov). Map prepared by Andrew King, Bloomington, Indiana Field Office, U.S. Fish and Wildlife Service.

Indiana Bat Summer Habitat (Scott Pruitt USFSW)



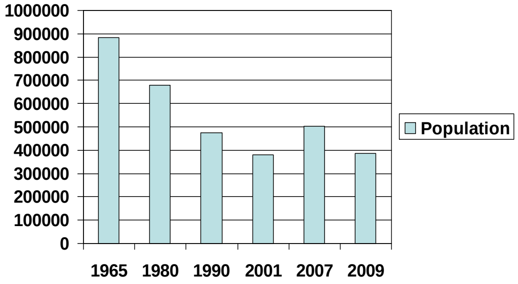
In summer, Indiana bats typically roost under the loose bark of dead or dying trees.

Indiana Bat Winter Habitat (Rick Clawson MO DNR)

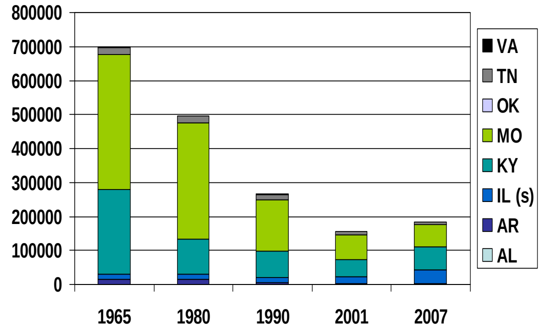
SMCRA PERMITING ISSUES FOR INDIANA BATS

- Inconsistency between States concerning Species Specific Protective Measures
- Inconsistent adoption of OSM/FWS 1996 Biological Opinion
- Overemphasis on Protection of Summer Habitat
- Inadequate emphasis on Protection of Winter Habitat

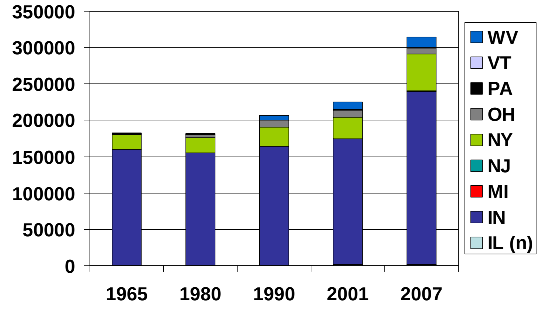
Range-wide Population of Indiana Bats



Southern Region Population of Indiana Bats

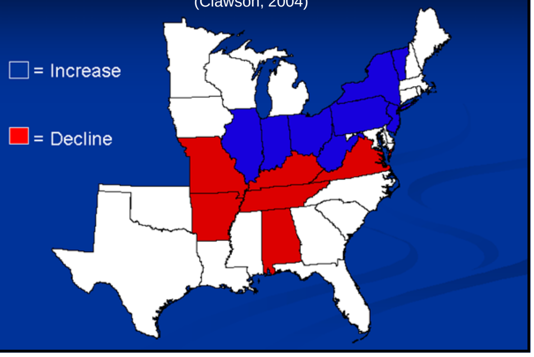


Northern Region Population of Indiana Bats



State Population Trends

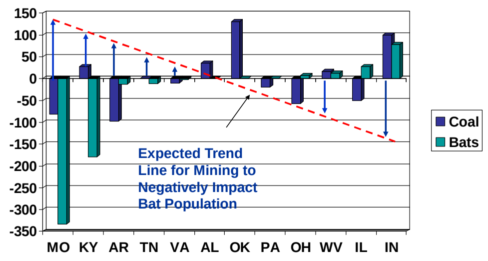
(Clawson, 2004)



OSM TREND ANALYSIS

- BAT POPULATION CHANGE VERSUS PERCENT COAL PRODUCTION CHANGE AS AN INDICATOR OF RATE OF GROWTH OR DECLINE IN COAL MINING ACTIVITY

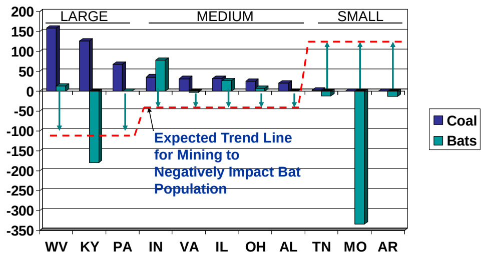
IN BAT POPULATION CHANGE (Thousands) VERSUS (%) CHANGE IN COAL PRODUCTION



TREND ANALYSIS

- POPULATION CHANGE VERSUS TOTAL COAL PRODUCTION AS AN INDICATOR OF THE INFLUENCE OF A LARGE VERSUS SMALL STATE COAL MINING INDUSTRY

TOTAL COAL PRODUCTION (Millions of Tons)
VERSUS IN BAT POPULATION CHANGE (Thousands)

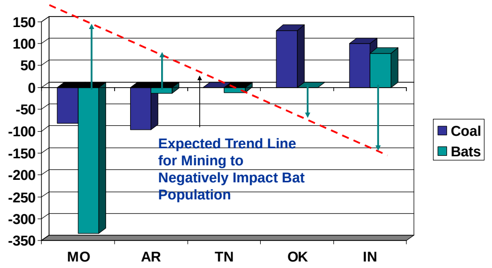


Expected Trend Line for Mining to Negatively Impact Bat Population

TREND ANALYSIS

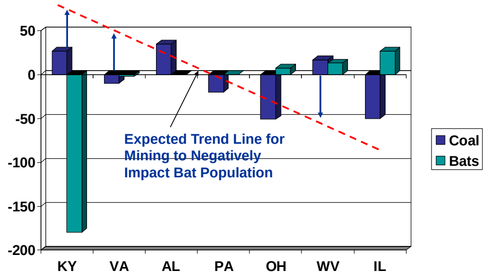
- POPULATION CHANGE VERSUS PERCENT COAL PRODUCTION TREND BY **SURFACE** VERSUS **UNDERGROUND** METHODS
  - GREATER THAN 60% OF COAL MINED IN THE STATE BY **SURFACE MINING** METHODS
  - GREATER THAN 60% OF COAL MINED IN THE STATE BY **UNDERGROUND METHODS**

IN BAT POPULATION CHANGE (Thousands)
VERSUS (%) CHANGE IN COAL PRODUCTION
FOR **SURFACE MINED STATES**



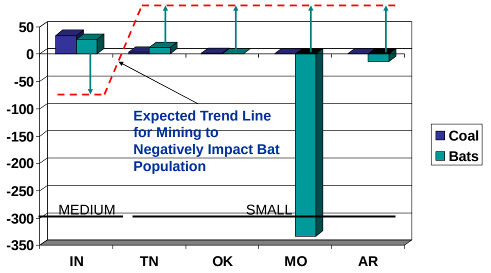
Expected Trend Line for Mining to Negatively Impact Bat Population

IN BAT POPULATION CHANGE (Thousands)
VERSUS (%) CHANGE IN COAL PRODUCTION
BY **UNDERGROUND MINED STATES**



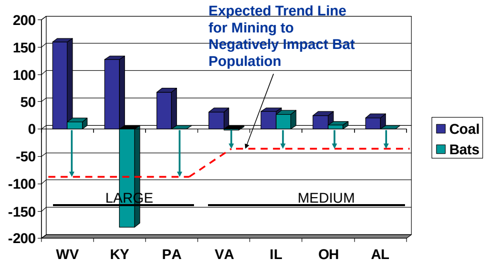
Expected Trend Line for Mining to Negatively Impact Bat Population

TOTAL COAL PRODUCTION (Millions of Tons)
FOR **SURFACE MINED STATES** VERSUS
IN BAT POPULATION CHANGE (Thousands)



Expected Trend Line for Mining to Negatively Impact Bat Population

TOTAL COAL PRODUCTION (Millions of Tons)
FOR **UNDERGROUND MINED STATES**
VERSUS IN BAT POPULATION CHANGE (Thousands)



Expected Trend Line for Mining to Negatively Impact Bat Population

RESULTS

- NO TREND COULD BE IDENTIFIED BETWEEN CHANGES IN INDIANA BAT POPULATIONS AND ASPECTS OF COAL PRODUCTION OR MINING METHOD EITHER POSITIVE OR NEGATIVE.

FOREST COVER IN EASTERN U.S.

- “No Significant Trend in Eastern US Forest Cover in last 100 Years” USDA Forest Service
  - Regional Increases due to:
    - Conversion of Marginal Farmland to Forest
    - Large Commercial Planting in South
    - Fire Suppression
  - Regional Decreases due to:
    - Increase in Urbanization, Agriculture, Reservoirs
    - Natural Disasters

Eastern US Forest Cover Related to Coal Mining

- 384,000,000 acres of Forest Cover in Eastern U.S.(USDA Forest Service 1997)
- 3,076,251 (OSM 2004) Total Permitted Acres of Surface Coal Mines in Indiana Bat Habitat
- Maximum of 0.8% of Eastern U.S. Forest Cover could be impacted by Coal Mining.

In Conclusion, What is Required for Recovery?

Detect, Restore & Protect Key Caves

Protect and/or Modify Potentially Suitable Abandoned Mines

Potential for Success?

Outstanding!
M. Tuttle BCI 2007

Bat Friendly Closure built by OSM at Glen Lyon Mine Pennsylvania 2007

Industry Perspective on Indiana Bat Protection Efforts[1]

Bernard Rottman
Peabody Energy, Midwest Group Operations
Evansville, Indiana

Abstract

Given the extent of coal mining throughout the 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 imperiled bat species is obvious. Conservation measures undertaken by the coal industry are primarily directed at limiting potential encounters during the warm season, protecting hibernacula, addressing any direct impacts to high value habitat, and restoring usable habitat during the land reclamation process. Habitat destruction is usually minimized to the extent possible, although it is recognized that by the nature of coal mining operations, some habitat will be removed from the landscape for some duration of time. General wildlife habitat restoration is a routine part of mine reclamation plans, and these habitat restoration efforts can be directed towards specific enhancement measures for specific species. Other efforts include work scheduling to avoid disturbances to a species during certain periods of their annual cycle. Regulation of the coal industry under the Endangered Species Act for conservation of threatened and endangered species has evolved through the years. The process has not necessarily been consistent from state to state, 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 and 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. The Indiana bat (*Myotis sodalis*) is the most significant imperiled bat species that we encounter at Midwest coal mining operations. The recent completion of the Range-wide Indiana Bat Protection and Enhancement Plan Guidelines has helped standardize conservation initiatives, but still differences exist between states as to how they implement these new guidelines. Implementation of protective measures for imperiled species will continue to grow stricter. White-nose Syndrome has profound implications on the population levels of all bat species. The coal industry continues to have a strong concern 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 Peabody Energy on behalf of 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 avoided where possible. Habitat destruction is usually minimized during the mining process to the extent possible, and habitat restoration following mining disturbance is a routine part of mine

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[1] *This paper was first presented in November 2004 at the U.S. Department of Interior, Office of Surface Mining Technical Interactive Forum on the Indiana Bat and Coal Mining. The contents have been updated from the original presentation to reflect the changes in recent years to regulatory programs and conservation efforts on behalf of the species.*

reclamation efforts. Specific habitat restoration objectives on behalf of the Indiana bat are undertaken during reforestation efforts. Other species-specific efforts include work scheduling to avoid disturbances to the species during important 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. In July, 2009, Range-wide Indiana Bat Protection and Enhancement Plan Guidelines were adopted. It was intended to standardize conservation requirements. The requirements of these guidelines continue to be implemented in a somewhat variable manner and are more stringent than previously required conservation measures.

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 or a 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. Foraging areas include forested habitats in riparian, floodplain and upland areas, forest clearings, old fields, along borders of agricultural fields, woody fencerows, woody ditch banks, farm ponds, and other types of water bodies. 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 summer use of maternity roost sites by maternity colonies. The understanding of spring through fall habitat selection by Indiana bats has expanded and the definition of this habitat now includes almost all forested and fragmented forest landscapes in the Eastern United States.

Where known hibernacula or site records identify the probable presence of Indiana bats within preset distances of a mine plan area, bat surveys are required to determine actual presence or absence. 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 determined through consultation with the state regulatory authority and the U.S. Fish and Wildlife Service. 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 state and federal regulatory agencies 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 the Range-wide Indiana Bat Protection and Enhancement Plan Guidelines. 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 Measures

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 state regulatory agencies and/or the U.S. Fish and Wildlife Service 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, specific conservation measures for Indiana bats 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 state regulatory agency and the U.S. Fish and Wildlife Service should be undertaken early in the permit application process to coordinate address on Indiana bat issues. The distance set by regional guidance include (1) a 10 mile radius of a Priority 1 or Priority 2 hibernacula, (2) a 5 mile radius of a Priority 3 or Priority 4 hibernacula, and (3) a 2.5 mile radius of a known maternity tree or male capture. 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 state regulatory agencies and the U.S. Fish and Wildlife Service 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. Range-wide tree removal dates are presented 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		Habitat Type
	From	To	
Range-wide	October 15	March 31	Summer habitat
Range-wide	November 15	March 31	Caves, mine openings, rock shelters, etc.

Peabody Energy has traditionally addressed Indiana bat conservation by removing high value habitat features during the winter timber harvest period. We typically coordinate this activity with the state regulatory authority and commit to this process in the permit documents. 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 that 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 to the extent possible. 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 re-establishment 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. Peabody Energy 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, dry dams, 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 the U. S. Department of Agriculture 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 re-establishment 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 re-establishment 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 Peabody Energy 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.

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 plantings 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 July 15th. 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 an advantageous situation arises.

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.

Peabody Energy operations in the Midwest will produce approximately 28M tons of coal in 2010 and will disturb approximately 2,500 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 Peabody Energy coal production, acres disturbed, and acres receiving final bond (Phase III) release in the Midwest during the past ten (10) years.

Table 2.
Reforestation and 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

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

Plant Species	Seeding or Planting Rate	Method of Application
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
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

Table 3.
Peabody Energy Coal Production
Land Disturbance and Land Reclamation in Midwest

Year	Coal Production Tons	Land Disturbance Acres	Land Reclamation (Phase III Release) Acres
2001	26 M	2,200	2,400
2002	25 M	2,100	300
2003	25 M	1,716	3,470
2004	29 M	1,948	2, 716
2005	21 M	1,937	2,913
2006	23 M	4,314	3,472
2007	38 M	2,509	2,867
2008	31 M	3,890	3,132
2009	32 M	1,953	1,637
2010	28 M*	2,500*	2,689*

*2010 projections.

Land use patterns on Peabody Energy 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 and 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 Peabody Energy 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 approximate the pre-existing land uses within the permit area and utilize slope and setting to finalize the reclamation plan for the permit area. These land use modifications involve minor changes and relocations. Peabody Energy 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 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 Peabody Energy mine sites.

Table 4.
Premine and Postmine Land Use Patterns

Land Uses	Premine	Postmine
Agricultural (Crop and Pasture)	65%-70%	65%-70%
Forest and 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 and 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 in the recovery of the listed species. It provides for consideration of the listed species, prior to any federal action that would potentially affect them. It provides for punishment of any entity that 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 to ensure 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 the tremendous regulatory uncertainty are additional issues of significant concern.

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. 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 agricultural 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 roosting 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 measured in diameter breast height (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. Pursuant to the recently adopted regional guidelines, habitat is now defined as any woody stem with a 5" DBH. The list of tree species most commonly utilized by Indiana bats for summer roosting 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 the most suitable roosting habitat for Indiana bats. Most forested areas in the Eastern United States will include many of these tree species.

The restriction on timber harvest, tree clearing, tree removal, etc. is another protective measure that has changed with adoption of the regional guidelines. Table 1, Approved Tree Removal Periods, identifies the current restrictions.

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*

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 the 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, both permitted and not permitted, 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.

One issue of immediate concern is the needless destruction of habitat in advance of mining operations. The new range-wide guidelines require, as a protective measure, removal of all woody vegetation that exceeds 5" DBH during a period from October 15 to March 15 for summer habitat and removal of all woody vegetation that exceeds 5" DBH during a period from November 15 to March 15 in areas near hibernacula. Past protective measures involved removal of potential roost trees that exhibited exfoliating or sloughing bark in larger size classes (10", 12", 15" DBH or other identified sizes). The new requirements result in the removal of all woody vegetation in all areas where mining operations might reasonably occur in the immediate future. The practice results in land disturbance to large areas during winter months. These disturbances result in extensive habitat loss, soil erosion and soil destruction, and the subsequent impacts on water quality.

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. The entire process since formalization of the 1996 Biological Opinion by the U.S. Fish and Wildlife Service has been carried out by guideline and internal policy of the regulatory agencies. The Indiana bat recovery plan is currently undergoing revision and was last updated and approved in 1983. That proposed revised plan does not necessarily recommend the expressed conservation and protection measures that are in force today for the coal industry. In the everyday working world of the coal industry, the current guidelines and internal policies have taken the weight of law. Even more ominous are the implications of the spread of White-nose Syndrome on the population levels of all bat species. Protective measures will most likely continue to grow more stringent.

Summary

Peabody Energy 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 will undoubtedly 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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State Survey of Indiana Bat Protection and Enhancement Measures and Interactive Panel Discussion on State-Specific Bat Protection Strategies at Coal Mines

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Abstract

This presentation, and the interactive discussion that follows, will provide an overview of how various state regulatory authorities are implementing the Range-wide Indiana Bat Protection and Enhancement Plan Guidelines that were adopted in September of 2009. The guidelines were developed through extensive state and federal collaboration and are intended to provide both state regulatory authorities and coal mining companies with a set of consistent and reasonable habitat protection and avoidance measures that can be used when proposed mining operations potentially impact the Indiana bat and its critical habitat. Over the past several months, the states have begun incorporating these guidelines into their permitting processes and this presentation will provide a status report on their progress and any implementation issues associated therewith. State presenters will speak specifically to the successes and challenges regarding bat protection and habitat enhancement of listed species within their respective borders and their experience implementing the 2009 Indiana Bat guidelines.

Introduction

In preparation for the Office of Surface Mining's Forum on "Protecting Threatened Bats at Coal Mines", the Interstate Mining Compact Commission was asked to survey the states regarding their experience with implementing the Range-wide Indiana Bat Protection and Enhancement Plan Guidelines that were adopted in September of 2009. IMCC was a contributor to the development of the guidelines which were a result of extensive state and federal agency collaboration. They are intended to provide both state regulatory authorities and coal mining companies with a set of consistent and reasonable habitat protection and avoidance measures that can be used when proposed mining operations potentially impact the Indiana bat and its critical habitat.

Most IMCC member states responded to the survey; however several were outside the range of the Indiana bat and therefore did not provide detailed information. The information I will present today provides an overview of the responses received from those states who are most directly affected by the presence, real or potential, of the Indiana bat and include AL, IL, IN, KY, MD, MO, OH, PA, VA, and WV. My overview also reflects input from the federal regulatory program in Tennessee implemented by OSM. Several of these states will present more detailed overviews of their state-specific bat protection strategies during the panel presentation that follows my remarks, so I will do my best not to steal their thunder.

Survey

Our survey was structured around several key questions related to implementation of the 2009 guidelines. We attempted to ascertain the degree to which the states had incorporated these guidelines into their regulatory programs, how well the guidelines were working in terms of developing protection and enhancement plans, problem areas that have arisen during implementation, and changes or adjustments that might be helpful for future consideration.

Our overarching question was as follows: Since the guidelines were officially approved in September of last year, how and to what extent have you put them to use in your state? If you have not implemented them, please explain the approach you are using in your state to address Indiana bat protection and enhancement measures. In addressing this question, I should note that the majority of states focused on the use of the guidelines at active mining sites, while a small minority also discussed their use in conjunction with abandoned mine land reclamation projects. While the guidelines specifically state that they are not intended to cover AML projects, there was recognition that they might be so used, as determined by the local U.S. Fish and Wildlife Service office.

Results

Four states (IL, KY, VA, and WV) are directly using the guidelines as part of their regulatory programs and the latter three states have provided training or workshops for the industry regarding use of the guidelines. Other states (IN, OH, PA) have found the guidelines to be a useful tool and were already implementing many of the specific conservation measures addressed in the guidelines in their existing programs. OSM's Tennessee program does not utilize the guidelines per se, but instead relies on a separate guideline document that was developed between OSM and the FWS in 2006. In many instances, the full extent of the guidelines does not become relevant until habitat is found to exist, at which point permit applicants are required to either survey for bats or develop protection and enhancement plans.

Two states specifically spoke to the applicability of the guidelines to AML projects. Alabama has incorporated some aspects of the guidelines into their own state-developed guidelines for AML projects on the off-chance that Indiana bats were ever identified. To date, that has not been the case. In Indiana, the state was required to implement the guidelines for AML projects, as well as for active mining operations – much to their surprise. Following a period of negotiation and collaboration, the state has worked out an agreement with the FWS concerning applicability of the guidelines to AML project bidding and contracting.

A repeated concern by some states was the mandatory nature of the guidelines. These states understood that the guidelines were intended to be just that – discretionary options that a coal mining applicant could incorporate into a permit application and that the regulatory authority could consider in reviewing the permit application in order meet the requirements of the 1996 Biological Opinion (BO) regarding species-specific protective measures. It was further understood that if the guidelines were followed in detail, there was a greater assurance, perhaps even a guarantee that the requirements of the BO would be considered fully complied with. However, these states still believed that there was flexibility in terms of the use of the guidelines, should a state choose to pursue its own version thereof. These states are now concerned that, in actual practice, there is little room for discretion regarding use of the guidelines and that they are mandatory for all surface coal mining permits. How this continues to play out will be one of the future challenges for all of the parties to debate.

The second question explored the relative value and success of the guidelines in terms of ease of use, effectiveness, and providing additional clarity concerning the issues associated with protection of the bat. The general consensus of those states that have used the guidelines is that they provide more clarity as to the measures that should be taken to evaluate sites for potential use by the Indiana bat and that they readily explain the step-by-step processes and procedures that are needed to develop effective protection strategies for individual mining permits. Several states mentioned the value of the flowchart (Figure 1, p. 4) as a useful tool to determine the steps necessary to ensure protection and to orient permit applicants around the data that needs to be collected and submitted in their applications. One state commented that the guidelines are particularly valuable for permit applicants who desire a greater degree of predictability, knowing that if they complete all of the steps, they can be assured of closure on this particular matter.

A handful of states indicated that the jury is still out regarding the effectiveness of the guidelines, especially since they have not yet fully implemented them. These states also noted the complexity of the issues surrounding protection and enhancement plans and the evolving nature of the process. In some cases, the guidelines do not seem to provide enough detail or explanation of new requirements, examples being habitat determination and tree clearing restrictions. The latter issue is a particular problem for the state of Indiana (particularly selective roost tree removal), and I am sure you will hear more about this from Ramona Briggeman later this morning.

Next we asked the question: What, if anything, would you change about the guidelines or their implementation? This elicited a variety of suggestions or concerns including the following:

- Change the tree size from 5" dbh to either 8" or 10" dbh. The larger tree size should provide a more secure area for bats to roost and raise their young.
- Will equating the concept of "take" under the Endangered Species Act with "assumption of presence" in the guidelines survive a legal challenge? Is there potential for significant differences of opinion arising between the state RA and OSM about assumption of bat presence at a mine site? Does it make sense to define "take" based upon acres disturbed?
- Allowing the practice of selective roost tree removal in non-occupancy season and removal of the remaining non-roost trees during the occupancy season.
- Providing a list of federal agency contacts that can provide further guidance and insight regarding the guidelines.

- Matching up the mist net survey term (5 years from survey completion) with the term of the permit (5 years from permit issuance). This could encourage premature tree removal.
- Keep the guidelines adaptable to change with new circumstances.
- In light of issues associated with White-nose Syndrome, are the guidelines too summer range specific, as opposed to preserving, acquiring, and protecting hibernacula?
- In one state, the guidelines are actually less stringent than the state guidelines which could result in less protection for the species.

There remains the question of how best to address these suggestions and concerns, including any new ones that may arise over time. As I recall, there was agreement among the parties who developed the guidelines that if new issues or concerns arose in the future, especially based on implementation of the guidelines, the parties would meet to discuss and ideally resolve these matters. I am hopeful that this will continue to be the case, even though we do not have a specific timeline for doing so.

The survey then turned to the question of the states' experience in working with coal operators in the development and approval of protection and enhancement plans as part of the SMCRA permitting process. There appears to be significantly different experiences among the states here. On the one hand, we have states that have had positive experiences in working with their coal mining companies, especially as the companies understand the benefits of complying with the guidelines. One state noted that the protection plans developed by permit applicants appear to be more effective in both protecting the Indiana bat and replacing suitable habitat during reclamation than under the previous guidelines used by the state. Another state noted that the guidelines have resolved many industry consultation concerns on issues such as tree clearing dates and the validity period for netting data. The fact that the guidelines provide a step-by-step process for development of protection plans, as reflected in the flowchart, has been particularly helpful to industry.

A few other states noted concerns that have been voiced by industry, especially with regard to the mandatory nature of the guidelines and the restrictive nature of some of the requirements. At the same time, the mining companies are working with the states to comply with the guidelines in order to obtain needed permits. In terms of working with other state and federal agencies on protection measures, the state mining agencies have so far found the guidelines to be useful in defining roles and responsibilities and thus they have led to a greater degree of coordination and cooperation.

We next asked whether the guidelines have proven successful in helping the states to implement and meet their responsibilities under the 1996 biological opinion, especially since this was one of the primary objectives for developing the guidelines. In general, the experience to date is that the guidelines have been useful in meeting the requirements under the BO, although some states believe that their own guidelines and regulations already adequately addressed this matter. For those that have actively implemented the guidelines, they have found the process to be more defined and workable and that a broader understanding of mining-related issues and concerns has been achieved. Those who are still working toward full implementation or who are syncing up the guidelines with their existing program requirements have found the guidelines to be useful in confirming their existing procedures under the BO. One state articulated that it is hopeful OSM will defend the concept of equating "take" with assumed presence in the context of the BO.

In response to a question of whether there is enough flexibility and discretion provided in the guidelines to allow the states to tailor their PEPs to site-specific needs, the general consensus was that this was true, although a lingering concern was mentioned by at least two states concerning the mandatory nature of the guidelines. One state put it this way: "Phrases such as 'must be implemented' and 'reclamation activities must result in' serve to limit flexibility and discretion. This language appears to be more regulatory than guidance. To answer the question, more experience with the process is needed to determine if sufficient flexibility has been provided." In this regard, several states noted that they have been able to work out issues with their FWS offices in developing PEPs, although one state noted that the FWS field offices are interpreting issues differently within the same regions.

We then asked a series of questions about the states' experience with several specific aspects of the guidelines and appendices that were identified as being critical components of the species protection protocol. With regard to **habitat determination**, one state noted that it can be difficult to determine whether a mine portal is actually being used by bats, especially if it is abandoned. One state recommended more science to support this particular requirement, while another indicated that its own guidelines were stronger in terms of favoring protection of the bat and acquiring bat habitat.

With regard to **demonstrating lack of adverse effects**, there was an overall sense that this was going to be difficult to establish and that in actual practice, a very small percentage of permit applicants have been able to demonstrate this. One state recommended that examples be cited. On the topic of **conducting bat surveys**, one state recommended the inclusion of more information in the appendices about the use of some of the less familiar survey methods. Another state noted that the five year limit could be an issue given the fact that it will never coincide with permit renewal, will encourage waiting until the last minute to do a survey and may encourage excessive clearing to reduce the need for additional surveys. On the topic of **avoidance measures**, one state noted the potential difficulty of compliance when performing reclamation work at high priority AML sites. Another state mentioned that some permit applicants have been changing their mine plans to avoid potential habitat and have been more receptive to limiting mining activities to areas already disturbed by previous mining activities. In this state, most applicants are opting to survey proposed sites, if possible, to demonstrate a lack of presence and thus show that the proposed plan is avoiding impact.

With regard to **minimization measures**, one state questioned the level of applicability at active mines of staged tree removal and flooded timber protocols. Another state noted the fact that its watering areas and reforestation rates are more stringent than the federal guidelines. And finally, with regard to **enhancement measures,** most states noted that these are becoming standard operating procedure. One state commented that more species of trees suitable for use as habitat are being planted and greater diversity in plantings, along with a focus on the use of native species, is increasing. The use of rough grading techniques to enhance tree survival has also increased. In one state, a joint program with a sister state agency has allowed mining companies to mitigate mining impacts to the bat by purchasing land that will be managed as bat habitat in perpetuity. In another state, one permittee has enhanced areas on their reclaimed permit by installing “bat boxes” designed by BMI.

We next asked whether any of the states have customized the guidelines in the areas I just discussed and whether those measures are more or less stringent than the federal guidelines. A few states, as mentioned earlier, have guidelines in place that do not exactly mimic the Range-wide guidelines but include most of the elements and protocols. In one case, the state guidelines are actually more stringent. A few of the differences among the states include the following: one state determines the need for site specific information and surveys on a permit by permit basis, not based on a minimum acreage requirement; one state has more stringent netting requirements; and one state has adjusted requirements for seasonal clearing restrictions, acoustic monitoring, tree plantings next to streams, minimum number of tree plantings, and minimum soil compaction. In large measure, the states are implementing the guidelines directly or have guidelines of their own that are no less stringent.

We also asked if there were other areas or aspects of the guidelines on which the states wished to comment. One state indicated that it would be helpful if there was a map that identified the range of the species habitat. Another expressed its concerns about off-site mitigation for the Indiana bat and how that might play out as part of a permitting process. In this regard, another state specifically mentioned its concern about the 40 acres of forest land outside the radii around hibernacula and roost trees. This state also noted that, while the 1996 BO is not applicable to non-coal mines, the state’s own guidelines do apply to these mines and this may become more of a concern in the future.

We completed our survey by asking states whether they had any data or information regarding the location of mines and caves that have been gated. Some of the states will be presenting this information during the forum, so I will not go into it at this point. Suffice it to say that many of the states have utilized gates to protect bat populations and hibernacula, especially at abandoned coal mines.

Gregory E. Conrad is Executive Director of the Interstate Mining Compact Commission (IMCC), a multi-state governmental organization representing 24 mineral producing states. Greg has served in his position since 1988 and is responsible for overseeing several issues of importance to the states in the legislative and regulatory affairs arenas including mining and reclamation, mine placement of coal combustion products, identification and restoration of abandoned mine lands, mine safety and health, and various environmental issues associated with mineral production such as surface and ground water quality and quantity. Prior to joining IMCC, Greg served for nine years as senior counsel with the American Mining Congress, which is now part of the National Mining Association. While with AMC, Greg had primary staff responsibility for several coal related issues including transportation, leasing, research and development initiatives, and surface mining and reclamation. Greg has spoken and presented papers at a variety of meetings and conferences hosted by such organizations as the Eastern Mineral Law Foundation, the National Academy of Science, the Conference of Government Mining Attorneys, the American Association of State Geologists, the Colorado School of Mines, the Office of Surface Mining, the National Association of Abandoned Mine Land Programs, the National Mining Association, the Environmental Law Institute and various state government groups. He has written extensively on mining issues for professional journals and magazines. Greg graduated from Michigan State University with a degree in business administration and later from the University of Detroit/Mercy School of Law where he was an associate editor of the law review.

State Survey Results

Survey of the States re Indiana Bat Protection and Enhancement Guidelines

Due to the fact that these states are outside the range of the Indiana bat, the following states did not respond: AK, AR, CO, LA, MT, ND, NM, MT, OK, TX, and UT. Others that are likely in this same situation, but did not respond, include WY, IA, KS, and MS. The following states did respond to the survey and their input is summarized generally below: AL, IL, IN, KY, MD, MO, OH, PA, VA and WV. We have also included input from OSM's federal program in TN.

1. **Since the guidelines were officially approved in September of 2009, how and to what extent have you put them to use in your state? If you have not implemented them, please explain the approach you are using in your state to address Indiana bat protection and enhancement measures.**

AL – For AML projects, we have not used the specific guidelines as listed in the document. However, in 1988, we hired two consultants from Kentucky to enter some of our abandoned mines to search for bats and to provide training on how to identify potential bat habitat. Since that time, we have used the guidelines provided by the consultants to determine whether each site has the potential to support bats. If it is determined that bats (any species) could possibly utilize an underground mine portal, we close it using a bat gate. We are unaware of any sightings or capture of Indiana bats during the spring or summer months while they are raising young or roosting in forested areas of Alabama. At this time, no PEP should be required for our AML projects. If and when additional bat surveys are conducted and Indiana bats are located, we will initiate a PEP as required. For active mining permits, no Indiana bats have been identified. We would implement the guidelines if any were discovered.

IN – Indiana has found the guidelines to be a useful tool containing guidelines for protection of the Indiana Bat. Indiana was already implementing many of the species specific conservation measures addressed in the guidelines. Other than the prohibition against selective roost tree removal there has not been substantive changes. Unfortunately, we apparently had misunderstanding as to the implementation of these guidelines as they are instead more to the effect of mandates.

<u>AML</u>

It was our understanding the guidelines were applicable only to the Regulatory Program but they were also immediately implemented for the Abandoned Mine Land Program. It took a lengthy cooperative effort with staff of the Abandoned Mine Land Program and the FWS to work issues that otherwise were problematic to bidding and contracting. At this point, the AML Program has agreement in concept on implementing the measures of concern and it appears the issue is close to resolution. It might have been worthwhile to consider a phasing in of the guidelines rather than immediate implementation due to changes that had to occur that, because of the time of year, were problematic.

<u>Regulatory</u>

Indiana had a representative on the team that developed these guidelines. Throughout the deliberation of the contents of this document by team members, the Indiana representative continually reported to Indiana's director and to Indiana's wildlife biologist assigned to SMCRA issues that "no practice in effect today will change as a result of this document". It was also our understanding the "guidance" document would contain items that could be considered, picked, and chosen for generating species specific protective measures and in no way was a mandate. The outcome was very different and the guidelines have instead become mandates.

I do want to note the two other state representatives on the team view this differently from our position although our representative did not indicate this to be the case. We did not realize they viewed it differently until we inquired with them after the FWS said seasonal cutting was no longer allowed. Kentucky has indicated concern with tree cutting and stated their research has shown that harming other trees could occur that then become an occupied tree or a limb being harmed that then becomes occupied. No reply was received upon asking for the details or the publication of this research. No reply was received when we asked for minutes of the meetings themselves either. The Indiana representative had since retired although we did find reference in his notes indicating his belief that seasonal tree clearing could continue.

Specific issues are as follows:

The FWS mandated that no cutting during the summer occupancy season can occur. Previously, the FWS had commented upon Indiana's policy for selective roost tree removal during the non-occupancy season and then cutting the remaining trees during the summer occupancy season in what otherwise would be the non-cutting season. Selective Roost tree removal during the non-occupancy season is a method to minimize temporal loss of summer foraging habitat and optimize the availability of such habitat during the mining operation. We believe selective roost tree removal is beneficial for a variety of reasons, including:

a. Foraging habitat is a vital component of the habitat of the Indiana bat. Selective removal allows foraging habitat for the bat to remain as long as possible.

b. Because the bat is reluctant to cross open areas, this habitat could serve as a travel corridor in the short term connecting unaffected areas.

c. Potential roost trees can remain to the last possible season prior to being affected then selectively removed during the non-occupancy season

d. Selective removal allows for the mining company to affect and handle soils at a drier time of year thus reducing compaction and increasing the capability of replaced soils to nurture trees.

e. Should the mining plan change- a viable forest habitat with many mature trees is still present and the time frame for development of roost trees in the future is more rapid.

f. Minimizes sedimentation in streams.

Most of these points have been mentioned in the PEP guidelines as important to the Indiana bat (not to mention other woodland species). Selective roost tree removal minimizes the area disturbed at one time, increases the life of foraging habitat, avoids clearing areas that potentially may not be mined, allows the timing of removal activities to be one year in advance of pit advancement, potentially provide future roosting habitat earlier if ultimately not affected by coal removal.

This practice worked well. It took away any concern of cutting by landowners many years in front of an application being received and it significantly reduced erosion from cutting activities during non-occupancy months at which time the ground surface is at the poorest for timbering.

The document, in Section 2.4.1, Page 9, Tree Clearing Restrictions, indicates: Seasonal tree clearing restrictions are a **required** (emphasis added) avoidance measure that can minimize potential adverse effects to Indiana bats caused by timber removal, or other disruptions of habitat, during Indiana bat occupancy periods. In general and when unavoidable, summer and swarming habitat may be removed when bats are not likely to be present, which is typically the winter months when Indiana bats are hibernating. **Tree clearing is defined as the removal of all trees greater than or equal to 5 inches dbh and does not include the selective removal of suitable bat roost trees.** (emphasis added). This underlined statement has been interpreted by Indiana's Division of Reclamation and by OSM's Alton staff to allow for seasonal tree clearing. The FWS disagrees and says it only allows for seasonal clearing during the non-occupancy period. We disagree with that position and question why that statement would be included when the previous sentence clearly indicates trees can be cut during the non-occupancy period.

IL – In Illinois we have started asking coal mine permit applicants a number of questions regarding Indiana bats taken from the new guidelines such as the following:

a. Are there any trees greater than or equal to 5 inch dbh with exfoliating bark within the proposed permit area?
b. If a above is "yes", then will the proposed operations affect those trees?
c. Is the site within 10 miles of an Indiana bat P1 or P2 hibernaculum?
d. Is the site within 5 miles of an Indiana bat P3 or P4 hibernaculum?
e. Is the site within 5 miles of a female or juvenile Indiana bat capture site?
f. Is the site within 2.5 miles of an Indiana bat maternity roost tree?
g. Is the site within 2.5 miles of a male Indiana capture site?

h. If c, d, e, f, or g is no, can a determination be made that no adverse effect on Indiana bats will occur? If yes, justify such a determination.
i. Is "take" of Indiana bats (as defined in the Endangered Species Act of 1973 as amended or in the Illinois Endangered Species Protection Act) anticipated to result from the proposed operations?
j. State whether or not an incidental take authorization is being sought to "take" Indiana bats incidental to the proposed operation. If an incidental take authorization is being sought, the number of Indiana bats proposed to be taken shall be specified.

So far, only 2 applicants have indicated that no habitat exists. The Department does not plan to require protection and enhancement plans, per the 2009 guidelines in these cases. Several other applicants have indicated that habitat does exist. The Department is working with those applicants to develop protection and enhancement plans meeting the specifications of the guidelines.

KY -- The Kentucky Division of Mine Permits has been making the use of the 2009 Guidelines as requirement for all new applications submitted after October 1, 2009. Outreach training by KYDNR and FWS on the Guidelines was given to the coal industry, permit reviewers and field inspection personnel. A reclamation advisory memorandum (RAM) with the new Guidelines attached was distributed to coal applicants. All applications are required to evaluate the proposed disturbance areas for potential impacts to the Indiana bat and potential habitat, and if habitat is found to be present, all applicants are being required to either survey for Indiana bats (where applicable) or develop protection & enhancement plans (PEPs) in accordance with the 2009 Guidelines.

MO -- No new permits or revisions have been received, hence we have not implemented these guidelines. For future permits, our approach will be to consult with FWS and the Missouri Dept. of Conservation, as in the past, to assure their concerns are addressed, if any.

OH -- Ohio is not using the guidelines but Ohio has incorporated some of the items in the guidelines into a Procedure Directive (Permitting 2010-1 located on our web page). The Procedure Directive was issued July 19, 2010. This Procedure Directive is an update of one we were already using. The regulatory and permitting staff are now following the new Procedure Directive.

PA -- The Pennsylvania DEP uses the regional guidelines as general guidance, but we also use the PA Guidance which is specific to PA (more restrictive in several ways) and includes steps for a Protection and Enhancement Plan.

TN -- To date, the Range-wide guidelines have not been implemented in Tennessee. We use the guidelines set forth in the document “Coal Mining in Tennessee, Minimum Guidelines for Development of Protection and Enhancement Plans for the Indiana Bat (*Myotis Sodalis*)”, dated March 2006. The Knoxville Field Office worked with the U.S. Fish and Wildlife Service, Cookeville Field Office to produce this document as a requirement of the 1996 BO.

VA -- The regulations have been distributed to industry via Presentations for the Virginia Mining Association and via an email to all consultants. A discussion at Technical Section Meetings has been held on how to administer the guidelines within the division. During the permit review process, ecologist have made numerous comments pertaining to the guidelines and directed numerous consultants to the document for permit planning. Ecologists have obtained the Fisheries and Wildlife Information Service from the state game department (VDGIF) and can access collection data (GIS) for all recorded Indiana Bat captures and hibernacula to aid in the permit review process.

WV -- West Virginia both implemented and web-published the Guidelines effective January 1, 2010. WVDEP hosted a related Workshop on the Guidelines in February, 2010. The new Range-wide Guidelines largely reflected the existing WV State Guidelines implemented January 1, 2007. The transition was thus a seamless one. The web link to the Guidelines including the WV State specific Preface is as follows:
http://www.dep.wv.gov/dmr/handbooks/Documents/Indiana%20Bat%20Guidelines%2003-22-10%20Revised.pdf

2. **How would you characterize the success of the guidelines in terms of ease of use, effectiveness, and providing additional clarity to the issues associated with protection of the bat? Please attempt to answer this question even if you are not actively using the guidelines, based on your review of them.**

AL – We do not use these guidelines at AML projects. However, our guidelines are very similar when dealing with abandoned underground mines. They should be effective and easy to use.

IN – For most issues the guidelines are fairly straightforward and easy to implement. The mining industry in Indiana had been including in mining applications many of the components of this final document. Our one issue remains that mentioned above.

IL -- It is too early to tell. As we gain more experiences with the guidelines, as we complete the permit application process with several pending applications, we will learn more about how easy they are to use and how successful they are. The flow chart in the guidelines seems pretty self explanatory and should be easy to follow.

KY -- The new guidelines have provided more clarity as to the measures that should be taken to evaluate sites for potential use by the Indiana bat, and readily explained the step-by-step the processes and procedures that are needed to develop protection strategies for individual mining permits.

MO -- This document is well organized and appears to adequately discuss the concerns and resolutions for addressing the Indiana Bat issue. I found the flow chart to be very useful.

OH -- Ohio was already using similar guidelines (Procedure Directive) that were developed between ODNR and USFWS. These new guidelines go into much more depth and details. The new Procedure Directive we developed has only been used for a very short time but it does make the process very clear for permitting and regulatory staff and also industry people. We had the mining industry in Ohio comment on the Procedure Directive prior to issuance.

PA -- The guidelines provide a good general overview, but this continues to be a complex issue and evolving process. We have developed a sample letter and will soon develop a guidance form that can be used by the permitting staff and applicants.

TN -- Ease of Use: Initially, the use of the guidelines would be difficult to use because it's a new document, it's a lengthy document, and it contains some new and additional requirements. Like any new guidelines, it will take time and effort to become familiar with them. More than likely it will require additional work to comply with and require changes in current procedures.

> Effectiveness: The guidelines are well written. They provide a good explanation why they were developed and how they should be implemented. In the long term, I think the use of these guidelines or similar guidelines will lead to better protection of the Indian bat and better understanding of the bat's habitat and needs.
>
> Clarity of Issues: The guidelines contain a lot of requirements. Some sections contain no real explanation as to why they are needed or the reasoning behind the requirement. Of particular concern is Section 2.2, Step 2: Habitat Determination and Section 2.4.1.1, Tree Clearing Restrictions.

VA -- Simply having a document to reference has provided clarification on many occasions. The flowchart included (Page 3) in the document works well as a tool to determine the steps necessary to ensure protection of the species and to serve as a simple model to orient applicants to the data that needs to be collected and submitted in their applications.

WV -- Most applicants want to know what to do and that if they complete the prescription that there would be some predictable end point or closure to the matter. This has been the case and the program has thus been effective.

3. What, if anything, would you change about the guidelines or their implementation?

AL – Change tree size from 5" dbh to 8" or 10" dbh. The large tree size should provide a larger more secure area for bats to roost and raise their young. Also, there might be a problem if a project investigator and an OSM oversight person differ on whether they want to assume bat presence.

IN – The single most significant issue for Indiana is the prohibition on selective roost tree removal. This has affected both the Title V and Title IV programs. Prior to issuance of the guidelines, Indiana practiced selective roost tree removal (any tree over 5 inches dbh with exfoliating bark, cracks, splinters or openings) during the non-occupancy season and allowed removal of the remaining non-roost trees during the occupancy season. The Bloomington USFWS field office interprets the new guidelines to prohibit this practice. Indiana would like to be able to continue the practice of selective roost tree removal in the non-occupancy season

> Clarity as to application and significant documentation of intent. Quite honestly, in retrospect, we would have sternly opposed generation of this document unless it was very clear as to its applicability. We do not believe the current approach concerning seasonal tree cutting considers balancing the issue of protection of the bat and protection of stream ecologic and hydrologic resources.
>
> Quantifying a take based upon assumption of presence and based upon acres disturbed seems an unreliable methodology and one that will eventually be used by opponents who will state that mines killed x number of bats even though there is no evidence indicating that to be the case. This seems strange, particularly when the guidelines to prevent a take are being implemented.

IL -- Equating an ESA "take" with assumption of presence seems to be giant leap in applying that aspect of the ESA. Do you folks who came up with that feel confident that it will withstand the test of litigation?

KY -- No changes appear to be necessary at this time.

MO -- Provide a list of Federal Agency contacts that can provide further guidance and insight to the development of these guidelines.

OH -- The one problem we see is the mist net survey term (5 years from survey completion) does not match the term of the permit (5 years from permit issuance). Inspectors may need to monitor this situation for requiring a new mist net survey if needed. This may also encourage premature tree removal.

PA -- It might be more convenient to be able to follow the Range Wide Guidance rather than the more restrictive measures in the PA Guidance, particularly for mining companies operating in several states. In the PA guidance, the habitat protection radius was expanded from 5 to 10 miles for P3 and P4 Hibernacula, reforestation is at a 90% rate compared with the 70% rate in the Range Wide Guidance, and watering areas may be required at the rate of one pond for every 50 acres of mined area in many cases.

TN -- I would rethink and possibly change/limit the options presented in Section 2.2, Step 2: Habitat Determination and Section 2.4.1.1, Tree Clearing Restrictions.

VA -- No changes currently, I do hope that there is a method to keep the guidelines adaptable and able to change when new circumstances develop (impacts of white nose syndrome research).

WV -- The Guidelines seem to be too summer range specific where the attention in heavily forested states might be better directed toward the preservation, acquisition and protection of hibernacula especially in view of White Nose Syndrome (WNS).

4. **What has been your experience in working with coal mining companies in the development and approval of protection and enhancement plans as part of the SMCRA permit? Have the guidelines proved useful in this process? If you are not using the guidelines, how are your own guidelines or approaches working?**

AL – None

IN – See above. Obviously the coal industry is in an uproar and question how these mandates have come about without any opportunity by them for comment. They feel this was rulemaking by policy. Although we disagree with the prohibition against roost tree removal, there have not been any other negative issues.

IL -- We are not aware that we have any choice in applying the guidelines. We sought clarification on that issue and are under the impression that the guidelines are binding. Our experience with the coal companies is that they see the guidelines as overly restrictive but will submit to them in the interest of obtaining their permit.

KY -- All of the coal mining companies we have dealt with appear to be amiable to using the new Guidelines, once the benefits of the new Guidelines were explained to them. Once the applicants have understood the guidelines, the protection plans developed by the applicants appear to be more effective in both protecting the Indiana bat and replacing suitable habitat during reclamation than previous guidelines used by our agency.

MO -- None. However our approach has been for the applicant to coordinate with the various agencies prior to submittal of the application and our staff conducts follow-up correspondence to assure the wildlife agencies satisfied. This has worked well in that there have been no significant conflicts and the permits have been completed in a timely manner.

OH -- Ohio has been requiring protection and enhancement for some time. Companies are beginning to get used to the system and are doing what is best for their individual situations. With over 130 permits reviewed and 80 surveys, no company has captured an Indiana Bat yet. The big changes from our previous procedure directive are the 5 year term for surveys, reforestation survival rate, and requirement for native herbaceous planting.

PA -- While each permit application presents unique circumstances, the guidelines provide a good framework.

TN -- I work as a permit reviewer on biology, revegetation, and soils issues. This requires me to work with companies on a regular basis to incorporate PEP's in their mining plans. I have worked directly with FWS to develop the Indiana bat and the blackside dace PEP guidelines for Tennessee mining permits. In both instances, mining companies were given opportunity to comment on the guidelines during the development of the guidelines and changes to the documents were made as a result of their comments.

Have the guidelines proved useful in this process? Yes, guidelines are like a recipe. They provide a step by step process to achieve the desired product.

If you are not using the guidelines, how are your own guidelines or approaches working? Currently we are not using the Range-wide plan in Tennessee, but I think we are achieving favorable results with the guidelines being used in Tennessee. We will be looking at the Range-wide plan to enable us be more consistent with other state programs and to address aspects of the Tennessee plan that could be improved.

VA -- Once again the guidelines, especially the flowchart included, have been a perfect reference to allow the companies to know how the agency will deal with Indiana Bats and their critical habitat.

WV -- See answers to questions 1 and 2 above. Also, WVDEP was keenly aware of the industry consultation concerns, such as: differences between state programs not based upon science (i.e. varying tree clearing dates, etc.). The Region-wide Guidelines resolved many of these and other concerns including the three year validity period of netting data which was extended to five years via the new Guidelines. Yes, the Guidelines are useful and they are working in WV where they are widely accepted by the varying government agencies.

5. **Have the guidelines proved successful in helping you implement and meet your responsibilities under the 1996 biological opinion? Again, if you are not actively using them, do you believe they would assist you in meeting your BO responsibilities?**

AL – Yes

IN – We believe the program was already meeting the responsibilities beneath the 1996 biological opinion. We believe these responsibilities are still being met but in a less balanced manner now that the guidelines are being mandated.

IL -- We believe aspects are useful. For example, the distances specified in the guidelines are helpful in making adjacent area determinations under 780.16. The equating of "take" with assumed presence does not seem to be particularly useful; however, if that was what was negotiated on our behalf and OSM is prepared to enforce that using their oversight powers, that is what we will pass along to the industry and we will rely on OSM to defend that position if contested.

KY -- In discussions I have had with the US Fish and Wildlife Service, it seems that they are pleased with the process and implementation of the guidelines by our agency and have had no complaints. Implementation of the guidelines has been successful thus far.

MO – N/A. We would only use the guidelines to assist in meeting the 1996 Biological Opinion if required to do so by the USFWS.

OH -- The guidelines have confirmed our process and helped add detail to our process. We used the guidelines to revise our Procedure Directive.

PA -- Yes, and we are doing much more to protect Indiana bats and habitat compared to a few years ago when we only worried about timber restrictions. For the impacted mining community, it seems as if costs resulting from Indiana bat issues have increased and more restrictions have come into place, almost overnight.

TN -- Our current guidelines have helped us successfully implement the 1996 BO. We will work with the FWS to determine when and how to implement the Range-wide plan in Tennessee.

VA -- The playing field is set, now the applicants know the rules to the game. The process is more defined and workable. It is no longer a surprise to many applicants when we ask them to do additional surveys due to their location in reference to known hibernacula or capture sites.

WV -- Yes in that per the '96 BO, both OSM and the State RA's had direct involvement with their development thus a broader based understanding of mining related issues and concerns.

6. **Is sufficient flexibility and discretion provided in the guidelines to allow you to tailor your PEPs for site specific needs?**

AL – Yes

IN – Indiana believes that the guidelines themselves support the option of tailoring the specific plans to each state but local USFWS field offices are still interpreting issues differently within similar regions and in some cases using the guidelines as if they are law.

IL -- We would note that phrases such as "must be implemented" (2.4.1 1st para.) and "Reclamation activities must result in …" (2.4.2.2, para. 2)) certainly serve to limit flexibility and discretion. This language appears to be more regulation than guideline. To answer the question, more experience with the process is needed to determine if sufficient flexibility has been provided.

KY -- Yes, the guidelines allow for enough flexibility to develop PEPs that effectively protect and replace Indiana bat habitat, while allowing the mining companies to tailor the plans to suit their specific needs with regards to tree clearing, post-mining land uses, etc.

MO -- There appears to be a sufficient amount of flexibility.

OH -- Generally, Yes

PA -- Yes, and to date we have been able to work out issues with the FWS primarily using the PA guidance for developing a PEP.

TN -- Yes

VA -- The on-site habitat and collection techniques seem to work throughout the coalfields. The mitigation measures suggested are sufficient but also allow for innovative practices when deemed necessary.

WV -- Yes, we believe that we have successfully been able to address endangered species presence when encountered in cooperation with USFWS, OSM, WVDNR and the applicants. This is not to say that it was always easy and without lengthy negotiations and process at times. Valuable experience with the process has also been gained which has improved current efficiency.

7. **If possible, please comment on your experience with and concerns (if any) regarding the following aspects of the guidelines (and appendices) – or with your experience under your own guidelines/approach:**

Habitat Determination

AL – Sometimes it is difficult to determine whether a mine portal is actually being used by bats. Examples = 1) portal accessible to bats; 2) fresh air flow from portal opening; 3) not flooded; 4) bat feces and/or insect parts not evident at portal entry (summer time). If a portal possesses potential for bat occupations, we would use a bat-friendly gate to close it.

IL – the guidelines seem pretty straight forward on this

KY -- The applicants are completing this for most every application, unless KYDNR personnel has evaluated the site and determined it is not necessary. Applicants have been very candid and forthcoming on their determinations, and have been honest about the amount of habitat present.

PA -- The PA Guidance favors protection of the Indiana bat and acquiring bat habitat; while the Range Wide guidance could be seen by some in the industry as more balanced.

TN -- I would like to see some science to support the habitat determinations.

Demonstrating Lack of Adverse Effects

IL -- Other than the situation where a particular portion of the permit area is not planned for disturbance, lack of adverse effects seems pretty nebulous.

KY -- A very small percentage of the applicants have been able to demonstrate a lack of adverse effects, and all of these were correct when evaluated by KDNR and USFWS.

PA -- Operators and the DEP may have difficulty getting the USFWS to agree that there are no adverse effects in some cases. The mining company might have to hire an environmental consultant with Indiana bat expertise to prove their case to the USFWS, although we have not experienced this as yet.

TN -- Examples could be cited.

Conducting Bat Surveys

IL -- The guidelines seem pretty straight forward on how the surveys are to be conducted.

KY -- The majority of the applicants thus far have been choosing to conduct a survey in areas where known bat records are not present. The number of surveys has more than doubled since the new guidelines were implemented.

OH -- 5 year time limit could be an issue, considering it will never coincide with permit renewal, will encourage “waiting until the last minute” to do a survey, and may encourage excessive clearing to reduce the need for additional surveys. May also encourage clearing of site prior to completion of 404/401 permitting process, leading to impacts to streams and wetlands if tree clearing around these resources occurs prior to alternatives analysis to avoid and minimize aquatic impacts.

PA -- It is hard to find Indiana bats, but if you do, more of your land will be deemed bat habitat, therefore placing more land off limits for mining. The cost of bat surveys is an additional cost placed upon the operator. Small mining companies who operate in the same area for years could be affected to a greater extent than larger operators.

TN -- More information about the use of some of the lesser used survey methods in the appendices would be helpful.

Avoidance Measures

AL – If we have a Priority 1 or Priority 2 surface mine that contains an Indiana bat roosting area a maternity area, we could not avoid the disturbance of these areas. However, if these habitats are located on spoil material that is required to backfill a highwall, we could minimize the effect of the disturbance by clearing the spoil area in the winter months when the bats are not present.

IL – The guidelines repeatedly use the phrase "a recommended avoidance measure". This language appears to be consistent with the idea of "guidelines", as opposed to the "must be" and "must result in" language cited above.

KY -- Some applicants have been changing their mining plans to avoid potential habitat and have been more receptive to limiting mining activities to areas already disturbed by previous mining activities. Most applicants are opting to survey proposed sites, if possible, to demonstrate a lack of presence and thus showing that the proposed plan is avoiding impact.

PA -- These measures work well.

TN -- What science drove the need to include two different tree clearing dates?

Minimization Measures

IL -- The guidelines have useful suggestions in this regard.

KY -- Applicants have been implementing avoidance measures more readily under the new guidelines, limiting the amount of disturbed area and adhering to the clearing restrictions, thus ensuring that habitat is only disturbed when bats are not present.

PA -- Watering areas and reforestation rates are more stringent in the PA Guidance requiring one watering pond per 50 acres of mined area in most cases, and 90% reforestation rate, all adding to costs to reclaim the site and limiting post mining land use.

TN -- I understand the basis behind staged tree removal and flooded timber but their applicability in an active mining scenario is limited.

Enhancement Measures

IL -- Rather than making recommendations regarding habitat measures, the guidelines dictate that applicants "must attempt" to replace water, "must result" in reforestation of 70%, use of native species is "required", forest habitat "must be replaced" by … six species from the supplied list. Again this sounds more like rulemaking and less like guidelines.

KY -- Applicants are using the enhancement measures in the guidelines. More species of trees suitable for use as habitat are being planted, and greater diversity in plantings along with a focus on the use of native species is increasing. Also, the use of rough grading techniques to ensure tree survival has also increased. All in all, it seems that the enhancement measures proposed under the new guidelines are being utilized and accepted by the mining companies.

PA -- A Habitat Compensation program was set up with the PA Game Commission to allow mining companies to mitigate mining impacts to Indiana bats by purchasing land that will be managed by the PA Game Commission as Indiana bat habitat in perpetuity. The PA Game Commission has yet to come up with land values for counties with no Indiana bat hibernacula but that still trip the 40 acre deforestation trigger.

TN -- Generally easy to incorporate in a mining operation plan and is becoming SOP in most permits.

VA -- The survey methods are pretty standard. Minimization and avoidance that occurs in Virginia usually result in time of year restrictions for tree harvest. One permittee has enhanced areas on their reclaimed permit by installing "bat boxes" of BMI's design. Many others have planted exfoliating bark species and converted sediment basins to wetlands to enhance habitat.

WV -- No major concerns over these particular items.

8. **Has your state "customized" the Guidelines with regard to the bullet topics above? Are these measures more or less stringent than outlined in the Guidelines? Please give examples if possible.**

IN – No

IL -- No we have not. We are under the impression that the guidelines are binding and we do not have the option to be less stringent.

KY -- The guidelines are being utilized as written. Our state does not have a minimum acreage requirement; rather we are determining the need for site specific information and surveys on a permit by permit basis.

MO -- No, again we will rely on coordination with USFWS and our state wildlife agency to determine the need for implementing these guidelines.

OH -- Changed seasonal clearing restrictions for summer habitat to April 1 – Sept 30.

- Eliminated requirement for acoustic monitoring. Not confident about reliability of species-level acoustic I.D. in Ohio.
- Grouped Avoidance and Minimization measures together as "Protection Measures."
- Required tree planting 100 feet either side of streams (instead of 50).
- Required minimum 600 trees planted/acre.
- Required demonstration of minimization of soil compaction for tree planting areas.
- Tried to condense the document to make it easily interpreted by industry
- Overall, Procedure Directive is about equally as stringent as range-wide guidelines

PA -- Yes, Pennsylvania has specific guidance for Indian bats that is more stringent in several areas than the Range-wide Guidelines. The examples appear above in several of our answers.

TN -- The guidelines we are using in Tennessee don't mimic the Range-wide guidelines. I don't see them as less stringent, but they don't include all of the alternatives and as much habitat information currently found in the Range-wide guidelines.

VA -- No customization has occurred in Virginia, after the guidelines have been instilled and practiced for a longer duration, we may find reasons to adjust them.

WV -- Yes, to a slight extent. WVDEP provides a brief web-page preface to the Region-wide Guidelines. The Preface addresses three WV specific items: 1.) State-Specific Acreage Threshold Options based upon forest cover (largely more stringent in that netting is required for all applications in excess of 247 acres). 2.) It addresses the slight changes of the Range-wide Guidelines versus the prior WV Guidelines and 3.) It Provides the Listing of WV Qualified Indiana bat Surveyors.

9. **Should you have other comments or concerns regarding the guidelines or their implementation, please identify them.**

KY -- None at this time.

MO -- It would be helpful if there was a map that identified the range of the species habitat.

OH -- We have a general concern about clearing site prior to coal application to avoid addressing Indiana bat. Not experienced with off-site mitigation for Indiana bat. Unknowns regarding how that process will play out.

PA -- Our major concern is the impact on 40 acres of forest land outside the radii around hibernacula and roost trees. This area does not show up on PNDI searches and is now just starting to be considered. We are working with Carole Copeyon to include a reminder for Indiana bat considerations when 40 acres of forest may be affected. This is also an issue for Non-Coal mining for which there is no 1996 biological opinion, and results in operators having to consult directly with the USFWS to get take coverage. The PA Guidance also applies to Non-Coal, which is helpful. The State College Office of the USFWS is just starting to deal with the Non-Coal issues and procedures are still evolving.

TN – good job on a difficult task.

VA – None

WV -- The issue of assumption of presence equating to Incidental Take (ITS) remains an area of concern.

10. **Do you have any data or information that you can share regarding the location of mines and caves that have been gated? Maps and numbers of bat gates or other bat-friendly closures installed would be particularly helpful.**

AL – Yes

IN – Not for the Regulatory Program which was the intent of implementation of this document. The coal region of Indiana has little topographic relief and any slopes or shafts from permanent program underground mining are required to be sealed.

KY -- No caves or portals usable by Indiana bats have been identified on any permit application since the guidelines were implemented. The Kentucky AML program often gates abandoned mine portals.

MD – The Maryland AML program hired the University of Maryland, Center for Environmental Studies, Appalachian Lab to complete a bat survey of 52 open portals in western Maryland from 2006 to 2008. The survey included mist netting to estimate the number of bats occupying the mine and the species. Management recommendations to accommodate bats were also provided in the study. No Indiana bats were found as part of this survey. Maryland has gated 2 mine openings since completion of the Bat Study. Five additional openings will be gated during the Summer/Fall of 2010. The remaining openings will be gated as funds become available.

MO -- Our AML program has reclaimed several portal openings by constructing a grate over the openings to prevent entry. These grates were constructed using heavy rebar welded to create a grate with 6” x 6” square openings. These grates allowed the wildlife, including bats, to continue to utilize the portal openings for wildlife habitat.

Additionally, a bat gate was designed and installed to prevent entry into a lead/zinc portal in Jefferson County (located at UTM 705,408,4,222,252). The bat gate and grates were placed in areas where there is a potential for Indiana and Gray bats. No population sampling was conducted and there were no apparent signs of bat use prior to the projects.

OH -- Ohio’s AML staff have gated about 30 mine openings with bat friendly gates over the years.

PA -- See the attached maps and list of deep mines that the Pa. DEP, Bureau of Abandoned Mine Reclamation has surveyed and gated. Cave issues are handled by the PA Game Commission, and we are unaware of a list of gated caves in Pennsylvania. Most caves in Pennsylvania are on private property.

TN -- No information. No mines or caves have been gated in Tennessee on a permitted mine site since our guidelines were put in place.

VA -- YES. This is exactly the information I am working to gather to present for Virginia’s portion of the Indiana Bat Conference held in Charleston, WV on August 31-Sept 3.

WV -- WVDEP Abandoned Mine Lands (AML) personnel will be presenting information regarding their gating efforts at the upcoming Forum. Other parties that have installed gates at mines include the National Park Service (NPS) in the New River Gorge. WVDEP is aware of but does not have the specifics on the NPS bat gates.

Industry Perspective on Bat Protection Efforts

- General Conservation Approach
- Protection and Enhancement Measures
  - Assessment of Future Mine Areas
  - Mine Permitting Procedures
  - Land Reclamation (Habitat Restoration) Practices
- Perspective on Regulatory Process

General Conservation Approach

- Determine possible presence or probable absence
- Reduce/eliminate disturbance when bats potentially present
  - Summer habitat & hibernacula
- Reduce disturbance to suitable habitat on mine sites
- Restore suitable habitat during mined land reclamation

General Conservation Approach
Specific to Indiana bat

- Determine distance to hibernacula or site record
- Assume presence or justify no adverse impact
- If assume presence, obtain Protection & Enhancement Plan
- Or, conduct mist net survey to confirm presence/absence
  - If present, obtain PEP
  - If absent, no further action required
- Basic PEP requirements:
  - Observe no disturbance periods
  - Reduce disturbance to suitable habitat on mine site
  - Restore suitable habitat during mined land reclamation

Protection & Enhancement
Assessment of Future Mine Areas

- Contacts with SRA and USFWS on known populations or critical habitat
- Habitat surveys
  - Determine presence or absence of suitable habitat
- Determine actual presence or absence of species
  - Mist net surveys or no mist net surveys

Protection & Enhancement
Mine Permitting Concerns

- Documented presence or critical habitat in area
- Contact & coordinate with SRAs & USFWS
- Issues
  - Modification of mine plan
  - Sterilization of reserves
  - Economic implications

Protection & Enhancement
Mine Permitting Procedures

- Assumed presence
  - Conservation measures
    - Tree removal (timber harvest/tree removal) periods
    - Minimize habitat loss in mining support areas
    - Maintain integrity of riparian zones, stream corridors, wetlands
    - Habitat restoration & enhancement
- Absence
  - Nothing more required

Protection & Enhancement
Land Reclamation Practices

Coal Production, Land Disturbance & Land Reclamation

Year	Coal Production tons	Land Disturbance acres	Land Reclamation (Phase III Release) acres
2001	26 M	2,200	2,400
2002	25 M	2,100	300
2003	25 M	1,716	3,470
2004	29 M	1948	2716
2005	21 M	1937	2913
2006	23 M	4314	3472
2007	38 M	2509	2867
2008	31 M	3890	3132
2009	32 M	1953	1637
2010	17 M	1291	2140

Protection & Enhancement
Land Reclamation Practices

- Contemporaneous reclamation
- Grade restoration & soil replacement
- Vegetation re-establishment
- Land use & habitat restoration
- Proof of vegetation success

Contemporaneous Reclamation & Minimization of Disturbance in Advance of Pit

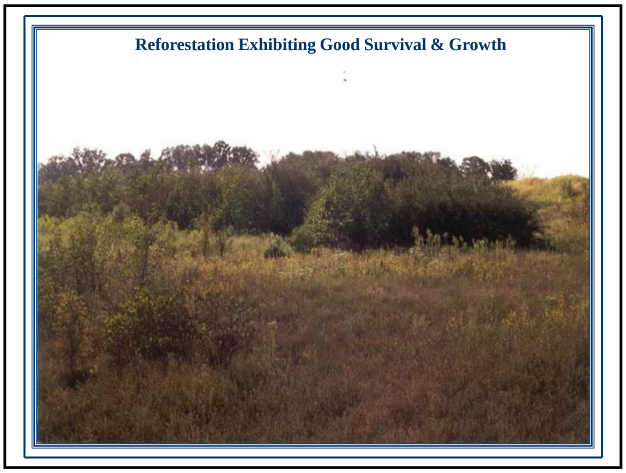
Pit Operations & Minimization of Disturbance in Advance of Pit

Crop Production & Proof of Productivity

Mine Site Reforestation in Midwest (circa 2000)

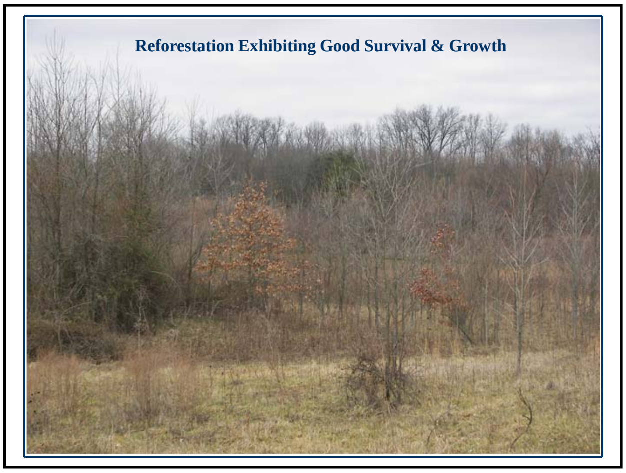
Mine Site Reforestation in Midwest (circa 2000)

Mine Site Reforestation in Midwest (circa 2003 -2005)

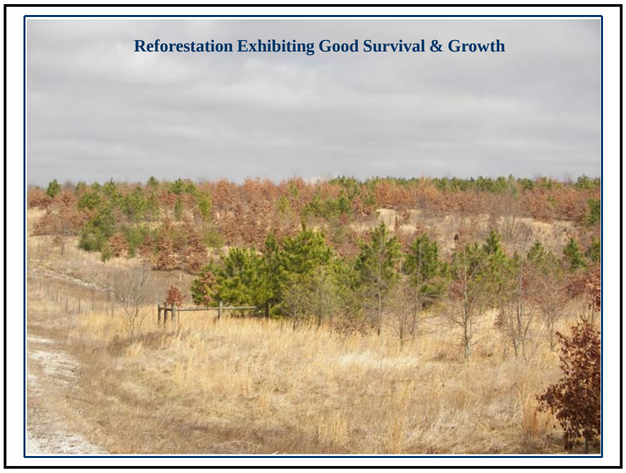


Reforestation Exhibiting Good Survival & Growth

Reforestation Exhibiting Good Survival & Growth



Reforestation Exhibiting Good Survival & Growth



Reforestation Exhibiting Good Survival & Growth

Protection & Enhancement
Land Reclamation Practices

Land Use Patterns & Replacement

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

- ESA straightforward environmental law
  - Requires listing, consideration & protection of imperiled species
  - Does not direct conduct of business
  - Provides no warning of potential conflicts

Perspective on Regulatory Process

- Major concerns of coal industry on protection of IN bat
  - Protection & enhancement grow continually stricter
  - Changes to habitat definition, habitat now includes everything
  - Changes in tree removal period more restrictive
  - Justification for changes anecdotal, not based on science
  - Relative conservation merit of PEPs undetermined

Perspective on Regulatory Process

- Protection & enhancement grows continually stricter
  - Conservation efforts carried out with guideline and policy (*ie* Range-wide Indiana Bat Protection and Enhancement Guidelines)
  - Guideline & policy carry weight of law in working world (IN Bat guidelines now declared to be "binding"
  - Justification not based on science
  - Implementation of new guidelines have already:
    - Required last minute modification of mine plans
    - Sterilized some portions of recoverable coal reserves
    - Negatively impacted economics of mine operations

Perspective on Regulatory Process

- Habitat definition all-inclusive
  - Caves, UG mine openings, rock shelters, bridges, tunnels, dams, etc.
  - Forests containing trees ≥ 5" dbh with exfoliating bark. (Today, includes upland forest, forest edges, fencerows, ditch banks, old fields, pastures with scattered trees, wetlands, isolated water bodies with standing snags, and more.)
  - Effectively, all forest & adjacent areas now habitat
  - Roost tree definition
    - Effectively everything over 5" dbh

Perspective on Regulatory Process

Approved Tree Removal Periods

State	Previous Approved Tree Removal Period From	To	Habitat Type
Illinois	September 30	April 1	All habitat types.
Indiana	September 15	April 15	All habitat types.
Kentucky	November 15	March 31	All habitat types.
Ohio	September 15	April 15	All habitat types.

State	New Approved Tree Removal Period From	To	Habitat Type
Range-wide	October 15	March 31	Summer habitat.
Range-wide	November 15	March 31	Caves, UG mine openings, rock shelters, bridges, etc.

Perspective on Regulatory Process

- Impacts to Coal Industry
  - Lead time for reserve evaluation & permitting
  - Delays in permit process/acquisition
  - If IN bats present, then additional regulatory entanglements
  - Negative impacts on environmental stewardship
  - Negative impacts on compliance with other portions of PL 95-87
  - Modifications to logical mine plans
  - Loss & sterilization of coal reserves
  - Increased operating costs
  - Preemptive to mining?

Environmental Impacts – Habitat Loss, Soil Erosion, Water Quality

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Environmental Impacts – Habitat Loss, Soil Erosion, Water Quality

Summary

- Committed to compliance with ESA
- Will continue to expend funds & take appropriate actions to protect & conserve IN bats & other imperiled species
- Believe much of effort is time & money not well spent
- Coal mining will not have significant impact on continued existence or recovery of IN bats (or other bats)
- Potential for isolated encounters & they will be costly, if not preemptive to mining
- Strong concern as to new & more restrictive conservation measures

PENNSYLVANIA REPRESENTATIVE: STATE-SPECIFIC BAT PROTECTION STRATEGIES AT COAL MINES

Geoff Lincoln
Pennsylvania DEP Bureau of Mining and Reclamation
Harrisburg, Pennsylvania

Abstract

The mining of coal in Pennsylvania and its impact on Indiana bat habitat has collided with the heightened effort to protect bat habitat due to White–nose Syndrome. White–nose Syndrome is spreading across Pennsylvania starting in the northeast and spreading south and west, devastating cave dwelling bat populations including the Indiana bat. In the past, Pennsylvania mine operators and regulators have had limited dealings with Indiana bats and the protection of their habitat. Until recently, the avoidance of known bat hibernacula and seasonal tree cutting restrictions were the only real impact bats and mining have had on each other. Pennsylvania has only 2-3% of the Indiana bat population with no P-1 and only one P-2 Indiana bat hibernacula. In July 2009, the Range-wide Indiana Bat Protection and Enhancement Plan Guidelines were finalized laying the foundation for species and habitat protection. That same month, the Pennsylvania Field Office of the U.S. Fish and Wildlife Service (USFWS) published the Indiana Bat Mitigation Guidance for Pennsylvania, focusing on all land development and the impacts on Indiana bats and supporting habitat. In September 2009, after meeting with the Office of Surface Mining and Pennsylvania Department of Environmental Protection, the USFWS Pennsylvania field office published a subsection of the guidance titled Coal Mining Projects and Indiana Bats Species-Specific Protective Measures. These protective measures specific to coal mining provided increased protection of the Indiana bat compared with the Range-Wide Guidance causing concern of many in the mining industry. First, the protective radius around hibernacula were increased from 5 to 10 mile radius for P-3 and P-4 hibernacula with the difference being an additional 235 square miles of protected habitat per hibernacula with a total impact of approximately 2.4 million acres of land. Second, the requirement of the PA Guidance to reforest the mine site at a 90% rate as opposed to the 70% rate in the Range-Wide Guidance leads to a considerable increase in habitat. Thirdly, areas of suitable habitat are now being protected in both guidance documents potentially impacting millions more acres all over the State (areas of forest with trees $\geq$5 inches diameter and greater than 40 acres). All of these measures, along with the off-site compensation option, have created an ever-increasing amount of habitat protection for an ever-decreasing number of Indiana bats. The results being, an ever-increasing cost to the mining industry with an ever-decreasing amount of land in Pennsylvania available for mining operations.

Geoff Lincoln is the Chief of the Environmental Studies Section in the Bureau of Mining and Reclamation, Pennsylvania Department of Environmental Protection (DEP). Geoff has 25 years of experience in the environmental, health, and safety fields working in the federal government, state government, and private sector. He is an Environmental Science / Safety Officer in the Pennsylvania Army National Guard. He served for five years as an environmental planning officer for Fort Indiantown Gap PA, managing Environmental Impact Studies (EIS) and developing natural resource management plans to include habitat management plans for threatened and endangered species. Currently, he is conducting statewide Indiana bat workshops with the US Fish and Wildlife Service for DEP staff, consultants, and mine operators. He has a MS and BA in Geoenvironmental Studies from Shippensburg University of Pennsylvania.

Protecting the Indiana Bats and Mining in Pennsylvania

U.S. Fish and Wildlife Service

Indiana Bat Mitigation Guidance for Pennsylvania

Site Assessment

- PNDI – online environmental review
- Site Reconnaissance
  - Forests
  - Potential Hibernacula
- Site Surveys
  - Mist-netting
  - Cave surveys
  - Portal surveys

Surveys: Mist-netting

- Mist-net surveys
  - ≥ 40 acres forest impacts anywhere in the State (unless presence is assumed)
- USFWS mist-netting guidelines
- Qualified surveyor – USFWS/PGC list
- Results to PADEP, USFWS & PGC

Project Coordination – Responsibilities

- Applicant
  - Site assessment and reconnaissance
  - Coordinate with USFWS and DEP on PEP
  - Fully implement the PEP
- PA DEP
  - Review PEP
  - Condition permit to include PEP as enforceable
  - Ensure PEP is fully implemented
  - Take tracking and reporting

Project Coordination - Responsibilities

- USFWS
  - Provide information on T&E species
  - Provide guidance on PEP development
  - Review PEP and assist with IBCF calculation sheet
  - Send PGC copy of IBCF calculation sheet
- PGC
  - Coordinate with USFWS on habitat purchases
  - Use escrow funds to purchase Indiana bat habitat

When is a PEP needed?

- Forest impacts
  - Within 10 miles of hibernacula
  - Within 5 miles of female or juvenile capture
  - Within 2.5 miles of maternity roost or male capture
- ≥ 40 acres forest impacts outside these areas if Indiana bat presence is assumed
- Forest impacts = trees ≥5" d.b.h.

PEP – Long-term Habitat Needs

Restore and conserve habitat <u>on-site</u> to provide for <u>long-term</u> habitat needs of the Indiana bat

- Watering areas – 1 per 50 acres
- Post Mining Land Use – "wildlife habitat"
- ≥ 90% reforestation using PEP specifications
- Written confirmation that landowner will retain forest cover for several decades (time necessary to meet long-term habitat needs of Indiana bats)
- Must result in long-term habitat conservation

PA vs Range-wide Guidance

- Expanding the radius from 5 to 10 miles for P-3 and P-4 Hibernacula is an additional 235 square miles of protected land creating 2.4 million additional acres of protected land.
- Reforestation rate for post mining land use "wildlife habitat" was increased from 70 to 90 percent expanding the amount of bat habitat.
- ≥ 40 acres forest impacts outside these areas is not more restrictive, but in practice will identify millions of additional land as bat habitat.

PEP – Long-term Habitat Needs

Protect and conserve habitat <u>off-site</u> to provide for <u>long-term</u> habitat needs of the Indiana bat

- Acquire habitat (fee simple or conservation easement) and place in conservation ownership
- Indiana bat conservation bank
- Indiana bat conservation fund (IBCF)
- Must result in permanent protection

Indiana Bat Conservation Fund

- Permanent protection of off-site forest by PGC
- In-lieu fee program
- Fee based on size & location of impact
  - Type of Indiana bat habitat
  - Number of forested acres affected
  - Land comparable values
- Fee paid within 2 weeks of DEP permit issuance
- Habitat to be purchased within 5 years of deposit

IBCF Calculation Sheet

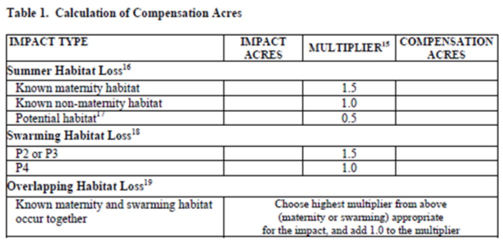


Table 1. Calculation of Compensation Acres

IMPACT TYPE	IMPACT ACRES	MULTIPLIER[15]	COMPENSATION ACRES
Summer Habitat Loss[16]			
Known maternity habitat		1.5	
Known non-maternity habitat		1.0	
Potential habitat[17]		0.5	
Swarming Habitat Loss[18]			
P2 or P3		1.5	
P4		1.0	
Overlapping Habitat Loss[19]			
Known maternity and swarming habitat occur together	Choose highest multiplier from above (maternity or swarming) appropriate for the impact, and add 1.0 to the multiplier		

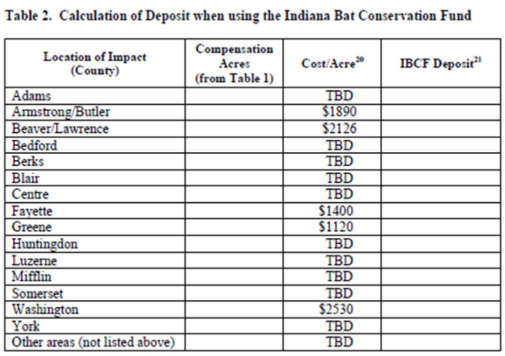
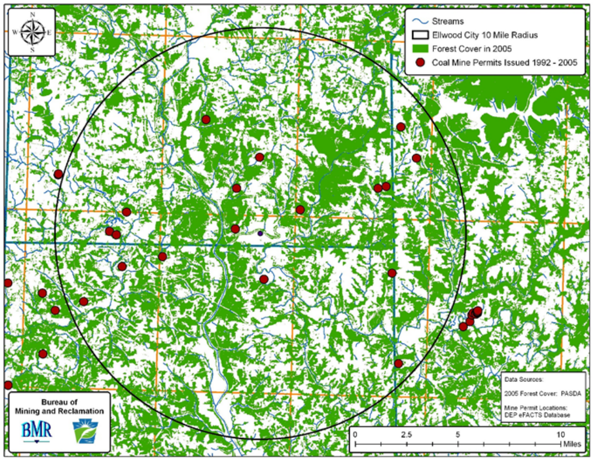


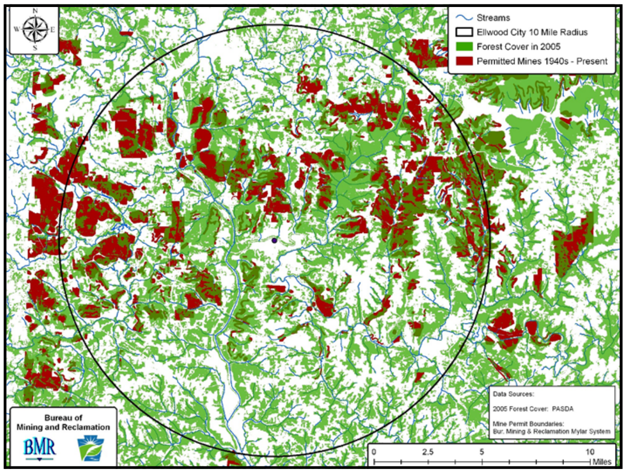
Table 2. Calculation of Deposit when using the Indiana Bat Conservation Fund

Location of Impact (County)	Compensation Acres (from Table 1)	Cost/Acre[20]	IBCF Deposit[21]
Adams		TBD	
Armstrong/Butler		$1890	
Beaver/Lawrence		$2126	
Bedford		TBD	
Berks		TBD	
Blair		TBD	
Centre		TBD	
Fayette		$1400	
Greene		$1120	
Huntingdon		TBD	
Luzerne		TBD	
Mifflin		TBD	
Somerset		TBD	
Washington		$2530	
York		TBD	
Other areas (not listed above)		TBD	

Bats, Mining and Urbanization

Encroachment on one of Pennsylvania's most urbanized hibernacula. Is it mining or industrial, commercial and residential development causing the most harm?





Conclusions

- More land being identified and protected as Indiana bat habitat; with less Indiana bats to use the increasing amount of protected habitat.
- Large tracks of land are being permanently protected for bat habitat but limiting future development and resource extraction.
- Increasing costs to the mining industry with ever decreasing amount of land available for mining.

Questions?

VIRGINIA REPRESENTATIVE: INDIANA BATS AND THE COAL MINING INDUSTRY IN VIRGINIA

John Lawson
Virginia Division of Mined Land Reclamation
Big Stone Gap, Virginia

Abstract

With the multitude of natural challenges facing the Indiana Bat in today's world, it is our mission as regulators to ensure that active mining has the least damaging effect on the species and their critical habitat and that reclamation provides the utmost benefit to the species. I will be discussing the steps taken in Virginia to protect the endangered species over the last 25 years. I hope to provide insight into the research and monitoring being done in Virginia and work within the mining industry, including collaboration, education, and on-the-ground protection of the Indiana Bat and their habitat.

Jon Lawson is an Ecologist for Virginia's Division of Mined Land Reclamation. His responsibilities include technical review of mining permits and field inspections for bond reduction. During his five years of service in the Commonwealth of Virginia, he has served on numerous committees including the Appalachian Regional Reforestation Initiative. He also writes articles for two regional outdoors publications about hunting, fishing, and natural resource issues. He received his BS from Virginia Tech in Fisheries and Wildlife Science in 2004.

State Specific Bat Protection Strategies at Coal Mines

VIRGINIA
Jon Lawson
DMLR Ecologist

DMME Virginia Department of Mines Minerals and Energy

2010 Technical Interactive Forum
Charleston, West Virginia

Resources to Protect

- 2009 Rangewide Population Estimate for the Indiana Bat (Myotis sodalis) by USFWS Region compiled by Andy King.
  - VIRGINIA

2001	2003	2005	2007	2009	% Change from 2007	% of 2009 total
969	1,158	769	723	730	1.0%	0.2%

Resources to Protect

- Clawson (2002) documented the presence of 11 hibernacula used by Indiana bats in Virginia.
- Maternity colonies in **Lee County** and hibernacula in Bath, Bland, Craig, Giles, **Dickenson**, Highland, **Lee**, Montgomery, Shenandoah, **Tazewell**, and **Wise** counties (Brack et al 2005c; USFWS 1999)

Protection Strategies

- Forestry Reclamation Approach
- Portal Surveys
- Mist Net Surveys
- Bat Gates
- Time of Year Restrictions
- GIS Database

Permit Review Strategies

- Incorporation of *2009 Range-wide Indiana Bat Protection and Enhancement Plan Guidelines*

Permit Review Strategies

- Time of Year Restrictions
- Application 1002163
  - The permittee may only clear trees for the mining project between October 1 and April 1, a summer habitat assessment for the Indiana Bat is required for any areas that were not cleared during the approved time frame. The assessment must be reviewed and approved by VA DMLR prior to any further clearing before or after the October 1 through April 1 timeframe.

Permit Review Strategies

- Mitigation Fees
  - Permit Number 1601871
  - $14,000 to Department of Conservation and Recreation for bat cave gating.
  - The Cave Conservancy of the Virginia's

Permit Review Strategies

- GIS DATA
  - VA DGIF WERMS Program

Reclaiming Forestland in Virginia

- Appalachian Regional Reforestation Initiative
  - Over 90% of Post-Mining Land Uses in Virginia is Now Forestry.
  - 100% of new permits with Forestland PMLU include the Forestry Reclamation Approach

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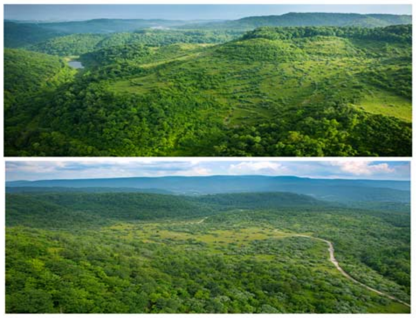
Reclaiming Forestland in Virginia

- **2008**
  - 841,662 trees planted
  - 1832.45 acres planted
  - FRA – used on 85% of permits reporting
- **2009**
  - 1,010,796 trees planted
  - 1,695.84 acres planted
  - FRA – used on 82% of permits reporting
- **2010**
  - 1,715,197 trees planted
  - 2,117.03 acres planted
  - FRA – used on 87.2% of permits reporting

Forestry Reclamation Approach



On-the-Ground Strategies

- Bat Boxes
- 6 Structures
- Installed on A&G Coal Corporation Permit in 2010.

On-the-Ground Strategies

- Bat Gates

On-the-Ground Strategies

- Bat Gates

Abandoned Mine Land

- Portal Surveys
- Bat Gates
  - Successes
  - Failures

On-the-Ground Strategies

- Bat Gates

Future Challenges

- White Nose Syndrome in East Tennessee and Virginia Caves
  - Suspected in Cumberland, Bland, and Rockingham Counties
  - Confirmed in Bath County and Giles County

OHIO REPRESENTATIVE: STATE-SPECIFIC BAT PROTECTION STRATEGIES AT COAL MINES

Scott Stiteler
Ohio DNR Division of Mineral Resources Management
Columbus, Ohio

Abstract

The Ohio Department of Natural Resources, Division of Mineral Resources Management (DMRM) is the principal state agency responsible for regulating coal mining in Ohio under the Surface Mining Control and Reclamation Act (SMCRA). DMRM has the unique and difficult responsibility of regulating the mining industry in a way that strikes a balance between protection of society and the environment from the adverse effects of mining operations and to ensure the reclamation of the land after mining. The state mining and reclamation law, 1513 of the Ohio Revised Code, and rule, 1501 of the Ohio Administrative Code requires mining operations to comply with a host of other local, state, and federal laws and programs to obtain and maintain a permit to mine coal in Ohio including the Endangered Species Act and the Fish andWildlife Coordination Act.

Ohio's coal regulatory program contains several references to protection of threatened and endangered species and their habitats, including the development and implementation of species-specific conservation measures as required by a 1996 U.S. Fish and Wildlife Service (FWS) Biological Opinion to the Office of Surface Mining (OSM).

The 1996 Biological Opinion stemmed from a formal consultation between FWS and OSM, required by Section 7(a)(2) of the Federal Endangered Species Act of 1973, as amended (ESA). The Biological Opinion states 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…" This conclusion is based on compliance with all provisions in 30 CFR. The Biological Opinion further provides that "the level of unanticipated take is not likely to result in jeopardy to any listed species…" In effect, this provision acknowledges that unanticipated take of endangered species may occur under the conditions specified by the Biological Opinion.

To be exempt from this take prohibition, the Division of Mineral Resources Management (DMRM) and mining operators must comply with the specific terms and conditions of the Biological Opinion. One of these conditions is that DMRM "must 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)." A Procedure Directive (PD) was developed in 2004 in consultation with FWS and OSM to comply with this requirement. This PD is currently being revised to incorporate requirements detailed in the July 2009 agreement among OSM, FWS, and the Interstate Mining Compact Commission entitled "Range-wide Indiana Bat Protection and Enhancement Plan Guidelines." The range-wide guidelines provide a minimum set of standards for development of protective measures on coal mining operations in all states within the range of Indiana bats.

R. Scott Stiteler is an Environmental Specialist for the Ohio Department of Natural Resources, Division of Mineral Resources Management. With 20 years of experience in the Permitting and Hydrology Section of the Division, his duties include field and office reviews of proposed coal mining application areas to evaluate potential environmental impacts (streams, wetlands, endangered species) and to evaluate the merits of the proposed mining and reclamation plans. He received his Associates of Science degree from Hocking College in Wildlife Management in 1985.

Success and Challenges for Protection and Habitat Enhancement of the Indiana Bat

Ohio Department of Natural Resources
Division of Mineral Resources Management

Since 2004 (PPD Permitting 2004-1)

- 130 permits reviewed under bat conservation guidelines
- 15 with no suitable habitat
- 115 with suitable habitat
- 80 surveys (all negative)
- 35 protection and enhancement plans

Reasons for Success

- Good working relationship among DMRM, OSM, and USFWS
- No known hibernacula in active coal mining areas of Ohio
- Remining areas typically have lower quality bat habitat
- No Indiana bats found on proposed coal sites
- Involvement of USFWS: reviews and comments on each proposed coal application

Past Challenges

- No success criteria for tree planting
- Tree clearing prior to application submittal

New Guidelines

- Differences between the Old PPD and New Guidelines
  - Stocking and success criteria for tree planting
  - 70% reforestation criteria
  - Off-site habitat mitigation permitted
  - Greater regulatory authority responsibility
  - Known vs. Potential habitat
  - Require radio telemetry
  - Staged tree removal
  - Short Term Habitat Replacement
  - Native herbaceous groundcover

PD Permitting 2010-01

- Changed seasonal clearing restrictions for summer habitat to April 1 – Sept 30
- Eliminated requirement for acoustic monitoring
- Grouped Avoidance and Minimization measures together as “Protection Measures”
- Require tree planting 100 feet either side of streams (previously 50 feet)
- Require minimum 600 trees planted/acre
- Require demonstration of minimization of soil compaction
- Condensed PD to make it easier to interpret
- PD is equally as stringent as range-wide guidelines

Potential Challenges

- Tree clearing prior to application submittal
  - Impacts to stream and wetland quality
  - Impact to bat habitat
- 70% reforestation criteria
- 5 year survey time limit
  - May result in more frequent pre-application clear cutting (also impacts stream/wetland quality prior to 401/404 permits
  - "Over clearing" to ensure all clearing is completed prior to expiration of 5 year limit
- Off-site mitigation
  - Agreements will need to be crafted to be enforceable by USFWS
  - DMRM does not regulate

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WEST VIRGINIA REPRESENTATIVE: STATE-SPECIFIC BAT PROTECTION STRATEGIES AT COAL MINES

Bob Fala
West Virginia DEP, Division of Mining and Reclamation
Charleston, West Virginia

Abstract

West Virginia State coal program-specific bat protection strategies have evolved significantly since SMCRA (1977). A trend from generalized to more site-specific baseline data and active implementation of avoidance and minimization measures is exhibited. The rate of change accelerated after the *Bragg v. Robertson (*1998*)* mountaintop mining litigation. A trying period ensued, ultimately resulting in applicants being channeled directly through U. S. Fish and Wildlife Service (FWS), WV Field Office. However, in accordance with the 1996 Biological Opinion ('96BO) between FWS and the U. S. Office of Surface Mining (OSM) and after development of species-specific guidelines in cooperation with FWS, OSM, and WVDNR, WVDEP took on the consultation process in 1997. On behalf of the Interstate Mining Compact Commission (IMCC), it then participated with FWS and OSM in the development of the Range-Wide Indiana Bat Guidelines (2008-09), implementing them January 1, 2010. Highlights of the Mountain State coal program include: The first in-state Indiana bat maternity colony discovery, blasting research on the effects of surface (over-mining) of underground mines harboring bats, and an active bat gating of pre-SMCRA mine portals program.

Bob Fala coordinates state Fish and Wildlife coal programs for the West Virginia DEP, Division of Mining and Reclamation where he has worked for the past 21 years while he has also been the outdoors columnist for the Logan (WV) Banner. Timely with the advent of SMCRA, he was formerly employed by Arch Coal, Inc. at similar capacities in the coalfields of Wyoming, Illinois, and West Virginia. Pre-SMCRA, he worked for the Pennsylvania Game Commission. A certified wildlife biologist, he holds a BS and MS in Forestry and Wildlife from Penn State University.

West Virginia Coal Permitting Program

Threatened Bat Highlights and Considerations

Bat Forum - Charleston, WV

September, 2010

Strong Legal Framework:

With Regard to Endangered Species (ES)

- Federal-P.L. 95-87 SMCRA (the Act)
- State-Chapter 22, Article 3 (the Act)
- State-Title 38, Series 2 WVSMRR (the Regs.)

The 1996 Biological Opinion ('96 BO)

- A broad-based, national coal program endangered Species Act (ESA)-Section 7 Consultation between the OSM and Fish & Wildlife Service
- Provides for unavoidable Incidental Take of endangered species associated with the otherwise lawful activity of coal mining in the US

Provided that:

- State coal program approved under SMCRA (since 1981)
- WV is approved primacy state RA (Regulatory Authority)
- RA must follow said Laws, Regs. and '96 BO
- With OSM Oversight and Guidelines Role

'96 BO Also Provides That:

- OSM, the State RA (DEP) and FWS develop species specific conservation measures for each species
- Indiana bat presented the greatest potential for WV ES encounter, it was dealt with first!
- As a result WV Guidelines were developed and implemented January 1, 2007

Here Are the Guidelines….

White Nose Syndrome (WNS)

- Largely Positive Bat News Disrupted by WNS in 2006 (2009 in WV)
- Should more emphasis been placed on hibernacula?
- This Forum.....

WV Coal Program Highlights:

- **I-bat maternity colony discoveries** in Boone County (2003, 2005) and their Case Histories
- **Abandoned Mine Lands (AML) bat friendly "gate" closures** in lieu of sealing up pre-law portals
- Office of **Explosives and Blasting (OEB) research** on blasting effects of over-mining
- **General science, research and data advances**

Indiana Bat Maternity Colonies:

- Discoveries
- Case Histories
- Avoidance and Minimization Measures
- Monitoring

AML Bat Friendly Portal Closures:

- Once unheard of, now a routine practice
- Could prove Instrumental to Species Recovery

Blasting Research:

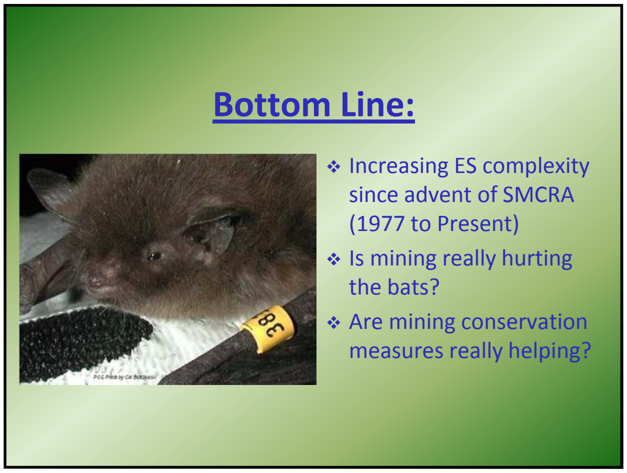
- Effects of surface mining above pre-law mines harboring bats below
- Predictive Curves and Research Results Available

General Science, Research, Data...

A New-Law (Post-SMCRA) History

WV Endangered species procedures

- 1977 to 1998-WVDNR Lands Inquiry and project FWS notification
- 1998 to 2001- all the above *but with* increasing litigation/concern for 'potential' habitats, issues arise, permit delays at the Corps/404 level…
- 2002-2006- Per FWS request, their early direct involvement; protocols quickly evolve; 11th hour delays at Corps/404 level gone
- 2007 and on…DEP to now handle routing processing; FWS expertise for ES presence, 'hit' or 'kick-out' situations. This is what the '96 BO calls for! White Nose Syndrome (WNS) rears its ugly head
- 2010 and on… Region-wide Guidelines and Electronic Processing; must remain adaptable per WNS in particular.



Bottom Line:

- Increasing ES complexity since advent of SMCRA (1977 to Present)
- Is mining really hurting the bats?
- Are mining conservation measures really helping?

Persisting Applicant Concerns:

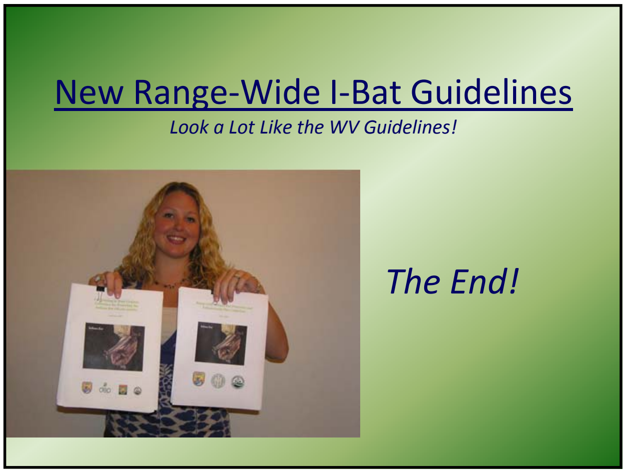
- Fairness and free-trade issues
- Oil, Gas, Logging, Farming, Housing do little or nothing
- Are Range-wide Guidelines being equally applied? (state to state)

Most Recent (ES) Implementations:

- **Fully Electronic Processing of ES Consultation Materials Effective February 1, 2010.**
  - **Send all materials to:**

end.species.coal@wv.gov

- **Implementation of New Range-wide Indiana bat Guidelines Effective January 1, 2010.**



New Range-Wide I-Bat Guidelines

Look a Lot Like the WV Guidelines!

The End!

INDIANA REPRESENTATIVE: STATE-SPECIFIC BAT PROTECTION STRATEGIES AT COAL MINES

Ramona Briggeman
Indiana Division of Fish and Wildlife
Jasonville, Indiana

Abstract

In July 2009, the Range-wide Indiana Bat Protection and Enhancement Guidelines were published as part of a collaborative effort of the USFWS, OSM and state regulators. The guidelines fulfill the Fish and Wildlife Service 1996 Biological Opinion, which stated that coal mining activities regulated by SMCRA, if augmented by species-specific protective measures in each permit, would not jeopardize the continued existence of any threatened or endangered species.

Indiana's current protection and enhancement plan consists of various line items included in the guidelines, including but not limited to the following: Tree clearing restrictions, minimization of disturbed area, reconstruction and reforestation of disturbed drainage corridors, tree species planted, constructing watering areas, and buffering and/or avoiding caves and abandoned mine openings known to harbor the Indiana bat.

The implementation of the range-wide plan has had significant impact on both the Title V and Title IV programs. Although the plan was not meant to apply to the AML program, Indiana's AML program has had to significantly change their procedures to comply with the guidelines. Prior to publication of the guidelines both the Title IV and Title V programs conducted selective roost tree removal in forest areas. With the new guidelines, this option has been removed.

Ramona Briggeman is currently the Reclamation Biologist with the Indiana Division of Fish and Wildlife. She serves as a field biologist in Indiana Division of Fish and Wildlife but is assigned to the technical services section of the Indiana Division of Reclamation. Prior to serving as the Reclamation Biologist, she was a Reclamation Specialist for the Indiana Division of Reclamation. With over 18 years experience with mining and reclamation, she is responsible for reviewing coal mining operations to evaluate environmental impacts, including effects on fish and wildlife resources (streams, wetlands, endangered species). She received her BS degree in Life Sciences from Indiana State University.

KENTUCKY REPRESENTATIVE: STATE-SPECIFIC BAT PROTECTION STRATEGIES AT COAL MINES

Dr. Richard Wahrer
Kentucky Department of Natural Resources
Frankfort, Kentucky

Abstract

The Kentucky surface mining program within the Department for Natural Resources (KYDNR) has employed procedures for the protection of the Indiana bat since 1995. Though the 2001 *"Guidelines for the Development of Protection and Enhancement Plans for the Indiana Bat,"* were authored by the U.S. Fish and Wildlife Service (FWS), the Kentucky Department of Fish and Wildlife Resources, and KYDNR, unresolved differences remained causing the coal applicant to perform duplicative and contradictory procedures for Indiana bat protection with the SMCRA and Clean Water Act permits. Due to varying bat protection requirements and measures utilized by the coal states and FWS field offices, it was requested that the Office of Surface Mining intervene and provide multi-state consistency on Indiana Bat protection and enhancement plans. With the assistance of the Interstate Mining Compact Commission, FWS and OSM, the 2009 *Guidelines* were created and implemented by KYDNR in October 2009. Successes and challenges encountered will be discussed.

Dr. Richard J. Wahrer is an Environmental Scientist in the Office of the Commissioner for the Kentucky Department for Natural Resources. He has been involved with the development of the regional Indiana Bat protection and enhancement guidelines and is a member of the Appalachian Regional Reforestation Initiative Core Team. He currently coordinates the Lands Unsuitable for Mining petition and Cumulative Hydrologic Impact Assessment programs. He is an instructor for the OSM/FWS Biological Opinion and Permit Findings classes. He holds a BS in Zoology and MS in Limnology from Stephen F. Austin University, and a Ph.D. in Aquatic Biology from Texas A & M University.

Session 4

STATUS OF ON THE GROUND RECOVERY EFFORTS

Session Chairperson:
Christy Johnson-Hughes
U.S. Fish & Wildlife Service
Arlington, Virginia

Creating Summer Bat Habitat on Surface Mines in Appalachia Using the Forestry Reclamation Approach (FRA)
Scott D. Eggerud, Office of Surface Mining Reclamation and Enforcement, Pittsburgh, Pennsylvania

Potential Effects of Surface Mine Blasts Upon Bat Hibernaculum
Jim Ratcliff, West Virginia DEP Office of Explosives and Blasting, Charleston, West Virginia

Active Mining Recovery Opportunities: Boone North No. 3 Surface Mine
J.D. Wilhide, Compliance Monitoring Labs, Inc., Chapmanville, West Virginia

West Virginia Department of Environmental Protection – Office of Abandoned Mine Lands (WVDEP/AML) Preservation Efforts of Potential Bat Habitat
Robert Rice, West Virginia DEP, Office of Abandoned Mine Lands, Philippi, West Virginia

Pennsylvania Bat Gating Efforts
Calvin M. Butchkoski, Pennsylvania Game Commission, Petersburg, Pennsylvania

Microclimate Research to Support Endangered Species of Bats in Hellhole and Schoolhouse Cave and Technological Advancements in Monitoring Systems
Mike Masterman, Anvesh Singireddy, and Shana Frey, Extreme Endeavors, Philippi, West Virginia

CREATING SUMMER BAT HABITAT
ON SURFACE MINES IN APPALACHIA USING
THE FORESTRY RECLAMATION APPROACH (FRA)

Scott D. Eggerud
Office of Surface Mining Reclamation and Enforcement
Pittsburgh, Pennsylvania

Abstract

Deforestation and forest fragmentation caused by mining has reduced bat habitat throughout much of the Appalachian Range. The reforestation of mined lands in Appalachia using the forestry reclamation approach (FRA) will return disturbed lands to forest habitat that closely resembles the pre-mining native forests, faster and more efficiently than traditional reclamation methods. The goals of the Appalachian Regional Reforestation Initiative (ARRI) are to plant more high-value hardwood trees on reclaimed coal mined lands in Appalachia, increase the survival rates and growth rates of planted trees, and to expedite the establishment of forest habitat through natural succession on both active mining operations and on previously reclaimed mine sites. The Forestry Reclamation Approach (FRA) is a five step process promoted by ARRI: That, 1) creates the best possible forestry growth medium with materials on site, 2) reduces compaction of the growth medium by utilizing alternative methods of placement or reduced grading, 3) uses tree compatible ground covers, 4: plants a mixture of early and later successionary, native hardwood tree species, and 5) uses proper tree planting techniques. Using these techniques, ARRI is working with the regulatory authorities and the coal industry to promote the use of the FRA on active and proposed operations, and on previously reclaimed mine sites where reforestation was not attempted or the results were unproductive. On sites close to documented bat activity, planting arrangements and tree species selection have been altered to promote summer bat habitat.

Introduction

The Office of Surface Mining Reclamation and Enforcement and the state regulatory authorities are working to improve mined land reforestation in Appalachia and throughout the United States. With the passage of SMCRA in 1977, many of the issues of stability, erosion, and acid mine drainage were addressed. However, many of the reclamation techniques advocated resulted in compaction of surface materials and persistent ground covers of exotic grasses and legumes. These techniques provided stability. However, they also slowed the natural healing process of plant and animal succession and in many cases drastically reduced site productivity (Angel and others, 2005). With the large dragline operations of the 1980's and 1990's vast areas were converted from forest cover types to grass and scrub/shrub cover types, especially in Appalachia (Saylor 2008).

Appalachian Regional Reforestation Initiative (ARRI)

To address the issue of forest habitat loss by surface mining, the Appalachian Regional Reforestation Initiative (ARRI) was created. ARRI is a broad-based group working to reestablish forest habitat on active and abandoned mine lands. ARRI's goals are to plant more high-value hardwood trees on surface mines, increase the survival rates and growth rates of those trees, and to expedite the establishment of forest habitat through natural succession. ARRI started as a joint effort between OSMRE and the seven central Appalachian states that had a coal regulatory program. These states include: Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. The ARRI Core Team consists of state and federal regulators from each of those seven states. An academic team was formed and was later more accurately referred to as the ARRI Science Team. The ARRI Science Team consists of all the major universities and reforestation researchers within Appalachia including: Ohio University, Ohio State University, Pennsylvania State University, Purdue University, Southern Illinois University, University of Kentucky, University of Maryland, University of Tennessee, Virginia Polytechnic Institute, West Virginia University, West Virginia State University, the US Forest Service, the US Geological Survey, The American Chestnut Foundation, and the Office of Surface Mining, Reclamation and Enforcement.

To promote proper mine land reforestation, the ARRI Science Team advocates using a set of best management practices called the Forestry Reclamation Approach (FRA) (Burger and Zipper, 2002). The FRA is a 5 step process that includes: 1) Creating the best possible growth medium with material on site that is at least 4 feet thick, 2) Minimize compaction of the growth medium, 3) Use tree compatible ground covers, 4) Plant the proper species of trees, and 5) Use proper tree planting techniques. ARRI's Core Team and Science Team have been working with the coal industry, academia, government agencies, conservation organizations, and environmental groups to promote proper mined land reforestation using the FRA. This includes: research, outreach, regulation and policy development, training, and mine site visits to promote the FRA. Reforestation research has been ongoing at Virginia Polytechnic Institute's Powell River Project for the last 20 years (http://www.cses.vt.edu/PRP/VCE_Pubs.html, 2010). Reforestation research from the University of Kentucky and West Virginia University has confirmed many research findings and formed the basis for the FRA. Studies are currently underway looking at parent materials used as a growth medium, depths of these growth mediums, compaction rates, and ground covers and seeding rates (Emerson and others, 2009). Now many of the research institutions associated with the ARRI Science Team are advancing the FRA into different aspects of reclamation such as stream restoration, water chemistry, and carbon sequestration.

ARRI started with an aggressive outreach campaign consisting of: a website, http://arri.osmre.gov, a Statement of Mutual Intent (SMI), a periodic newsletter, several brochures, seven Forest Reclamation Advisories thus far, Arbor Day and volunteer tree planting events, awards program for both active mine sites (Title V) and abandoned mine sites (Title IV), videos, and numerous television, newspapers, and radio appearances.

The Core Team held an initial Statement of Mutual Intent signing ceremony on December 15, 2004 at Stonewall Jackson Lake State Park, West Virginia during which 36 individuals, mostly leaders in their fields, signed the Statement committing to mine land reclamation using the FRA. Today over 1,000 individuals, representing over 200 organizations have signed ARRI's SMI.

ARRI's Science Team has collaboratively written seven Reforestation Advisories and is currently working on two more. These advisories provide details on how to implement different aspects of the Forestry Reclamation Approach. These advisories are available on ARRI's web site at: http://arri.osmre.gov/FRA/Advisories/Advisories.shtm.

ARRI's outreach also consists of Arbor Day events and volunteer tree planting events. The Arbor Day events are now mostly industry driven to showcase their reforestation and overall environmental stewardship efforts. The coal companies hosting these events invite local school groups, conservation groups, regulators, and academics to join the tree planting. To date over 5,000 people, mostly young students, have participated in these events. An awards program, "Excellence in Reforestation" has also been developed for both active mining operations and Abandoned Mined Lands (AML) operations to further promote the FRA. These annual awards, one for each state for each category, are usually presented at the Arbor Day Events. An Awards Committee chooses the best state awards for a regional award that is presented at the annual ARRI Conference.

ARRI has worked closely with state and federal regulatory agencies to incorporate the Forestry Reclamation Approach into policies and regulations. In 1996, the state of Kentucky drafted Reclamation Advisory Memorandum (RAM) 124. RAM 124 fully incorporated the reforestation techniques later described as the FRA. Ram 124 has been recently upgraded with RAM 144 allowing no strike-off grading (KY DNR, 2009). KY RAM 144 allows for no strike-off grading, providing landowner approval and a commercial woodland planting plan. This type of grading leaves the mine soil material, used as a forestry growth medium, dumped into 50 to 100 ton piles, (approximately 6 to 8 feet high) depending on the size of the rock truck, with no grading allowed. This material slowly levels off with weathering and leaves a non compacted rooting medium excellent for tree growth and very conducive to invasion of native vegetation, and infiltration and retention of rain water.

State Programs

The Office of Surface Mining Reclamation and Enforcement approved West Virginia's forestland post mine land use regulations at 38CSR2-7.6 on May 8, 2005. These regulations fully incorporate the FRA. These rules apply to Approximate Original Contour (AOC) compliant sites only, and the planting plans must be prepared by a WV registered professional forester and reviewed by a forester employed by the WV-Department of Environmental Protection. These regulations establish limits on what materials can be used in the growth medium, the thickness of this growth medium, and the amount of grading allowed. These rules also prohibit seeding Kentucky-31 fescue, *Serecia lespedeza*, all vetches, and clovers (except ladino and white clover). Native hardwoods are also required. View the complete rules at: http://www.dep.wv.gov/dmr/codes/Pages/default.aspx.

Both the Tennessee Federal Program and the Virginia State Program reduced or eliminated the ground cover standard for forestry post mining land uses to a level that controls erosion and promotes good tree growth and natural invasion. By

choosing a ground cover vegetation level that is appropriate for achieving the post-mining land use of an individual site, these states have taken an important step in removing regulatory barriers to implementing the FRA.
OSM followed suit with their own policy, TSR-16, which fully supports and encourages the FRA (OSM, 2008). An exhaustive search of the state and federal programs within the Appalachian Region found no regulatory barriers to implementing of the FRA.

Training

Numerous reforestation training sessions have been provided to industry, mining and forestry consultants, state and federal regulators, landowners, and watershed groups. Most of the seven Appalachian States conduct at least one FRA training session annually for their permitting staff and their inspection and enforcement staff. Most of these sessions include State Core Team members, OSM Core Team members, and Science Team members from within that state. FRA training has also been provided to industry groups including equipment operators, mining and forestry consultants who prepare the mining and reclamation plans, the equipment operators who actually carry out the work, landowner groups who often own the land being mined, conservation groups, and environmental groups. Several reforestation workshops, which tend to be more detailed and often include field activities, have also been conducted.

Site Visits

An aggressive campaign of site visits to promote the FRA in the field is also showing results. Site visits with coal operators, mining consultants, landowners, and local inspectors to promote the FRA prior to mining and reclamation is an effective method to spread the technology of the FRA. Pre-inspections on proposed mine sites are an example of such visits. Once a mining or forestry consultant drafts the proper reforestation language for a planting plan, he or she can often use this as a template for other planting plans. Once a coal operator gets a reclamation/reforestation plan and is able to successfully implement that plan, he or she is likely to reuse the techniques specified in that plan. These approaches have been repeated in most of the Appalachian states by the regulatory authorities and the coal industry. On oversight inspections conducted by OSMRE inspectors, the FRA is often emphasized.

Results

The results of ARRI’s efforts on the active operations have been remarkable. Most of the mining permits now issued propose forestland as the post mine land use. In Virginia 100% of the permits issued in 2009 propose FRA compliant forestland as the post mine land use (Eggerud, 2010). In WV, over the last 5 years about 85% of the acreage permitted for surface mining proposes reclamation to forestland and about 10% to wildlife habitat. Collectively, this is over 90% of the acreage to be disturbed in WV (Quick, 2010). All of this disturbed acreage should be reclaimed and reforested using the FRA.

The success of these reforestation efforts is due to the partnerships that have been formed. Partners include but are not limited to: ARRI Core Team members, ARRI Science Team members, mining and forestry consultants, conservation groups, environmental groups, students of all ages, and citizen groups, etc. Our strongest partner has been the coal industry. Since 2004, over 70 million seedlings have been planted on just over 100,000 acres of mine lands in Appalachia alone (Angel and Bower, 2010).

Another one of ARRI’s more successful partnerships has been with The American Chestnut Foundation (TACF). The natural range of the American chestnut and the Appalachian coal fields overlap almost perfectly. TACF has been providing blight resistant, American chestnut seedlings for reintroduction back into Appalachia’s forests, so far on a trial basis. Surface mines are a perfect place to attempt reintroduction of the American chestnut and may serve as springboards for large scale efforts. ARRI has the infrastructure and organization in place to facilitate large scale plantings on active and previously reclaimed mine sites. Members of the ARRI Science Team also have numerous research projects underway involving American chestnuts on surface mines.

ARRI is not only promoting proper mine land reforestation on active coal mining operations but is also working on previously reclaimed sites where reforestation was not attempted or where the results were undesirable. In the last two years, ARRI has partnered with watershed groups, coal operators, and several other organizations to coordinate 22 volunteer tree planting events throughout Appalachia. These events, usually organized by watershed groups or the Appalachian Coal Country Watershed Team (ACCWT), planted over 177,500 trees on about 250 acres of mined land. ARRI’s role in these endeavors is to facilitate communication between the watershed groups and the coal industry and to provide technical assistance using a slightly modified FRA for previously reclaimed sites. The FRA on these sites includes deep ripping with large bulldozers to mitigate compaction and reduce competition of the ground covers, selecting and planting proper species of trees, and using proper tree planting techniques. The significance to ARRI on these volunteer tree planting events is not necessarily the acreage being restored to future forests, but the outreach and awareness of proper mine land reforestation and the research potential that is being created. On all 2009 volunteer planting sites, 51 chestnut trees were planted in the ripped areas, along with all the other hardwood seedlings. These chestnuts consisted of 17 pure American chestnuts, 17 Chinese chestnuts, and 17 15/16 backcrosses. The backcrosses are 15/16 American for form and functionality, and 1/16 Chinese for blight resistance. All chestnuts were protected with tree tubes, stakes, and weed mats. Locations were established using GPS. TACF and several of the university researchers will monitor these plantings. In the last two years, over 2,500 volunteers participated in these tree planting events. The volunteer tree planting events are now evolving into large scale plantings funded by grants, cost share programs, utility companies seeking carbon credits, and corporate donations. Most of this money is used for site preparation and purchasing seedlings. In many situations, volunteer tree planters will still be needed. Over 1,000 acres of previously reclaimed mine lands in Appalachia are being prepared for spring tree planting in 2011.

On each legacy (previously reclaimed) planting site, we have been trying to establish side by side demonstration plots to learn about the effectiveness of different practices and establish outdoor classrooms. We have been conducting annual monitoring of the volunteer tree planting sites and have noticed vigorous colonization of native plants such as ragweed (*Ambrosia spp*.), aster (*Aster spp*.), and goldenrod (*Solidago spp*.). In fact, the vegetation has been coming in so fast we are concerned about competition to the tree seedlings. On some demonstration plots, we have established a temporary ground cover of annual ryegrass to slow the invasion of native vegetation to give the seedlings a head start. The adjacent plots had no ground cover established. On some sites, we have ripped in one direction on one plot and then cross ripped (ripped in perpendicular directions) on the adjacent plot. Other demonstrations include using herbicide on one plot and no herbicide on the adjacent plot, herbicide with mowing, and herbicide without mowing, etc. We will continue to monitor these sites attempting to find the most efficient methods of reforestation of previously reclaimed sites. A recent study from Virginia Tech estimates close to 750,000 acres of grass and shrub/scrub cover types on old mine lands in Appalachia (Zipper and others, 2007).

ARRI is also working with the AML programs throughout Appalachia. General recommendations for implementing the Forestry Reclamation Approach (FRA) on abandoned mined lands have been provided to West Virginia's AML program. Many of the AML projects are relatively small compared to the active mining operations, and material is often pushed by bull dozer instead of being loaded and hauled by truck. Also, on many of the AML projects, materials to be used as a growth medium are limited. These factors will require further modifications to the FRA for AML sites. Several different methods of material placement were offered in the WV recommendations. These included: end-dumping of the forestland growth medium on flat to gently sloping areas with minimal grading using trucks, highwall elimination by hauling and dumping the forestland growth medium from above using trucks, push-up method perpendicular to the high wall using bull dozers, and push-up method parallel to the high wall using bull dozers. We are trying to come up with new, innovative techniques of material placement.

The State of Maryland is using a push down method on some of their active operations, basically windrowing mine soils on contour, in parallel rows with bull dozers. Maryland officials have coined this technique the Mongold Method after the local inspector. These windrows are connected to form long ridges. Care must be taken to construct the ridges on contour without any downhill slope. A practice called flipping has also been used on a 5 acre demonstration plot on an AML project in WV. Since the demonstration area was located on a borrow area (old contour mine), material would not be brought in but taken area. This limited our method of placement. The contractor and the local inspector developed a method they called 'flipping' using an excavator. First the bucket was plunged into the ground about 3 to 4 feet deep. Then the material was lifted up and dumped in place. This was repeated over and over until the entire 5 acres was prepared. The site was then planted to a mixture of native hardwoods including red spruce. The USF WS partnered on this project due to the concern of the then endangered northern flying squirrel. Red spruce is a critical component of the northern flying squirrel habitat. No ground cover was sowed on the FRA demonstration plot. Ferns, forbs, cherries, and big-tooth aspen are invading, in addition to the red spruce, black cherry, white oak, red oak, sugar maple and black walnut that were planted. ARRI attended the pre-bid meeting to brief the vendors on the FRA and how it was to be used on this project. Site specific recommendations have been provided on two other AML projects in WV.

ARRI has also partnered with Kentucky's AML program on several volunteer tree planting sites. The York site in Morgan County, KY and the Dollar Branch site in Harlan County are examples of this. The York site was a contour operation with point removals. The site was reclaimed to hay land/pastureland and the landowner has actually been mowing hay off portions of the mine site for close to twenty years. Overburden materials and the resulting mine soils were physically and chemically very similar to the pre mining native soils. Thirty foot highwalls, flat benches about 200 feet wide, and small valley fills dominated the site. KY Department of Fish and Wildlife (KYDFW) paid for site prep (ripping) through the cost share program Landowner Incentives Program (LIP). Half the area was cross ripped and half the area was ripped in one direction. The site was planted by volunteers. KY AML paid for 26,560 tree seedlings and will pay for post-emergent herbicide to release trees from ground cover competition. Planting supervision was also provided by the KY Division of Forestry (KYDOF).

The Dollar Branch AML site is another volunteer tree planting event where ARRI, KY AML, KYDFG, and KYDOF partnered. This site is located just north of Pine Mountain. Pine Mountain has limestone strata that are commercially mined. Indiana bat activity, including hibernacula, has been documented nearby by the KYDFW. This AML site contains old coal refuse from a processing plant. We could not deep rip for fear of disturbing the acidic refuse, so we disked the surface to a depth of about 8 inches. This site is surrounded by beaver ponds, elk habitat, and Indiana bat habitat. We tried to have a theme or goal at each volunteer tree planting event. Here, we targeted bats, bees, and beavers. Eastern Kentucky University and Berea College student volunteers helped with the planting, along with local volunteers. Several bat boxes were provided and erected by the KYDFW. Exfoliating bark tree species such as white oak, hickory, and black cherry were planted for future roost trees for the endangered bats. We could not find sycamore seedlings for riparian areas and bat habitat, so we sowed sycamore seed along the creeks and all other wet areas. We also sowed a wildflower seed mix provided by the KYDFW for bee habitat. KY AML paid for the tree seedlings and the post-emergent herbicide to release these trees.

ARRI has been involved with forest habitat restoration involving other endangered species such as the northern flying squirrel and the Cheat Mountain salamander. Our best contribution to forest habitat restoration is to encourage reforestation, including expediting the natural healing process of succession, using the Forestry Reclamation Approach. Tree species recommendations can be slightly altered to favor the species of concern. However, the best restoration plan is usually one that tries to reestablish a forest that mimics the pre-mining native forest as much as possible and as quickly as possible. On sites with documented bat activity, we try to slightly alter our tree species to favor exfoliating bark species, erect bat boxes if available, and maintain pools, wetlands, and encourage vernal pool creation.

Conclusions

Large scale surface mining in Appalachia is a major contributor to forest habitat loss. Forest habitat loss threatens species such as Indiana bats and other endangered species that depend on forest habitat. The Appalachian Regional Reforestation Initiative (ARRI) promotes reforestation of mined lands using the Forestry Reclamation Approach (FRA). The FRA is set of best management practices developed by reforestation scientists. Applying the FRA will return mined lands to forest habitat that closely resembles the pre-mining native forests, faster and more efficiently than traditional reclamation methods. The Forestry Reclamation Approach (FRA) is a five step process promoted by ARRI: That, 1) creates the best possible forestry growth medium with materials on site; 2) reduces compaction of the growth medium by utilizing alternative methods of placement or reduced grading; 3) uses tree compatible ground covers; 4) plants a mixture of early and later successionary, native hardwood tree species; and 5) uses proper tree planting techniques. ARRI is working with the regulatory authorities and the coal industry to promote the use of the FRA on active and proposed operations, and on previously reclaimed mine sites where reforestation was not attempted or the results were unproductive. On sites close to documented bat activity, planting arrangements and tree species selection have been altered to promote summer bat habitat (roosting trees). Bat boxes have been erected and wetlands have been preserved or created.

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Saylor, KL (2008) Land Cover Trends: Central Appalachians. US Department of the Interior, US Geological Survey. Washington, DC, 2008. Accessed on line 21 November 2010. http://landcovertrends.usgs.gov/east/eco69Report.html

Quick, KG (2010) Post Mining Land Use Trends in WV 1998 to 2008. 2010 National Meeting of the American Society of Mining and Reclamation, Pittsburgh, PA ***Bridging Reclamation, Science and the Community***

Zipper CE, Burger JA, McGrath JM, Amichev B. (2007) Carbon Accumulation Potentials of Post-SMCRA Coal-Mineds. 2007 National Meeting of the American Society of Mining and Reclamation, Gillette, WY ***30 Years of SMCRA and Beyond***

Scott D. Eggerud is a forester with the Office of Surface Mining Reclamation and Enforcement. Currently his job is to promote reforestation of mined lands using the Forestry Reclamation Approach (FRA). He has been a professional forester for 24 years with the USDA Forest Service, the West Virginia Division of Forestry the Department of Environmental Protection and the State Soil Conservation Committee and the Tri-State Timber Management, Inc. He holds a BS Degree in Forest Management and Integrated Natural Resource Management from the University of Wisconsin at Stevens Point.

CREATING SUMMER BAT HABITAT ON SURFACE MINES IN APPALACHIA USING THE FORESTRY RECLAMATION APPROACH (FRA)

PROTECTING THREATENED BATS AT COAL MINES: A TECHNICAL INTERACTIVE FORUM

SEPTEMBER 2, 2010 - SOUTH CHARLESTON, WEST VIRGINIA

Scott D. Eggerud, Forester
United States Department of Interior
Office of Surface Mining Reclamation and Enforcement
Pittsburgh, PA
412-266-0726
seggerud@osmre.gov

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25 YEAR OLD SURFACE MINE SLOWLY REVERTING BACK TO FOREST

THE APPALACHIAN REGIONAL REFORESTATION INITIATIVE

APPALACHIAN REGIONAL REFORESTATION INITIATIVE (ARRI)

ARRI is a broad-based group working to reestablish forest habitat on active and abandoned mine lands.

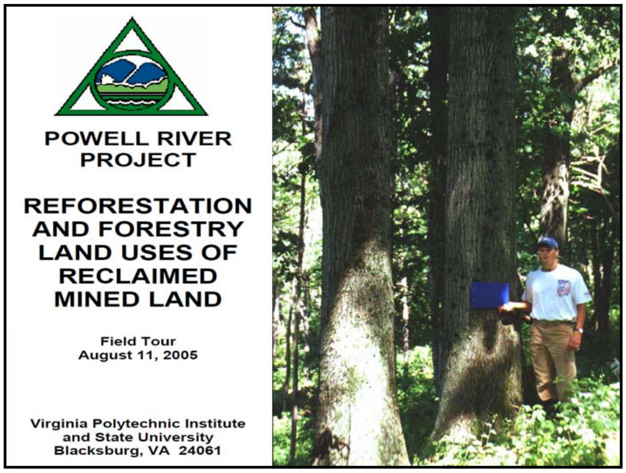
ARRI'S GOALS:

- PLANT MORE HIGH-VALUE HARDWOOD TREES...
- INCREASE THE SURVIVAL RATES AND GROWTH RATES OF PLANTED TREES...
- AND EXPEDITE THE ESTABLISHMENT OF FOREST HABITAT THROUGH NATURAL SUCCESSION

ARRI STARTED AS A JOINT EFFORT BETWEEN OSM AND THE APPALACHIAN COAL STATES

ARRI'S SCIENCE TEAM

- OHIO UNIVERSITY
- OHIO STATE UNIVERSITY
- PENNSYLVANIA STATE UNIVERSITY
- PURDUE UNIVERSITY
- SOUTHERN ILLINOIS UNIVERSITY
- UNIVERSITY OF KENTUCKY
- UNIVERSITY OF MARYLAND
- UNIVERSITY OF TENNESSEE
- VIRGINIA POLYTECHNIC INSTITUTE
- WEST VIRGINIA UNIVERSITY
- WEST VIRGINIA STATE UNIVERSITY
- US FOREST SERVICE
- US GEOLOGICAL SURVEY
- TACF
- OSM

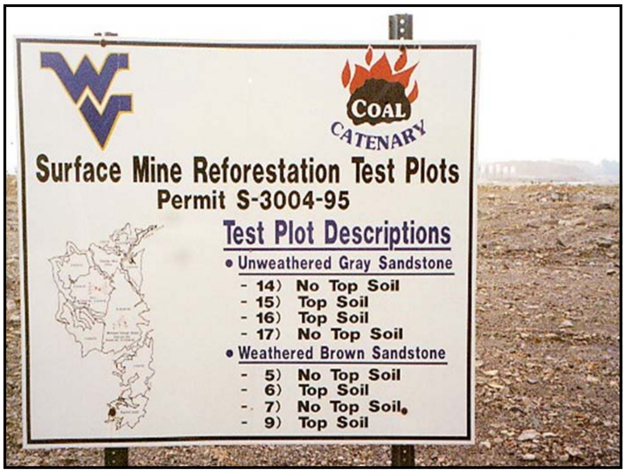


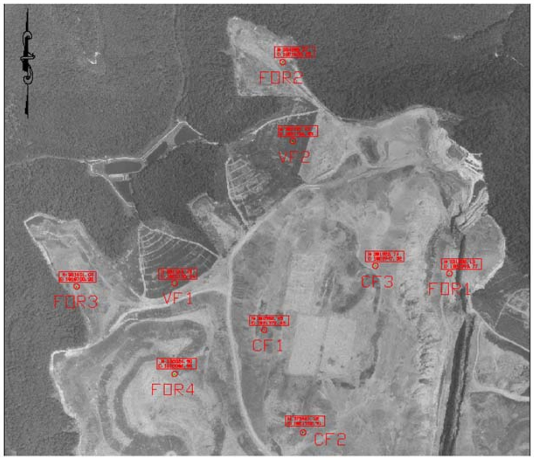
POWELL RIVER PROJECT

REFORESTATION AND FORESTRY LAND USES OF RECLAIMED MINED LAND

Field Tour
August 11, 2005

Virginia Polytechnic Institute
and State University
Blacksburg, VA 24061





UK'S BENT MOUNTAIN RESEARCH COMPLEX

UK'S BENT MOUNTAIN RESEARCH COMPLEX

FORESTRY RECLAMATION APPROACH (FRA)

1: CREATE BEST POSSIBLE GROWTH MEDIUM WITH MATERIALS ON PERMIT AREA.
2: LOOSELY PLACE TO AVOID COMPACTION
3: USE A TREE COMPATIBLE GROUND COVER
4: PLANT PROPER SPECIES OF TREES
5: USE PROPER TREE PLANTING TECHNIQUES

COMMERCIAL FORESTRY GROWTH MEDIUM AT FOLA COAL

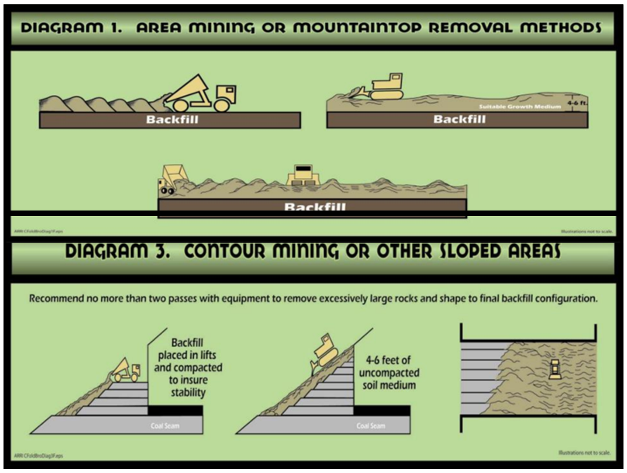
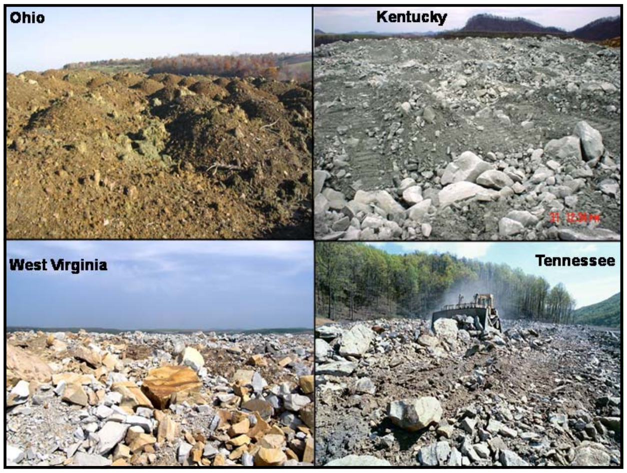
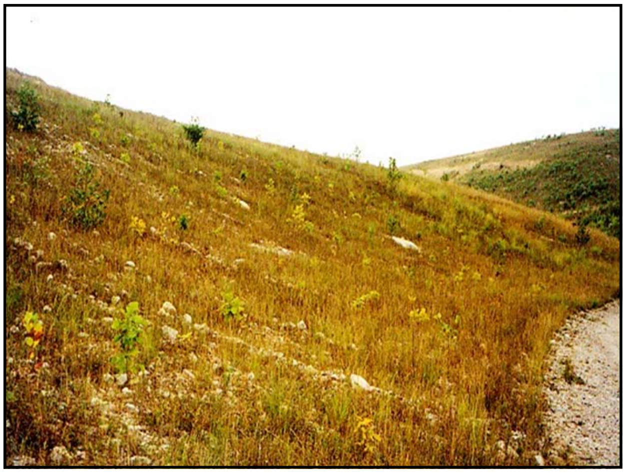


DIAGRAM 1. AREA MINING OR MOUNTAINTOP REMOVAL METHODS

DIAGRAM 3. CONTOUR MINING OR OTHER SLOPED AREAS

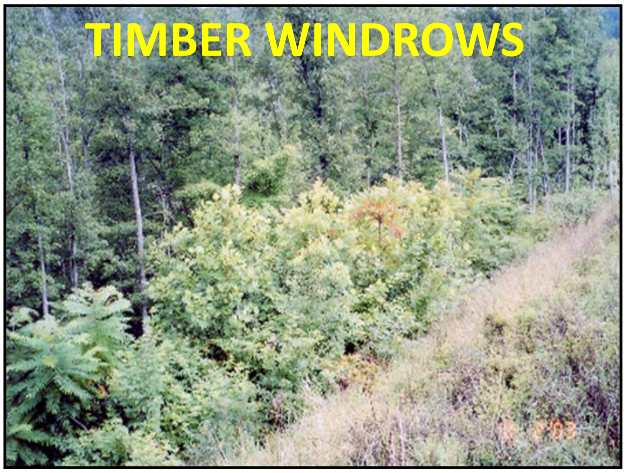
Recommend no more than two passes with equipment to remove excessively large rocks and shape to final backfill configuration.



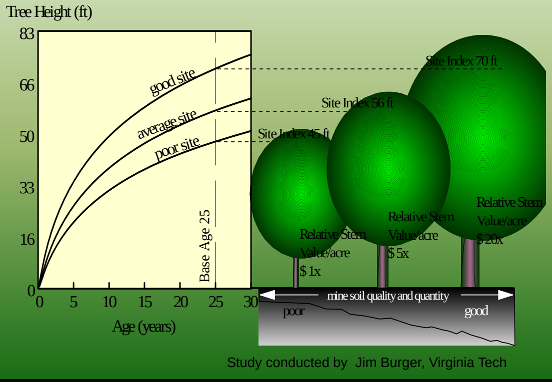



5 YEAR OLD
RED OAK IN
PUSH UP AREA
07/13/2010

TIMBER WINDROWS



Site Index



Study conducted by Jim Burger, Virginia Tech

ARRI's OUTREACH:

- The ARRI website at: http://arri.osmre.gov
- Statement of Mutual Intent
- ARRI's Newsletter
- Brochures
- Forest Reclamation Advisories
- Arbor Day & Volunteer Tree Planting Events
- Awards Program for both Title IV & Title V
- Videos
- Television, newspapers, and radio

ARRI'S STATEMENT OF MUTUAL INTENT

STATEMENT OF MUTUAL INTENT
for the
APPALACHIAN REGIONAL REFORESTATION INITIATIVE

The States of Appalachia including the Regulatory Authorities in Kentucky, Maryland, Ohio, Pennsylvania, Virginia, and West Virginia; the Office of Surface Mining, including the Tennessee Federal Program, and all other parties of this Statement of Mutual Intent desire to work together to promote and encourage planting more trees on active and abandoned coal mined lands. We will increase efforts, cooperate and partner among ourselves to plant economically viable trees, while using current Forestry Reclamation Approach (FRA) technology. This technology will increase survival rates and growth rates of crop trees, increase overall productivity, and promote natural invasion and succession of plant and animal communities.

FRA technology is a five-step reclamation process that has been proven by forestry research to increase tree survival and tree productivity. The five steps in the FRA are:

1. 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.
2. Loosely grade the topsoil or topsoil substitutes established in step one to create a non-compacted growth medium.
3. Use ground covers that are compatible with growing trees.
4. Plant two types of trees, early succession species for wildlife and soil stability, and commercially valuable crop trees.
5. Use proper tree planting techniques.

Reforestation of coal mined land using the FRA will provide multiple environmental and economic benefits:

Environmental Benefits of Reforestation

- Increased diversity of plant succession
- Natural succession of native forest plants
- Reduced potential for establishment of invasive species

STATEMENT OF MUTUAL INTENT
APPALACHIAN REGIONAL REFORESTATION INITIATIVE

☐ ☐ ☐ ☐ ☐ ☐

Signature

Date

INITIAL SMI SIGNING CEREMONY DECEMBER 15, 2004

ARRI'S STATEMENT OF MUTUAL INTENT

968 signatories represent **207** different organizations:

- 52 Government Agencies
- 59 Industry Organizations
- 17 Watershed/Citizens Groups
- 10 Environmental Groups
- 17 Academic Institutions
- 17 Conservation Groups
- 8 Faith-Based Groups
- 7
- 5
- 15 Other
- 382 individuals

Kentucky's
Kingdom Come Elementary School
Governor Fletcher
ARRI Arbor Day Event
08-17-05

ARRI NEWS-LETTERS

APPALACHIAN REGIONAL REFORESTATION INITIATIVE

ARRI News

VOLUME 1, ISSUE 7 JANUARY 2008

Conference Imparts Reforestation Knowledge

By Linda Keene
Photos by Gail Smith

The 2007 Mined Land Reforestation Conference was held August 7-8 at the Southwest Virginia Higher Education Center in Abingdon, Virginia. The conference had over 200 attendees.

The conference began with Dr. Carl Zipper from Virginia Tech moderating the morning session and opening it with "Why Better Mine Reforestation?"

Next, Brent Wahlquist, Director of the Office of Surface Mining Reclamation and Enforcement (OSMRE), discussed "OSMRE's Commitment to Better Mine Reforestation."

Bob Zic, TECO Coal, Corbin, KY, followed with "A Coal Miner's Perspective on Mine Reforestation."

Les Vincent, Virginia Division of Mined Land Reclamation, spoke on "The Appalachian Regional Reforestation Initiative and the Forestry Reclamation Approach: A State-Federal Reforestation Initiative."

"Advances in Scientific Knowledge and the Forestry Reclamation Approach," was the topic of Dr. James Burger's, Department of Forestry, Virginia Tech, talk and slide presentation.

Mary Beth Adams, US Forest Service was the moderator of the mid-morning presentations.

Becky Hatmaker, OSMRE, continued the morning presentations with "Federal and State Regulations, Bond Release and the Forestry Reclamation Approach."

"Overburden, Topsoil Substitutes, Topsoil Handling: Influence on Tree Growth," was Patrick Angel's, University of Kentucky and OSMRE, talk.

Dr. Jeff Skousen, Plant and Soil Sciences, West Virginia University, spoke on "Influence of Herbaceous Groundcover Vegetation on Reforestation Success."

Dr. Christopher Barton, Department of Forestry at the University of Kentucky, ended the morning session with a discussion on

(Conference continued on page 2)

Conference participants enjoyed mingling amongst the vendors .

OSMRE Director, Brent Wahlquist presents Jimmy Adkins with the 2006 ARRI Regional Award.

BROCHURES

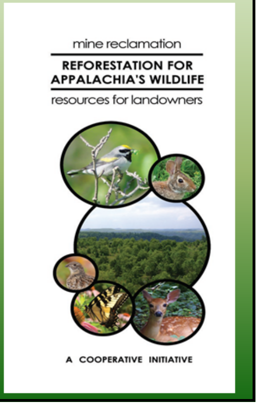
APPALACHIAN REGIONAL REFORESTATION INITIATIVE

ARRI

TREES FOR APPALACHIA'S FUTURE

A COOPERATIVE EFFORT AMONG:

The States of:
Kentucky, Maryland, Ohio,
Pennsylvania, Tennessee, Virginia,
and West Virginia;
the Office of Surface Mining
Reclamation and Enforcement;
their partners in industry;
environmental organizations;
academia; local, State and Federal
government agencies;
and local citizenry.



mine reclamation

REFORESTATION FOR APPALACHIA'S WILDLIFE

resources for landowners

A COOPERATIVE INITIATIVE

FRA RECLAMATION ADVISORIES

APPALACHIAN REGIONAL REFORESTATION INITIATIVE (ARRI)
FOREST RECLAMATION ADVISORY

FRA Number 2 December 2005

THE APPALACHIAN REGIONAL REFORESTATION INITIATIVE

The FRA's Five Steps

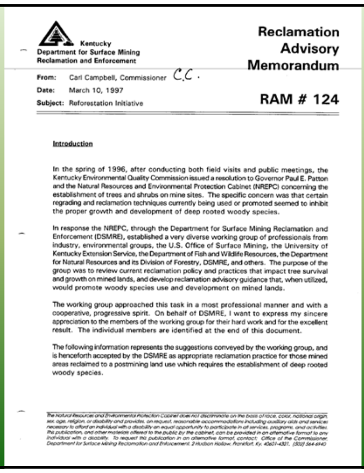
Step 1. Create a suitable rooting medium.

2008 ARBOR DAY AT BLACK CASTLE

ARRI PARTNERSHIPS

FRA PROVISIONS IN STATE AND FEDERAL PERMITS:

ARRI HAS WORKED CLOSELY WITH STATE AND FEDERAL REGULATORY AGENCIES TO INCORPORATE THE FRA (FORESTRY RECLAMATION APPROACH) INTO POLICIES AND REGULATIONS.



Kentucky
Department for Surface Mining
Reclamation and Enforcement

Reclamation Advisory Memorandum

From: Carl Campbell, Commissioner C.C.
Date: March 10, 1997
Subject: Reforestation Initiative

RAM # 124

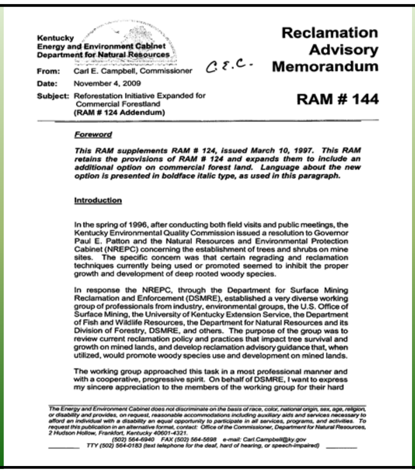
Introduction

In the spring of 1996, after conducting both field visits and public meetings, the Kentucky Environmental Quality Commission issued a resolution to Governor Paul E. Patton and the Natural Resources and Environmental Protection Cabinet (NREPC) concerning the establishment of trees and shrubs on mine sites. The specific concern was that certain regrading and reclamation techniques currently being used or promoted seemed to inhibit the proper growth and development of deep rooted woody species.

In response the NREPC, through the Department for Surface Mining Reclamation and Enforcement (DSMRE), established a very diverse working group of professionals from industry, environmental groups, the U.S. Office of Surface Mining, the University of Kentucky Extension Service, the Department of Fish and Wildlife Resources, the Department for Natural Resources and its Division of Forestry, DSMRE, and others. The purpose of the group was to review current reclamation policy and practices that impact tree survival and growth on mined lands, and develop reclamation advisory guidance that, when utilized, would promote woody species use and development on mined lands.

The working group approached this task in a most professional manner and with a cooperative, progressive spirit. On behalf of DSMRE, I want to express my sincere appreciation to the members of the working group for their hard work and for the excellent result. The individual members are identified at the end of this document.

The following information represents the suggestions conveyed by the working group, and is henceforth accepted by the DSMRE as appropriate reclamation practice for those mined areas reclaimed to a postmining land use which requires the establishment of deep rooted woody species.



Kentucky
Energy and Environment Cabinet
Department for Natural Resources

Reclamation Advisory Memorandum

From: Carl E. Campbell, Commissioner C.E.C.
Date: November 4, 2009
Subject: Reforestation Initiative Expanded for Commercial Forestland
(RAM # 124 Addendum)

RAM # 144

Foreword

This RAM supplements RAM # 124, issued March 10, 1997. This RAM retains the provisions of RAM # 124 and expands them to include an additional option on commercial forest land. Language about the new option is presented in boldface italic type, as used in this paragraph.

Introduction

In the spring of 1996, after conducting both field visits and public meetings, the Kentucky Environmental Quality Commission issued a resolution to Governor Paul E. Patton and the Natural Resources and Environmental Protection Cabinet (NREPC) concerning the establishment of trees and shrubs on mine sites. The specific concern was that certain regrading and reclamation techniques currently being used or promoted seemed to inhibit the proper growth and development of deep rooted woody species.

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(502) 564-6940 FAX (502) 564-5698 e-mail: Carl.Campbell@ky.gov
TTY (502) 564-0183 (text telephone for the deaf, hard of hearing, or speech-impaired)

KY RAM 144:

ALLOWS FOR NO STRIKE OFF

NEED LANDOWNER APPROVAL

NEED COMMERCIAL WOODLAND PLANTING PLAN

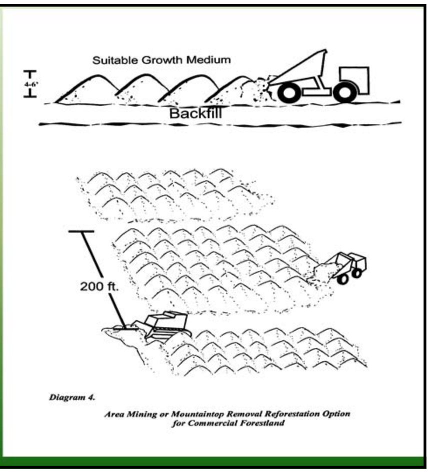


Diagram 4.

Area Mining or Mountaintop Removal Reforestation Option for Commercial Forestland

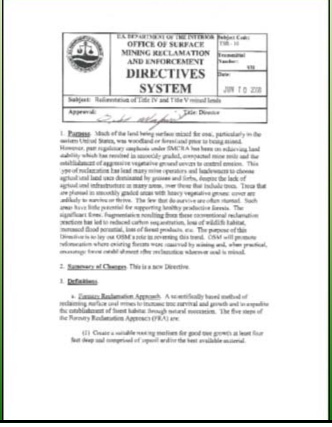
WV FORESTLAND POST MINE LAND USE REGULATIONS (38CSR2-7.6)

- APPROVED MAY 8, 2005
- AOC COMPLIANT SITES ONLY
- PLANS PREPARED BY RPF AND REVIEWED BY A FORESTER EMPLOYED BY THE WV-DEP
- FULLY INCORPORATES FRA

TN & VA

- CHANGED GROUND COVER REQUIREMENTS ON FORESTRY POST MINE LAND USE
- ELIMINATED NUMERICAL STANDARD
- ONLY TO THAT NECESSARY TO CONTROL EROSION BUT ALLOW FOR TREE GROWTH
- PERMIT BY PERMIT BASIS

OSM'S REFORESTATION DIRECTIVE: TSR-16



OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT
DIRECTIVES SYSTEM

JUN 10 2008

Subject: Reforestation of Title IV and Title V mined lands

Approval:

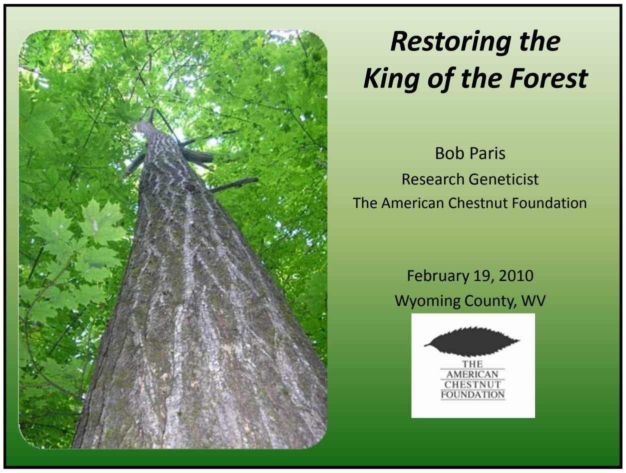
Title: Director

2. Summary of Changes. This is a new Directive.

3. Definitions.

COAL INDUSTRY:

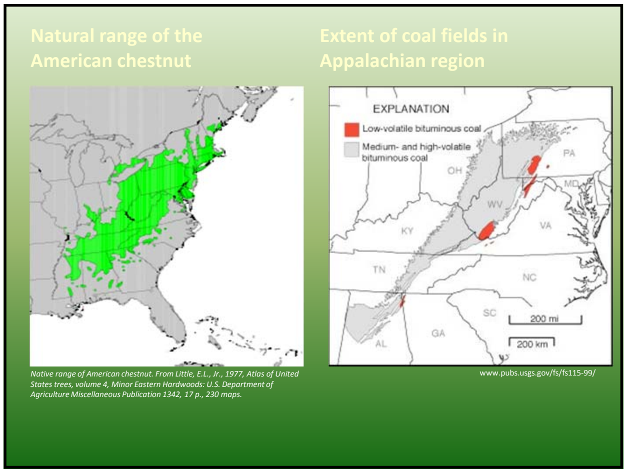
Between 2004 and 2009… approx 60 million trees have been planted on about 87,000 acres



Restoring the King of the Forest

Bob Paris
Research Geneticist
The American Chestnut Foundation

February 19, 2010
Wyoming County, WV



Natural range of the American chestnut

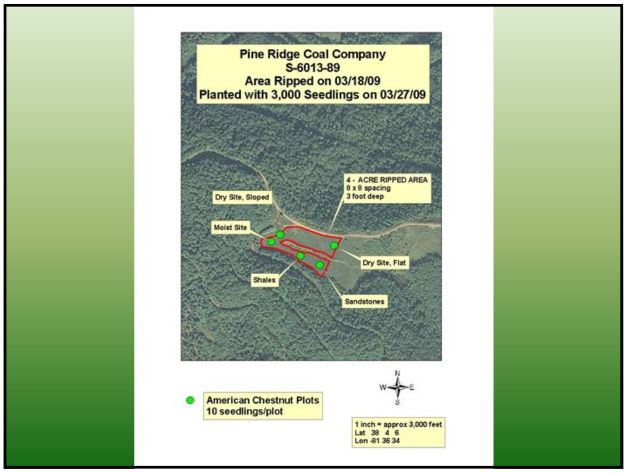
Extent of coal fields in Appalachian region

Native range of American chestnut. From Little, E.L., Jr., 1977, Atlas of United States trees, volume 4, Minor Eastern Hardwoods: U.S. Department of Agriculture Miscellaneous Publication 1342, 17 p., 230 maps.

www.pubs.usgs.gov/fs/fs115-99/

AMERICAN CHESTNUT BACKCROSS FROM SEED

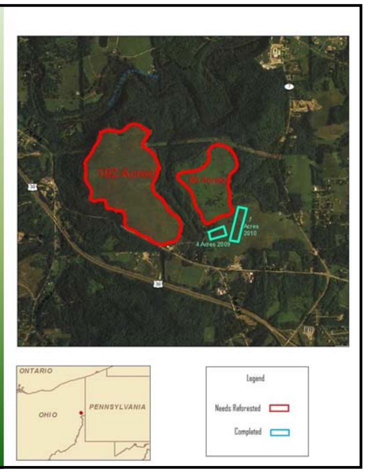
1 YEAR OLD AMERICAN CHESTNUT BACKCROSS



THE APPALACHIAN COAL COUNTRY WATERSHED TEAM (ACCWT)
AN OSM/VISTA INITIATIVE WWW.ACCWT.ORG

2009 & 2010
177,500 TREES
250 ACRES
22 SITES IN 6 STATES
OVER 2,500 VOLUNTEERS

HELLBENDER BLUFF
Columbiana County, OH



PA 2009 STATE ARRI TITLE V EXCELLENCE IN REFORESTATION AWARD: MOUNTAINTOP COAL COMPANY

TN 2009 STATE ARRI TITLE IV EXCELLENCE IN REFORESTATION AWARD: PANTHER BRANCH STREAM RESTORATION PROJECT

JAMES RIVER COAL COMPANY MINE FOREMEN AND EQUIPMENT OPERATORS REFORESTATION TRAINING

02/12&13/10

PAUL ROTHMAN, KY DNR
PATRICK ANGEL, OSM
SCOTT EGGERUD, OSM

Headwater Stream Recovery

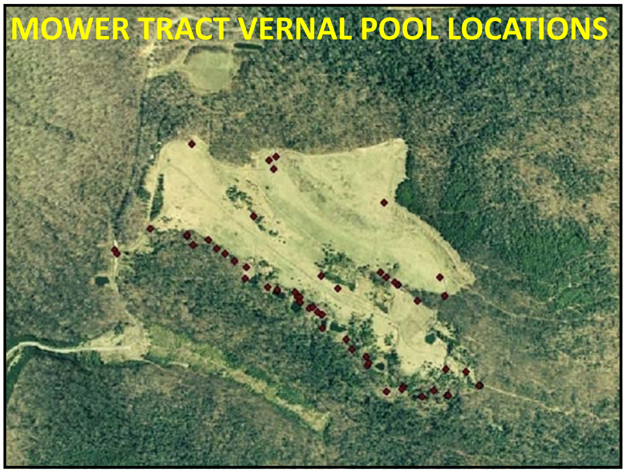
(A New Direction)

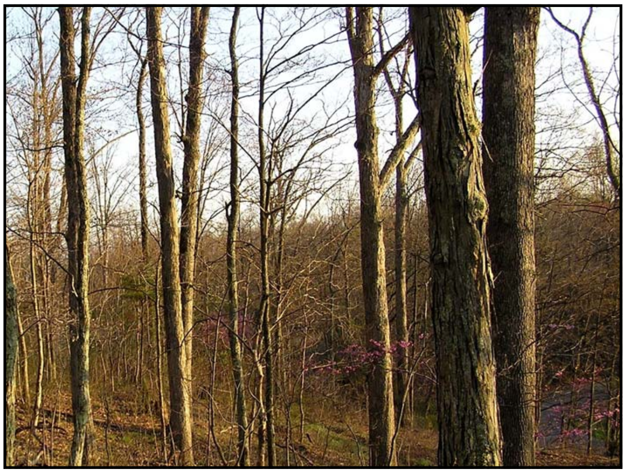
Restored Hollow Fill
(UK Laurel Fork Mine – Guy Cove)

Un-mined Headwater Stream
(UK Robinson Forest – L. Millseat)

Red Spruce at Kempton Refuse AML Project

06/17/2010


MOWER TRACT VERNAL POOL LOCATIONS




STATE OF WEST VIRGINIA
DEPT. OF ENVIRONMENTAL PROTECTION
Division of Land Restoration
Office of Abandoned Mine Lands & Reclamation
Project Cost: $2,004,345.90
Funding: US Department of the Interior- OSM with fees paid by the Coal Industry
Joe Manchin
Governor
dep
Stephanie Timmermeyer
Cabinet Secretary
DLR
Ken Ellison
Director
Project Name: Kempton Refuse and AMD Project
DEP# 13907
Contractor: Cowgirl Up Inc.
Project Start Date: 08-13-07
For Info on NPDES Storm Water Permit
Call: 800-654-5227
7/19/07
OFFICE ABANDONED MINE LANDS & RECLAMATION
Reclamation Project


CATERPILLAR
CAT 245B


CATERPILLAR
CAT 245B


CATERPILLAR

ARRI IS WORKING IN TWO DIRECTIONS:

FORWARD… to get coal operators and landowners to adopt the FRA

- Regulations & Policy
- Training, Research & Demonstrations
- On site visits to offer Technical Assistance

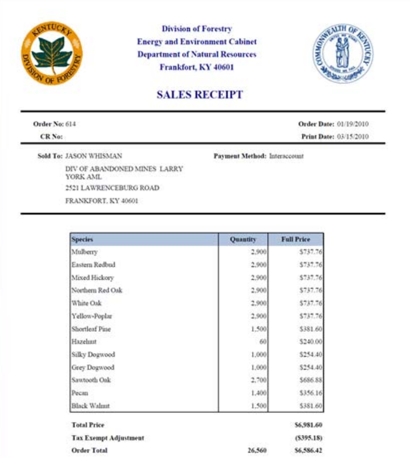
BACKWARD… to enhance past reclamation efforts through site prep and supplemental tree planting

KY AML INVOLVEMENT

LARRY YORK SITE, MORGAN COUNTY


02/11/2010


02/23/2010



Division of Forestry
Energy and Environment Cabinet
Department of Natural Resources
Frankfort, KY 40601

SALES RECEIPT

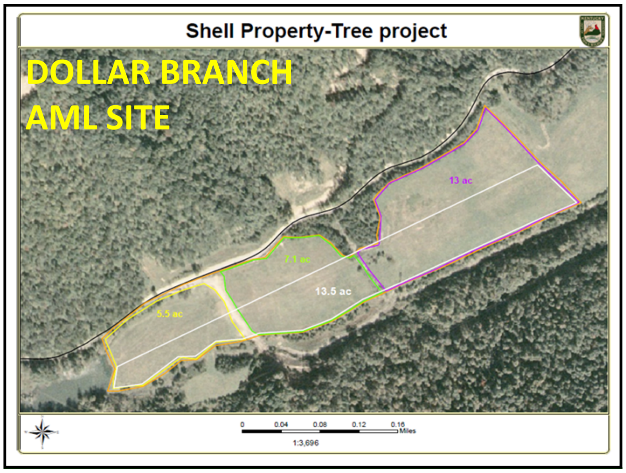
Order No: 614 **Order Date:** 01/19/2010
CR No: **Print Date:** 03/15/2010

Sold To: JASON WHISMAN
DIV OF ABANDONED MINES LARRY YORK AML
2521 LAWRENCEBURG ROAD
FRANKFORT, KY 40601

Payment Method: Interaccount

Species	Quantity	Full Price
Mulberry	2,900	$737.76
Eastern Redbud	2,900	$737.76
Mixed Hickory	2,900	$737.76
Northern Red Oak	2,900	$737.76
White Oak	2,900	$737.76
Yellow-Poplar	2,900	$737.76
Shortleaf Pine	1,500	$381.60
Hazelnut	60	$240.00
Silky Dogwood	1,000	$254.40
Grey Dogwood	1,000	$254.40
Sawtooth Oak	2,700	$686.88
Pecan	1,400	$356.16
Black Walnut	1,500	$381.60
Total Price		**$6,981.60**
Tax Exempt Adjustment		**($395.18)**
Order Total	**26,560**	**$6,586.42**

KY AML PAID FOR TREE SEEDLINGS & POST EMERGENT HERBICIDE



Shell Property-Tree project

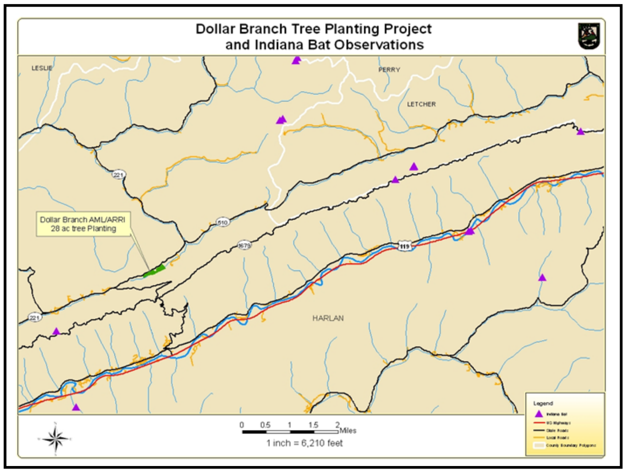
DOLLAR BRANCH AML SITE

03/19/2010

03/21/2010

03/20/2010

03/20/2010



Dollar Branch Tree Planting Project and Indiana Bat Observations


03/20/2010

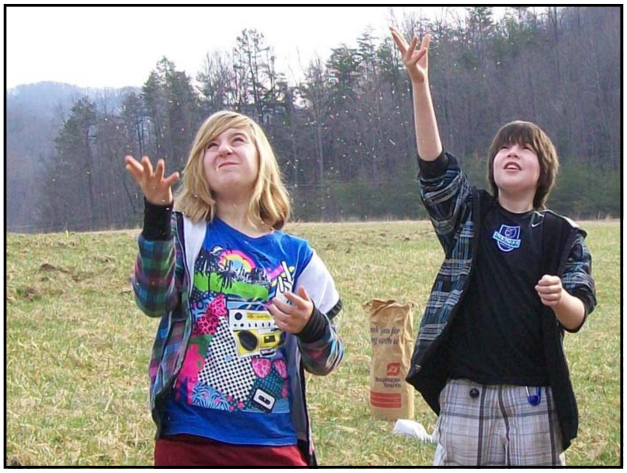

03/20/2010

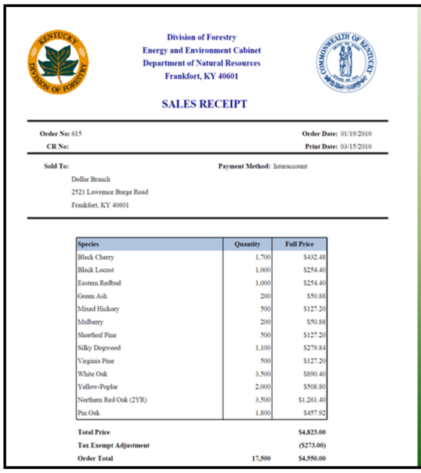

KENTUCKY
DIVISION OF FORESTRY
KENTUCKY DIVISION OF FORESTRY
PREMIUM SELECT TREE SEEDLINGS
WHITE OAK 100
KENTUCKY'S RENEWABLE RESOURCE
HANDLING INSTRUCTIONS
MUST BE KEPT COOL
MEND TEARS PROMPTLY
ALLOW FOR VENTILATION BETWEEN PACKAGES
PROTECT FROM FREEZING
PROTECT ROOTS FROM DRYING
PLANT PROMPTLY
KEEP ROOTS WET DURING PLANTING
Kentucky Proud
03/20/2010


MIXED HICKORY 100
KENTUCKY DIVISION OF FORESTRY
PREMIUM SELECT TREE SEEDLINGS
03/20/2010


KENTUCKY DIVISION OF FORESTRY
BLACK CHERRY 100
PREMIUM SELECT TREE SEEDLINGS
03/20/2010


03/21/2010





Division of Forestry
Energy and Environment Cabinet
Department of Natural Resources
Frankfort, KY 40601

SALES RECEIPT

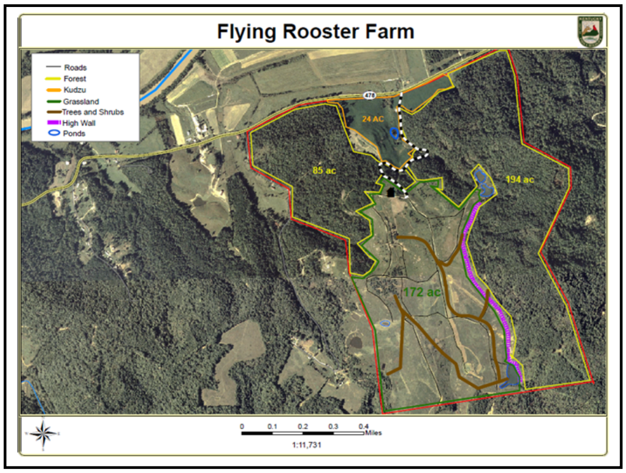
Order No: 615 **Order Date:** 01/19/2010
CR No: **Print Date:** 03/15/2010

Sold To: **Payment Method:** Interaccount

Dollar Branch
2521 Lawrence Burge Road
Frankfort, KY 40601

Species	Quantity	Full Price
Black Cherry	1,700	$432.48
Black Locust	1,000	$254.40
Eastern Redbud	1,000	$254.40
Green Ash	200	$50.88
Mixed Hickory	500	$127.20
Mulberry	200	$50.88
Shortleaf Pine	500	$127.20
Silky Dogwood	1,100	$279.84
Virginia Pine	500	$127.20
White Oak	3,500	$890.40
Yellow-Poplar	2,000	$508.80
Northern Red Oak (2YR)	3,500	$1,261.40
Pin Oak	1,800	$457.92
Total Price		**$4,823.00**
Tax Exempt Adjustment		**($273.00)**
Order Total	**17,500**	**$4,550.00**

KY AML PAID FOR TREE SEEDLINGS & POST EMERGENT HERBICIDE



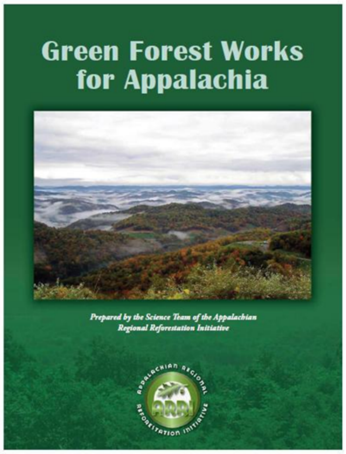
GERERAL RECOMMENDATIONS FOR IMPLEMENTING THE FORESTRY APPROACH (FRA) ON ABANDONED MINED LAND (AML) PROJECTS IN WEST VIRGINIA 01/06/10

THIS CONSISTED OF ALL 5 STEPS OF THE FRA WITH EMPHASIS ON MATERIAL PLACEMENT

- END-DUMPING OF THE FORESTLAND GROWTH MEDIUM ON FLAT TO GENTLY SLOPING AREAS WITH MINIMAL GRADING
- HIGH WALL ELIMINATION BY HAULING AND DUMPING MINE SOIL/SPOIL MATERIALS FROM ABOVE
- PUSH-UP METHOD OF THE FORESTLAND GROWTH MEDIUM PLACEMENT, PERPENDICULAR TO THE HIGH WALL, ON FLAT OR SLOPED AREAS
- PUSH-UP METHOD OF THE FORESTLAND GROWTH MEDIUM PLACEMENT, PARALLEL TO THE HIGH WALL, ON FLAT OR SLOPED AREAS

FRA SUMMARY:

1. GROWTH MEDIUM:
   MIXTURE OF ABOUT 60% SANDSTONES, 30% SHALES & 10% SOILS, INCLUDE COARSE FRAGMENTS & ORGANICS, 4 FEET THICK MIN.
2. MINIMIZE COMPACTION:
   INNOVATIVE METHODS OF PLACEMENT
3. TREE COMPATIBLE GROUND COVER:
   NO AGGRESSIVE OR TALL GRASSES OR LEGUMES: SERECIA LESPEDEZA, TALL FESCUE, RED CLOVER OR VETCHES
4. PROPER TREE SPECIES:
   60% LATER SUCCESSIONARY SPECIES, 30% EARLY SUCCESSIONARY SPECIES, 10% NURSE TREES
5. PROPER TREE PLANTING TECHNIQUES



Green Forest Works for Appalachia

Prepared by the Science Team of the Appalachian Regional Reforestation Initiative

ARRI'S GREEN JOBS PROPOSAL:

•1 MILLION ACRES

•2000 GREEN JOBS

•125 MILLION TREES

•175,000 ACRES

POTENTIAL EFFECTS OF SURFACE MINE BLASTS UPON BAT HIBERNACULUM

Jim Ratcliff
West Virginia DEP Office of Explosives & Blasting
Charleston, West Virginia

Abstract

Issues arising in 2006, with respect to effects of surface mine blasting on the underground habitat for the endangered Indiana (Myotis sodalis) and Virginia big-eared (Corynorhinus townsendii virginianus) bats sparked debate between federal and state regulatory authorities and private industry. To address the concerns of the National Park Service (NPS) and the Fish and Wildlife Service (FWS), seismographs were installed at two abandoned mine portals in the New River Gorge National River Park where the bats have been observed and to ensure that agreed blasting vibrations were not exceeded. Seismographs were also placed on the mine-site to record blasting impulses that would be analyzed for ground vibration decay rates over horizontal distances.

Due to restricted access, the underground roofs in the abandoned mines the bats were using for shelter were not monitored for blasting vibrations. As an alternative, seismograph geophones were bolted to the roof of an active underground coal mine in southern West Virginia. Surface geophones were placed directly overhead. These recordings were then used to predict the ratio of surface to underground peak vibration levels that could be observed at the non-accessible underground mine roof.

In 2005, federal and state regulatory authorities and private industry conducted a winter bat survey at a West Virginia surface limestone operation. Blast and seismic data and bat survey data were used to compare the relationship of blasting vibration levels and the bat population at this location. These findings could be indicative of the effects of blasting on any existing endangered bat populations.

Introduction

Discussions between the NPS and FWS, both federal regulators, and the coal mine permitee began in mid-2005, concerning proposed mining near old underground mine workings that potentially harbored endangered Indiana and Virginia big-eared bats. Although mining would be conducted on private property adjacent to the New River Gorge National River Park, the mine portals the bats would use to enter and exit were located on park property.

There were four main concerns of the NPS and FWS with regard to blasting: 1) damage to the mine portal used by Indiana bats (November 15 to March 31) and Virginia big-eared bats (year round); 2) potential for substantial collapses within the abandoned Fire Creek coal mine workings from surface blasting that potentially could destroy roosting habitat for the endangered bat species; 3) fear of partial collapses of the mine workings could make the mines unsuitable for bat habitat due to changes in airflow patterns and/or internal temperatures; 4) hibernating bats disturbed by blasting vibrations could lose energy stores and starve to death. West Virginia Department of Environmental Protection (WVDEP), in response to these concerns, requested that the Office of Explosives and Blasting (OEB) monitor blasting compliance at the nearest gated portals.

Questions arising at the beginning of this study included:

1) maximum blasting vibration levels allowed at the Fire Creek coal mine portals and those levels necessary to maintain roof integrity;
2) distance the bats migrate underground to hibernate;
3) maximum blasting vibration levels allowed that would not disturb hibernating bats in the winter months; and
4) variances between surface and underground seismic responses from surface blasting.

Consultations between the NPS, FWS, and Office of Surface Mining Reclamation and Enforcement (OSM) revealed that a vibration limit of 0.30 inches per second (ips) should not be exceeded at the mine portals. Given that the underground Fire Creek seam was not accessible, the permitee's blast design was based upon the use of the scaled distance formula. Scaled distance is defined as $D / W^{0.50}$ where D equals the distance from the blast to a protected structure and W equals the maximum pounds per delay initiated on the blast. In this case, the protected structure was the abandoned coal mine roof located approximately 455 feet below active mining. Regulatory scaled distance factors and maximum peak particle velocities needed for various horizontal distances are:

Distance From Blast to Protected Structure	Minimum Scaled Distance Required	Maximum Peak Particle Velocity (Ppv)
0' – 300'	50	1.25 ips
301' – 5,000'	**55**	**1.00 ips**
5,001'+	65	0.75 ips

For example, a particular blast that is 550 feet above the abandoned coal mine roof would need to maintain a maximum of 100 pounds per delay ($W = (550 / 55)^2$). Since existing data on blasting vibration levels indicate 1.00 ips will maintain roof integrity, it was decided by OEB, NPS, FWS, and OSM, to allow the use of the scaled distance formula to minimize vibration effects.

A detailed 2005 report titled "Bat – Swarming Inventory at Abandoned Mine Portals at New River Gorge National River, West Virginia" states,

> "Neither spring emergence, nor fall swarm surveys, will absolutely confirm presence of hibernating bats in NERI [New River Gorge Area] mines. Conducting internal surveys is the only method that can reliably assess hibernating bat communities. However, that is very dangerous and should only be attempted by qualified personnel aware of the risks to life and limb."[1]

This same study includes bat survey data that 2,346 bats were captured from 19 mine portal entries including the Virginia big-eared and Indiana bats. It is assumed, for the sake of this report, bats do use the abandoned mines in the New River Gorge National River Park as hibernacula.

Using hibernating information obtained from published and unpublished research, the New River Gorge Park study conducted by OEB focuses on the predicted blasting vibrations on potential underground bat hibernacula. Previous studies measured vibrations of approaching blasting at the cave openings. OEB research addresses blasting impacts to the roof of the abandoned underground coal mine and vibration levels that endangered bats might tolerate during their hibernation periods.

Field Data Collection Sites

Protected coal mine portals 2D and 2A are located in Fayette County, West Virginia and open into the Fire Creek seam that was mined in the 1940's. These sites were used as data collection points. The Fire Creek seam lies approximately 455 feet below the Sewell coal seam that is actively being mined. Figure 1 shows the plan view of the permitted area with respect to the portal openings.

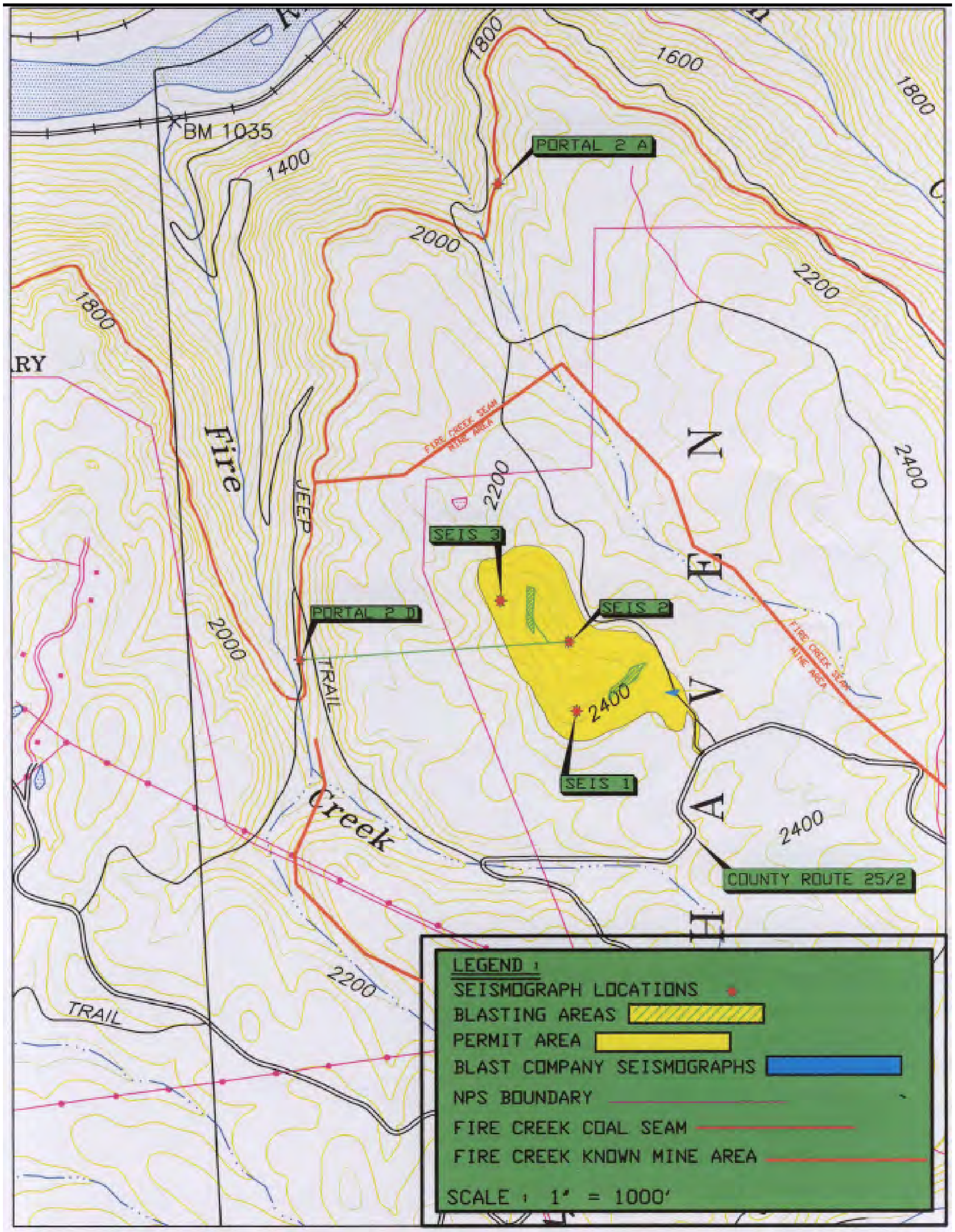


Figure 1 Plan view of permitted area, Fayette County, WV.

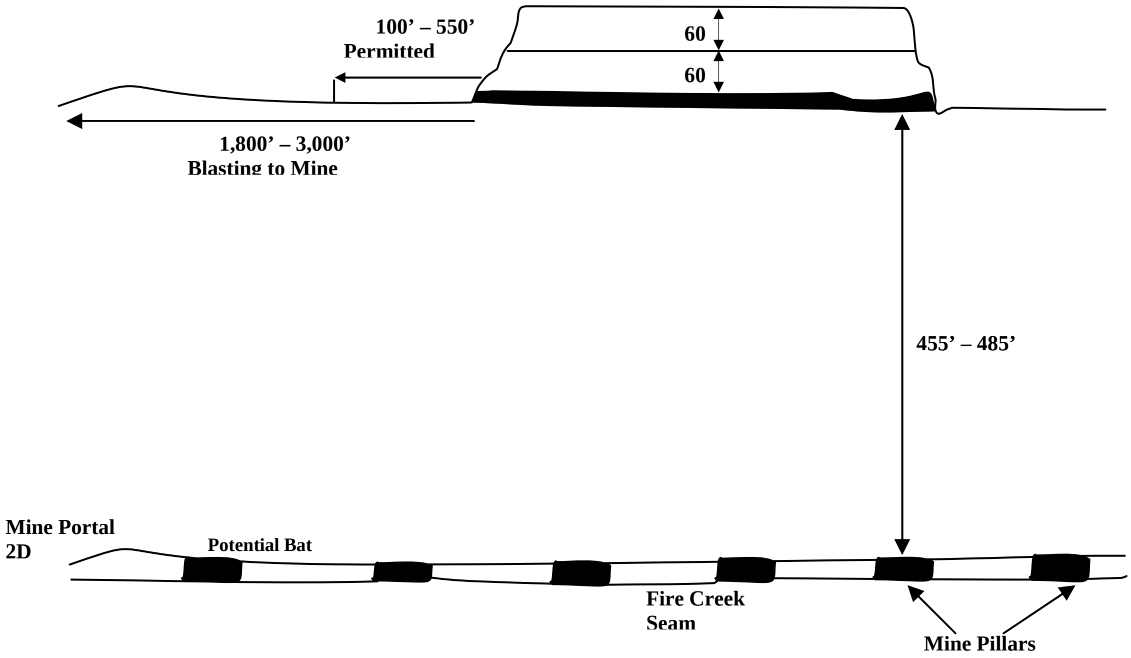


Figure 2. Cross section of the permitted area and portal openings (Not to scale).

Geologic layers between the Sewell “B” seam and the bat hibernacula (Fire Creek seam) as described by the West Virginia Geological Survey[2] are as follows:

MATERIAL	THICKNESS (FEET)	TOTAL FEET
Coal, Sewell “B”	0 - 5	2,540
Shale	10 - 24	2,564
Coal, Sewell “A”	0 - 1	2,565
Sandstone, Lower Guyandot	0 - 50	2,615
Shale, Hartridge	0 - 5	2,620
Coal, Sewell	0 - 10	2,630
Shale	0 - 5	2,635
Sandstone, Welch	0 - 50	2,685
Shale	0 - 5	2,690
Coal, Welch	0 - 5	2,695
Shale	0 - 5	2,700
Sandstone, Upper Raleigh	50 - 75	2,775
Coal, Little Raleigh “A”	0 - 3	2,778
Shale	0 - 25	2,803

MATERIAL	THICKNESS (FEET)	TOTAL FEET
Coal, Little Raleigh	4 - 2	2,805
Shale	15 - 5	2,810
Sandstone, Lower Raleigh	100 - 50	2,860
Coal, Beckley “Rider”	0 - 2	2,862
Shale	0 - 17	2,879
Coal, Beckley	0 - 10	2,889
Sandstone, Quinnimont	0 - 66	2,955
Shale, Quinnimont	0 - 35	2,990
Coal, Fire Creek, “Quinnimont”	0 - 5	2,995

This table would suggest a potential for 22 layers of various geologic material between the Sewell "B" coal seam and the bat hibernacula (Fire Creek seam). It includes nine layers of shale (126 feet thick), five layers of sandstone (291 feet thick), and eight layers of coal (33 feet thick). Due to the inability to gain access to the abandoned mine roof of the bat hibernacula, seismograph geophones were bolted to the mine portal roof, or rib, outside the bat gates of portal 2D and 2A to monitor for compliance (Figure 4).

Figure 3. Bat gates installed to protect bat roosting and hibernacula in portal 2D.

Figure 4. Geophone Bolted to Roof of Portal 2A.

Figure 5. Geophone Bolted to Roof of Portal 2D.

Seismographs were put into place on May 24, 2006, although blasting did not begin until June 19, 2006. These were to record baseline data and possibly measure any natural movement of the roof before blasting began. The seismographs were manufactured by White Seismology and were able to detect ground vibration levels as low as 0.002 ips. Seismic results prior to blasting at portal 2D are as follows:

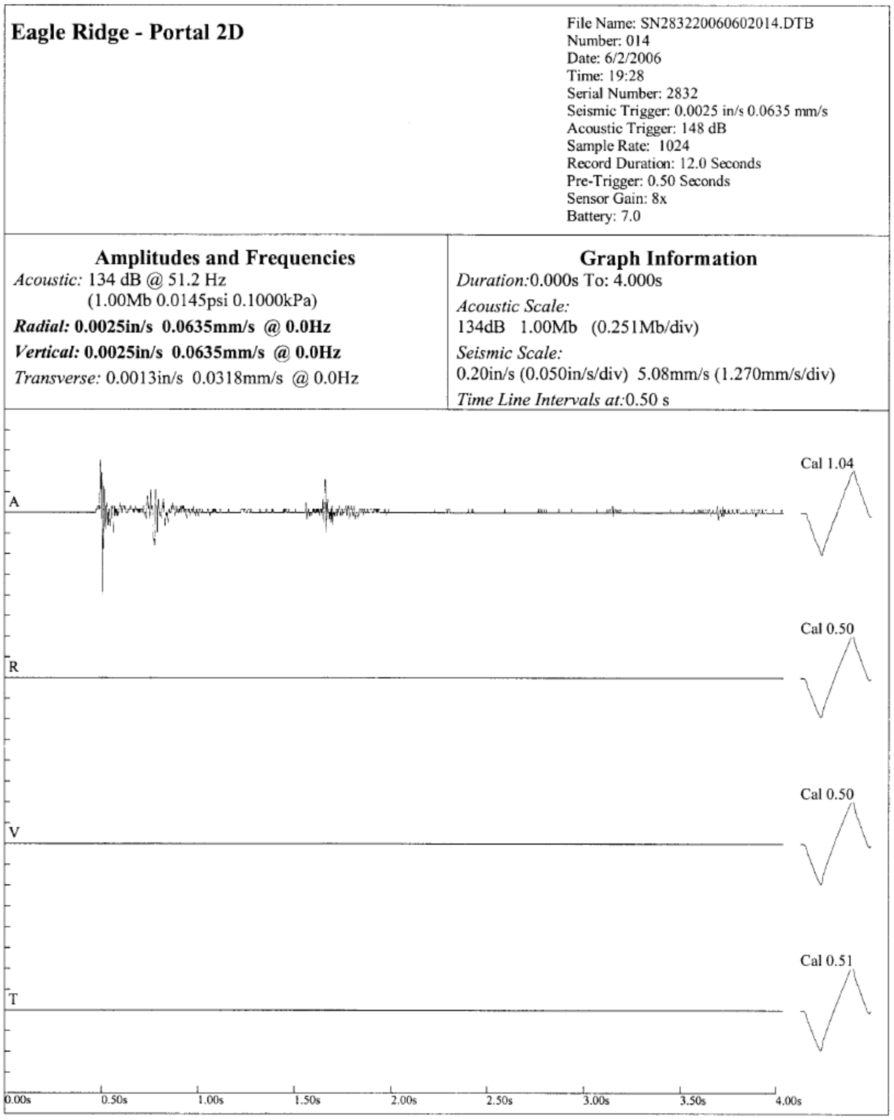
DATE	TIME	PPV (IPS)	AIRBLAST (dB)
5/30/2006	12:05 AM	.005	<100
5/30/2006	12:07 AM	.0075	<100
5/30/2006	12:12 AM	.0113	<100
5/30/2006	12:58 AM	**.0288**	<100
5/30/2006	1:00 AM	.0188	<100
5/30/2006	1:09 AM	.0025	<100
6/2/2006	7:28 PM	.0025	**134**
6/14/2006	8:11 AM	.0075	<100

Seismic results prior to blasting at portal 2A are as follows:

DATE	TIME	PPV (IPS)	AIRBLAST (dB)
5/24/2006	11:10 PM	.0125	<100
5/28/2006	11:00 PM	.0025	<100
6/9/2006	5:29 AM	.005	<100
6/11/2006	4:32 AM	.0025	<100
6/13/2006	10:20 PM	**.0300**	<100
6/15/2006	1:00 PM	.0175	**106**

A maximum vibration of 0.03 ips was recorded at Portal 2A on June 13, 2006. This can be attributed to any number of non-blast occurrences, such as wind moving the geophone cable, animal disturbances, thunder storms, etc. Figure 6 shows 134 decibels (dB) recorded on June 2, 2006. Normally this measurement would be considered non-compliant in regards to blasting outside a permitted area. Although the unit of airblast measurement is denoted as decibels, it is actually recorded in pounds per square inch (psi). The 134 dB equates to 0.0145 psi. which is equivalent to a wind gust of 20 – 28 miles per hour. It is not known what caused this air overpressure pulse.

Once blasting began on June 19, 2006, bi-weekly hikes were made into the park to retrieve seismographs for data download and to install fresh machines.



Eagle Ridge - Portal 2D

File Name: SN283220060602014.DTB
Number: 014
Date: 6/2/2006
Time: 19:28
Serial Number: 2832
Seismic Trigger: 0.0025 in/s 0.0635 mm/s
Acoustic Trigger: 148 dB
Sample Rate: 1024
Record Duration: 12.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 8x
Battery: 7.0

Amplitudes and Frequencies

Acoustic: 134 dB @ 51.2 Hz
(1.00Mb 0.0145psi 0.1000kPa)
***Radial:* 0.0025in/s 0.0635mm/s @ 0.0Hz**
***Vertical:* 0.0025in/s 0.0635mm/s @ 0.0Hz**
Transverse: 0.0013in/s 0.0318mm/s @ 0.0Hz

Graph Information

*Duration:*0.000s To: 4.000s
Acoustic Scale:
134dB 1.00Mb (0.251Mb/div)
Seismic Scale:
0.20in/s (0.050in/s/div) 5.08mm/s (1.270mm/s/div)
*Time Line Intervals at:*0.50 s

Figure 6. Seismic results at portal 2D, June 2, 2006.

Blast distances varied from 1,887 to 2,828 feet at portal 2D. Seismic data obtained from June 19 to November 21, 2006, is as follows:

SHOT #	DATE	TIME	PPV (IPS)	AIRBLAST (dB)
1	6/19/2006	1:01 PM	0.0100	106
2	6/22/2006	12:48 PM	0.0150	106
3	7/10/2006	1:36 PM	**0.0225**	**120**
4	7/11/2006	2:45 PM	No Trigger	No Trigger
5	7/13/2006	3:35 PM	0.0075	106
6	7/18/2006	3:50 PM	No Trigger	No Trigger
7	7/27/2006	5:28 PM	0.0125	<100
8	8/2/2006	2:51 PM	0.0075	106
9	8/10/2006	2:43 PM	No Trigger	No Trigger
10	8/21/2006	2:58 PM	No Trigger	No Trigger
11	9/7/2006	2:39 PM	0.0100	<100
12	9/13/2006	2:47 PM	0.0075	<100
13	9/18/2006	11:21 AM	0.0075	<100
14	9/20/2006	11:25 AM	0.0100	<100
15	9/22/2006	1:05 PM	No Trigger	No Trigger
16	9/27/2006	1:34 PM	0.0100	<100
17	10/9/2006	5:06 PM	0.0100	<100
18	10/11/2006	3:14 PM	0.0075	<100
19	10/16/2006	5:03 PM	0.0200	<100
20	11/3/2006	3:02 PM	No Trigger	No Trigger
21	11/8/2006	1:38 PM	No Trigger	No Trigger
22	11/13/2006	3:57 PM	0.0100	<100
23	11/21/2006	5:03 PM	0.0100	<100

Blast distances varied from 3,514 to 4,514 feet at portal 2A. Seismic data from June 19 to November 21, 2006:

SHOT #	DATE	TIME	PPV (IPS)	AIRBLAST (dB)
1	6/19/2006	1:01 PM	0.0050	106
2	6/22/2006	12:48 PM	0.0050	**106**
3	7/10/2006	1:36 PM	**0.0075**	<100
4	7/11/2006	2:45 PM	No Trigger	No Trigger
5	7/13/2006	3:35 PM	No Trigger	No Trigger
6	7/18/2006	3:50 PM	No Trigger	No Trigger
7	7/27/2006	5:28 PM	No Trigger	No Trigger
8	8/2/2006	2:51 PM	No Trigger	No Trigger
9	8/10/2006	2:43 PM	No Trigger	No Trigger
10	8/21/2006	2:58 PM	No Trigger	No Trigger
11	9/7/2006	2:39 PM	No Trigger	No Trigger
12	9/13/2006	2:47 PM	No Trigger	No Trigger
13	9/18/2006	11:21 AM	No Trigger	No Trigger
14	9/20/2006	11:25 AM	No Trigger	No Trigger
15	9/22/2006	1:05 PM	No Trigger	No Trigger
16	9/27/2006	1:34 PM	No Trigger	No Trigger
17	10/9/2006	5:06 PM	No Trigger	No Trigger
18	10/11/2006	3:14 PM	No Trigger	No Trigger
19	10/16/2006	5:03 PM	0.0063	106
20	11/3/2006	3:02 PM	No Trigger	No Trigger
21	11/8/2006	1:38 PM	No Trigger	No Trigger
22	11/13/2006	3:57 PM	No Trigger	No Trigger
23	11/21/2006	5:03 PM	No Trigger	No Trigger

These recordings show that the maximum ground vibration as of November 21, 2006, at either mine portal is 0.0225 ips. Since a maximum blast vibration level of 0.30 ips is allowed at the portal for compliance, the scaled distance formula is a very conservative blast design criteria to protect the portal openings.

Existing Bat Research

During research, the following relevant information was found:

1) **Maximum blasting vibrations that would maintain roof integrity.**

David Siskind's book titled "Vibrations From Blasting" had very encompassing information on maximum blasting vibrations and underground mine roof failures. Dr. Siskind evaluated nine separate studies from the United States, India, and South Africa. These studies included coal and hard rock. He declares:

> "There is much variation between the structure and geologic conditions represented by the nine studies (and 12 sites) detailed above. A general observation is that major failure such as roof collapse and pillar failure would require vibrations greater than about 12 in/s. In some cases, loose pieces were dislodged at lower vibration levels of about 1.2 to 5 in/s. Low-level vibrations, certainly below 1.0 in/s, have been found to be totally harmless to underground workings, even active ones where rockfalls are a personal hazard." [3]

2) **Distances that bats migrate underground for hibernation.**

Temperature, humidity, and airflow levels generally determine how far bats migrate underground for hibernation. Temperatures need to range from 37° to 43° F and have an average relative humidity of 87%. Only two references could be found that documented distances that hibernating bats were found underground. The first was a report written by Dr. Richard F. Myers, in 1975 titled "Effect of Seismic Blasting on Hibernating *Myotis Sodalis* and Other Bats".[4] Dr. Myers' winter study in east-central Missouri determined that several bat clusters were found anywhere from the cave entrance to 500 feet inside the limestone cave. The other reference was from a 2005 winter bat survey performed at Greer Lime's Hellhole Cave in Pendleton County, West Virginia. Figure 7 reveals that bats had migrated up to 614 linear feet from the limestone cave opening. Discussions with Alan Hicks, biologist with the New York State Department of Environmental Conservation, revealed that endangered bats migrated up to 2,300 feet in abandoned iron ore mines in New York.

Little has been published on vibration levels that might awaken bats during their hibernation period. Dr. Myers report concluded,

> "There is no evidence from this study that blasting of the type and magnitude used here, as close as 120 m (394') to M. *sodalis* and 30 m (98') to P. *subflavus*, is disturbing to these species during hibernation. Nor is there reason to think other types of blasting in which PPV reaches 0.02 ips will affect them. The presence of humans was the most disruptive force acting upon the bats during the study." [4]

This study was disputed by Alan Foster, of Vibra-Tech Engineers, Inc., after his study at Germany Valley Limestone (Greer Lime Hellhole Cave) in 1985. Mr. Foster states,

> " … there is very little source data available to enable us to determine what vibration levels can be expected to disturb the hibernating bats. The one published paper; 'Effect of Seismic Blasting on Hibernating *Myotis Sodalis* and other Bats' 1975 by Richard F. Myers, simply states that the bats were not disturbed at 0.02 inches per second. This is an unrealistic criteria since no disturbance was noted and in the same report it states that four people walking within 6' of the geophone produced levels of 0.055 inches per second."[5]

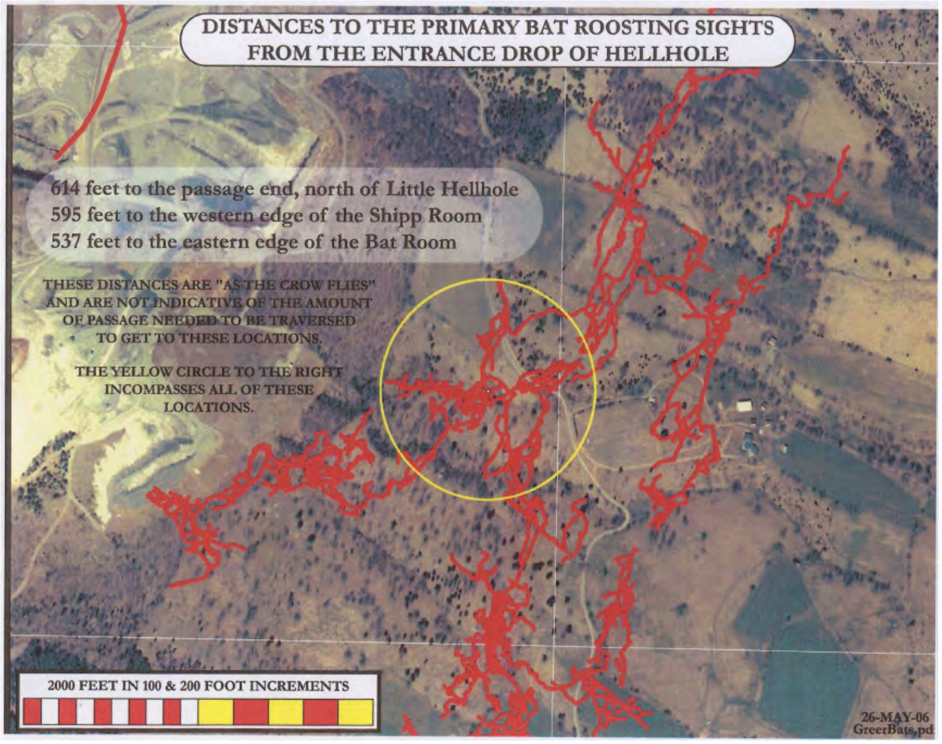


Figure 7. Distance to Primary Bat Roosting Sites from Entrance Drop of Hellhole Cave.

Mr. Foster also references the “Glen Park Hydroelectric Project”, a study conducted in Watertown, New York, by James A. Besha P.E., by saying,

> “Another unpublished study, carried out by Glen Park Associates, on a hydroelectric project in Watertown, NY, involved the video taping of bats using infra-red lights during a period from January to May, 1985. All blasts were monitored at the cave entrance and peak levels of up to 0.20 inches per second were recorded. … This more relevant data tends to indicate that 0.20 inches per second as recorded at the cave entrance, is a more practical lower limit since it has been shown to cause no disturbance to the Watertown bats.”[5]

The “Glen Park Hydroelectric Project” study states,

> “As reported in the Conservationist (Nye), a habitat of *Myotis* is located in the Jamesville area near Syracuse in a limestone formation that has been under continuous quarrying activity by the Allied Chemical Corp. since 1920. This quarrying activity involves blasting of all types. Loading limits of 200 pounds of explosive per delay as close as 1,000 feet from the caves during the winter are common. Observers have recorded PPV of 0.05 ips 1,400 feet from the blast site. The habitat is located 1,000 feet from the quarrying operation, thus seismic velocities are certainly higher at the caves. It is extrapolated that the PPV at the caves is no less than 0.25 ips. … There has been no decrease in the population at Jamesville since observations began in 1969 (Hicks) recent observations since 1977 have found increasing number of bats.”[6]

This same bat study concludes in the Blast Plan,

> “Based upon the experience of [Richard] Myers, the observations at the Jamesville site, and the Off Site test blast program, a limitation of 0.10 inches per second of peak particle velocity is planned.”[6]

Another method to determine vibration levels that disturb hibernating bats is an attempt to correlate blast log and seismic recordings with bat survey data. Information from Vibra-Tech Engineers report in 1985, blast log and seismic records from 2004 through 2005, and data from a winter bat study at Greer Lime Hellhole Cave in Pendleton County, West Virginia, were analyzed. Although many blasts were conducted, there were numerous no triggers recorded at the Hellhole site.

Vibra Tech Seismic Data – Hellhole Cave			
DATE	SCALED DISTANCE	SURFACE PPV (IPS)	SUB-SURFACE PPV
8/13/1985	129	0.05	0.03
8/14/1985	100	0.10	0.05
8/15/1985	98	0.10	No Recording
8/16/1985	102	0.05	0.0375
8/21/1985	99	0.12	0.0435
8/28/1985	133	0.12	No Recording
9/5/1985	94	0.07	No Recording
9/10/1985	101	0.07	No Recording
9/26/1985	162	0.02	No Recording

2004-2005 Greer Lime Seismic Data – Hellhole Cave		
DATE	SCALED DISTANCE	SURFACE PPV (IPS)
1/8/2004	106	0.10
1/12/2004	327	0.01
1/23/2004	323	0.01
1/29/2004	107	0.10
2/19/2004	175	0.06
2/27/2004	173	0.06
3/26/2004	176	0.06
4/5/2004	98	0.16
5/11/2004	80	0.16
4/13/2005	212	0.04

Regression analysis of the data determined its validity as a predictive model for various scaled distances. This is important for predicting surface blast vibrations in areas directly over bat nesting areas of the cave system.

As seen in Figure 8, a minimum of 0.70 has been obtained as a correlation coefficient (R^2). Although only 19 surface data sets were obtained, it is felt that the calculated regression surface equation has some validity as a predictive model.

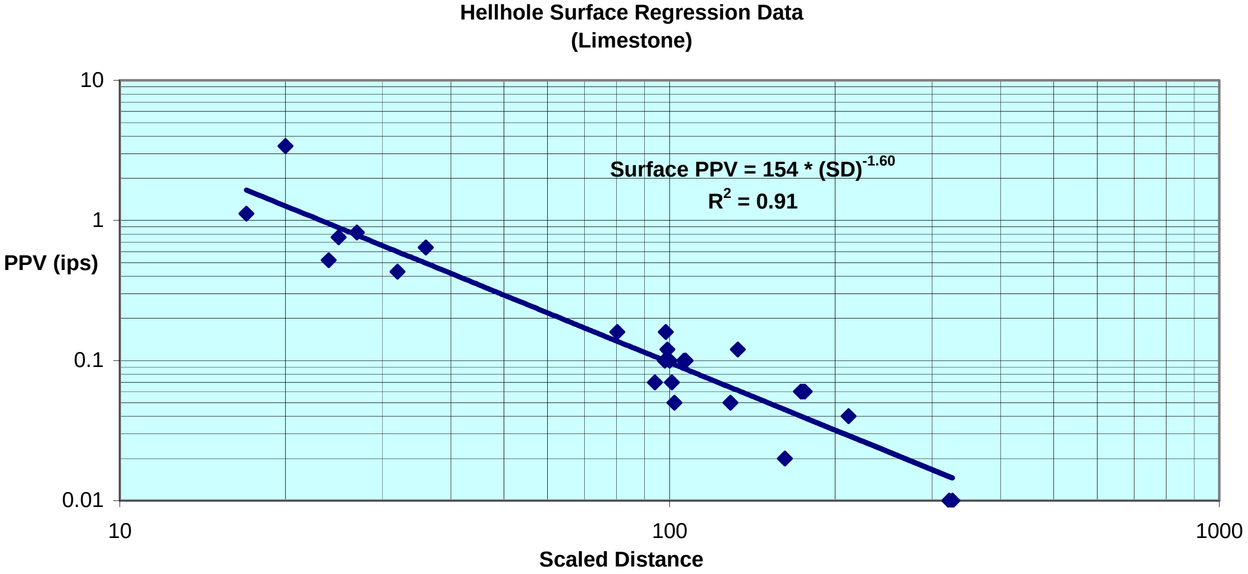


Figure 8. Hellhole Cave Data.

Figure 7 shows that the endangered bats are roosting approximately 537 to 614 feet farther than the seismograph locations.

Using the predictive equation of $154 * (D / W^{.5})^{-1.6}$ where:

D = Seismograph distance from the blast
W = Maximum pounds per delay detonated within an 8-millisecond delay period

Calculations can now be made to predict the surface ground vibrations at a point 614 feet from than the cave openings. For the blast of May 11, 2004,with a scaled distance of 80 and a recording of 0.16 ips at the cave opening, 614 feet away would equate to a surface vibration of 0.081 ips.

Another potential set of valuable data is subsurface ground vibration measurements and corresponding surface vibrations. The table "Vibra Tech Seismic Data – Hellhole Cave" reveals that underground measurements are 1.33 to 2.76 times less than surface measurements. The predicted 0.081 ips surface vibration would now indicate a subsurface vibration level of 0.03 to 0.06 ips.

During the winter of 2005, a bat survey was conducted at Hellhole Cave by the West Virginia Division of Natural Resources (WVDNR) and included participants such as FWS and consultants with bat expertise. This report concluded that between 2001 and 2005, the Indiana bat population increased from 8,566 to 11,890 bats. The Virginia big-eared bat increased from 5,286 to 5,359 bats over the same time period. It is surmised from the analyzed data and research that endangered bat populations can prosper even when exposed to blasting vibration levels of 0.06 to 0.20 ips. According to FWS, hibernating bats awaken every 8 to 10 days to join small bat clusters or fly about elsewhere in the cave. Vibration level intensities necessary to waken a bat during this sleep cycle would vary.

Underground/Surface Geophone Data

To establish the relationship between surface and subsurface ground vibration differences, research was conducted at both an active underground and a surface mine. Initial discussions with mine managers conducted in May, 2006, established a research location. Coordinates were obtained for an existing underground geophone being used as a compliance point for the active underground mine. A surface seismograph geophone was placed directly above the underground geophone using these same coordinates. Fortunately, the surface location was not in the path of surface production blasting or excavation operations. The surface geophone was kept at this location from May 3, 2006 until June 13, 2006. Three events were recorded on the surface and underground geophones during this period. The seismic trigger information is as follows:

DATE	SURFACE EVENT (PPV)	UNDERGROUND EVENT (PPV)	SURFACE/UNDERGROUND RATIO
5/16/2006	0.220	0.060	3.7x
5/18/2006	0.230	0.060	3.8x
5/22/2006	0.110	0.040	2.8x
		Average	**3.4x**

Because mining was progressing away from the seismographs, it was decided to establish a new OEB surface and underground geophone location for research purposes. On July 13, 2006, geophones were placed vertically in-line with each other (Figure 9 and 10).

Figure 9. Surface Geophone Location.

Figure 10. Underground Geophone Location.

Underground seismic trigger levels were reduced to 0.005 ips to ensure as many blasts as possible were recorded. From July 13, 2006 to November 13, 2006, a total of 40 surface and underground blast events were recorded. They are as follows:

DATE	SURFACE EVENT (PPV)	UNDERGROUND EVENT (PPV)	SURFACE/UNDERGROUND RATIO
7/13/2006	0.095	0.020	4.8x
7/17/2006	0.235	0.030	7.8x
7/20/2006	0.110	0.028	5.5x
7/25/2006	0.155	0.033	4.7x
8/2/2006	0.140	0.030	4.7x
8/4/2006	0.120	0.020	6.0x
8/8/2006	0.145	0.038	3.8x
8/9/2006	0.025	0.005	5.0x
8/10/2006	0.025	0.010	2.5x
8/16/2006	0.080	0.025	3.2x
8/18/2006	0.020	0.005	4.0x
8/21/2006	0.065	0.018	3.6x
8/24/2006	0.020	0.005	4.0x
8/25/2006	0.055	0.015	3.7x
8/28/2006	0.120	0.048	2.5x
8/29/2006	0.075	0.020	3.8x
8/31/2006	0.235	0.058	4.0x
9/5/2006	0.020	0.008	2.5x
9/6/2006	0.210	0.033	6.4x
9/7/2006	0.020	0.010	2.0x
9/11/2006	0.025	0.008	3.1x
9/12/2006	0.400	0.085	4.7x
9/15/2006	0.300	0.058	5.2x
9/18/2006	0.115	0.023	5.0x
9/19/2006	0.165	0.028	5.9x
9/21/2006	0.088	0.028	3.1x
10/17/2006	0.050	0.010	5.0x
10/18/2006	0.090	0.018	5.0x
10/19/2006	0.030	0.013	2.3x
10/20/2006(1)	0.500	0.095	5.3x
10/20/2006(2)	0.020	0.008	2.5x
11/9/2006	0.030	0.010	3.0x
11/13/2006	0.030	0.010	3.0x
11/14/2006(1)	0.035	0.013	2.8
11/14/2006(2)	0.100	0.020	5.0
11/15/2006	0.020	0.008	2.7
11/20/2006	0.120	0.023	5.3
11/21/2006	0.085	0.020	4.3
11/27/2006	0.170	0.025	6.8
11/28/2006	0.105	0.013	8.4
		Average	**4.3x**

Figure 11 depicts the surface blast locations in the above table from August 25 to October 20, 2006, in relation to the underground seismograph geophone locations and coal pillars.

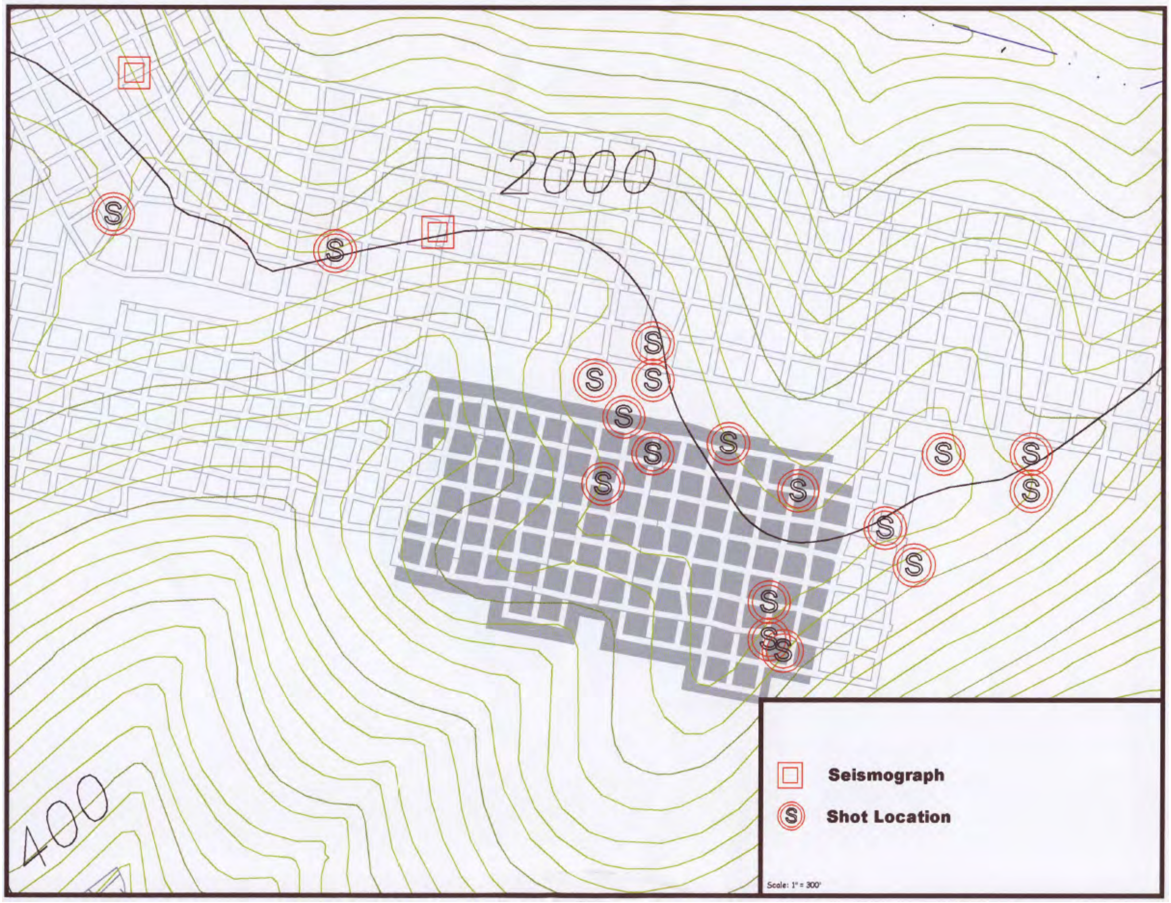


Figure 11. Surface Blast Locations, August 25 – October 20, 2006.

By plotting the surface PPV recordings versus the corresponding underground PPV measurements, a linear trend line can be created (Figure 12). This trend line allows the prediction of underground roof vibrations based on surface vibration levels of 0.50 ips or less.

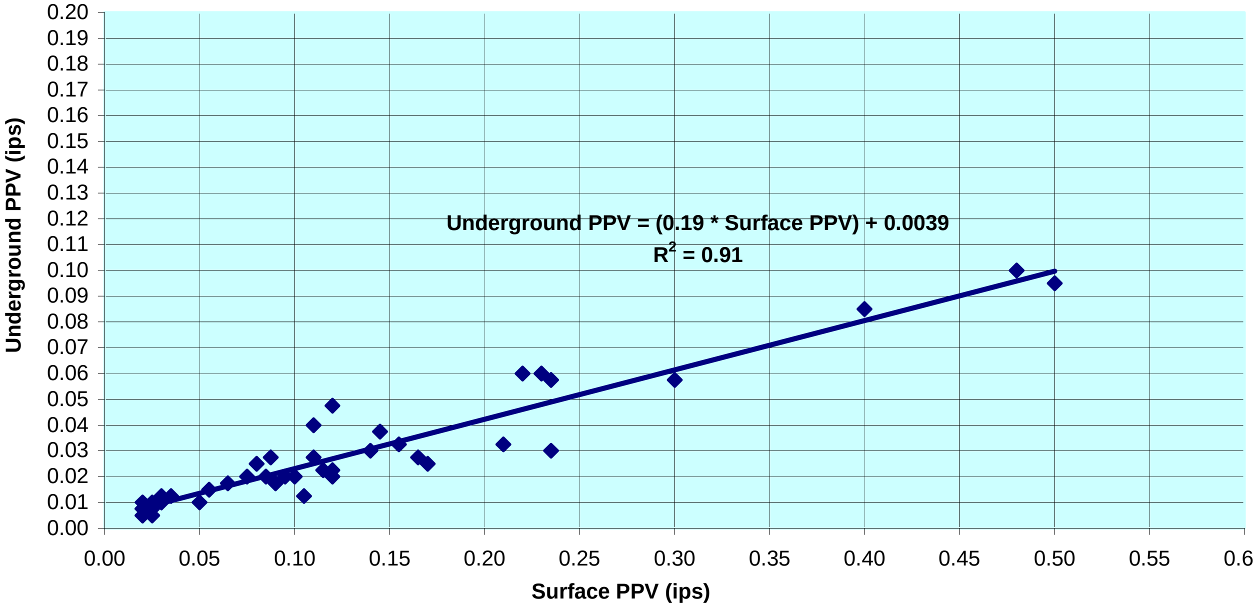


Figure 12. Active Surface vs Underground PV.

Reasons for the difference between Hellhole cave and coal mine ratio levels are thought to be from:

- Larger vibration data sets for the active surface and underground mine;
- Differences in geophone placement - Hellhole Cave had the subsurface geophone coupled to the cave entrance floor, while the active mine geophone was bolted directly to the mine roof. A 1980 report from Hayatdavoudi and Brown states:

  > "During the course of investigation, seismic monitoring had to be standardized. In essence, several places in the underground mine were investigated for instrumentation. Later on, it was found that monitoring of pillars and mine floor vibration should be avoided and the best place that gave the highest response was found to be the center of crosscuts."[7]

- Strata type and thickness were varied. Hellhole Cave seismic responses were measured in limestone to an approximate vertical difference of 190 feet. The active coal mine seismic events were measured through sandstone, shale, and coal layers to a depth of 376 feet. This is shown in the table below; and
- Differences between quarrying and surface mine blasting techniques.

MATERIAL	THICKNESS (FT.)	TOTAL FT.
Sandstone	30	30
Sandy Shale	4	34
Sandstone	4	38
Coal, Upper Kittaning	2	40
Sandstone	5	45
Coal, Middle Kittaning	2	47
Sandstone	20	67
Coal, Middle Kittaning Rider	5	72
Shale	3	75
Sandy Shale	27	102
Sandstone	16	118
Coal, Lower Kittaning Rider	2	120
Sandy Shale	10	130
Shale	22	152
Coal, Lower Kittaning	4	156
Sandstone	80	236
Shale	6	242
Sandy Shale	6	248
Sandstone	16	264
Coal, Stockton	10	274
Sandstone	46	320
Sandy Shale	11	331
Sandstone	45	376

Other research on surface to underground vibration ratios reflected in the following table are varied because of many blasting, seismic, and geologic variables. This type of research could be enhanced by studies conducted at other surface and underground operations with different rock strata and thicknesses.

OTHER SURFACE / UNDERGROUND PPV RATIO RESEARCH			
MINE TYPE	**GEOPHONE LOCATION**	**VERTICAL DISTANCE**	**SURFACE / UNDERGROUND RATIO**
Coal[8]	Mine roof and rib	160’	Avg. 2.4
Limestone[9]	Inside Borehole	50’	Avg. 2.0
Coal[10]	Mine rib	100’-187’	1.26 – 2.99

Research Findings

OEB research revealed that surface seismographs would record ground vibrations at a level of 2.0 to 7.8 times higher than underground vibrations. To calculate theoretical vibrations on the Fire Creek mine roof, surface seismograph units were placed at various distances from the blasts to generate data used for regression analysis. Data from the mine portals were also used in the analysis. A regression analysis on 44 seismic data points can be used to predict surface vibrations at various distances from the blast site. The regression curve is shown in Figure 13.

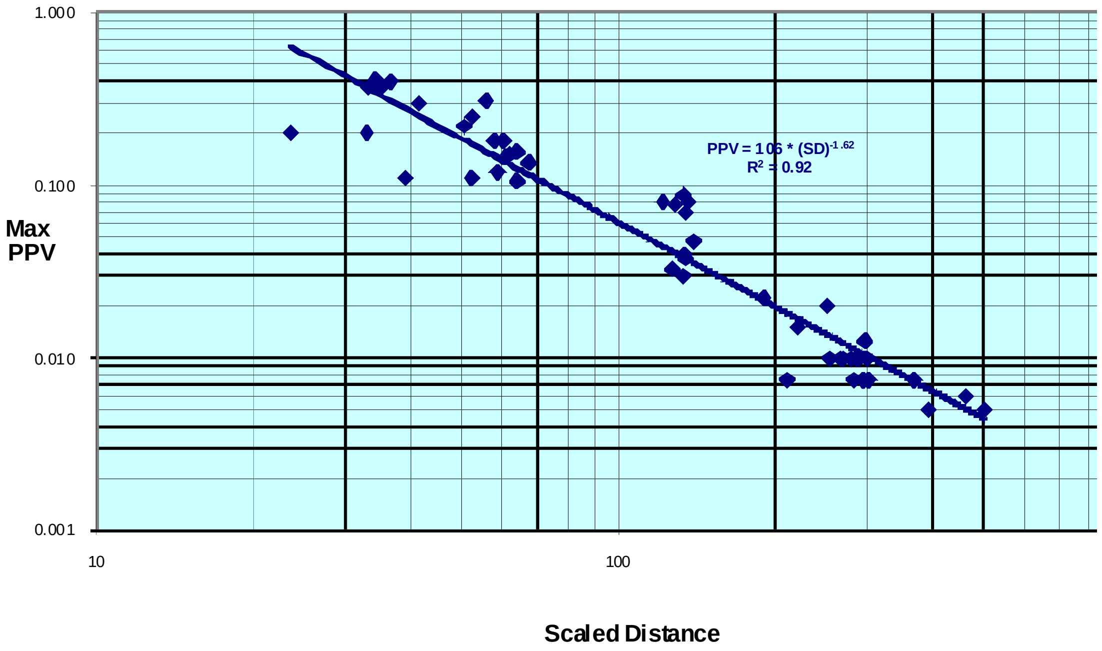


Figure 13. Regression Analysis – NPS, June 19 – November 21, 2006.

The graph indicates several important parameters. Mainly, with an R^2 of 0.92, the data is of sufficient quality and quantity to use as a predictor of blast vibrations at this site.

Using the predictive equation (PPV = 106*$(SD)^{-1.62}$), current surface blasting near the NPS using a maximum of 100 pounds per delay, would calculate a surface vibration of 0.065 ips at 959 feet from the permitted area (approximate extent of the bat hibernacula). Using the underground predictive equation 0.19 * surface vibration + .0039, a value of 0.016 ips is calculated for a roof vibration.

A maximum of 0.41 ips was recorded on during a blast on July 13, 2006. Seismograph location was 306 feet from the blast and 1,887 feet from portal 2D. Based on calculations using this data, should the bats hibernate more than 1,887 fee from the portal opening, a roof vibration of 0.082 ips is predicted.

Under the premise that hibernating bats can withstand vibration levels of up to 0.20 ips, this research implies not only is the scaled distance formula adequate to protect the immediate Fire Creek roof, but that current blasting would not affect hibernating bats. This scenario is depicted in Figure 14.

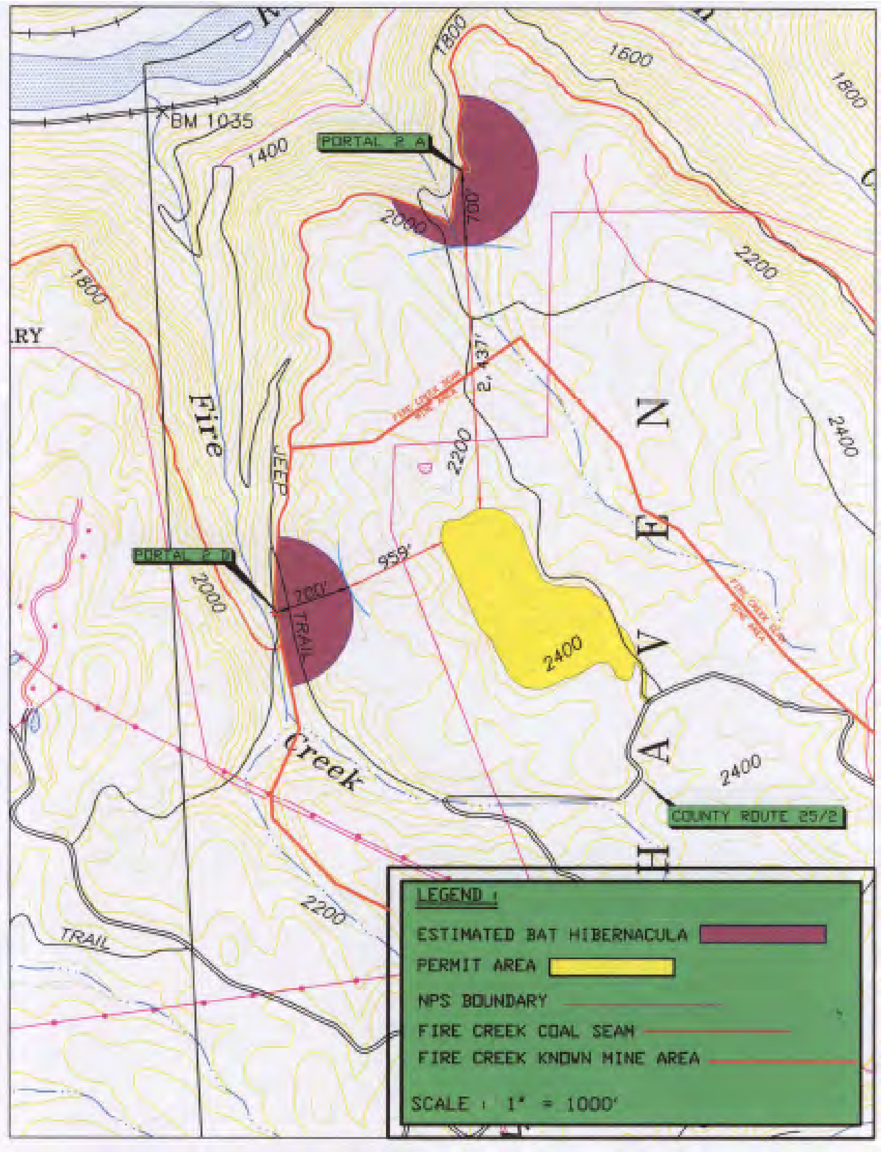


Figure 14.

Conclusions

Information concerning blasting vibrations and bat hibernacula is very scarce. OEB research indicates:

- As proposed by the permittee in the Blast Plan, scaled distance is more than adequate for compliance at New River Gorge National River Park portals and will protect the integrity of the abandoned underground coal mine roofs (bat hibernacula). The scale distance formula is also sufficient for protecting hibernating bats that may migrate up to 1,877 feet into the Fire Creek seam.

- The immediate Fire Creek roof should not be jeopardized by vibration levels of 1.00 ips;

- Per OEB data, underground vibration levels are 2.0 to 7.8 times less than surface vibration levels. A predicted linear equation for underground PPVs [0.19 * (surface vibration) + 0.0039] was generated for surface vibrations of less than 0.50 ips;

- Hibernating bats may withstand vibration levels of 0.06 to 0.20 ips (Hellhole and Watertown conclusions) without adverse effects; and

- Bats have migrated up to 2,400 feet in abandoned iron ore mines. In West Virginia limestone caves, bats have migrated up to 614 linear feet into their hibernacula.

Research collected for this project will also have great benefit for site-specific blast plans submitted to OEB by surface coal operators. These site-specific blast plans are required when blasting within 500 feet of active underground operations.

Currently, the coal mine permittee mentioned in this report has submitted a Surface Mining Application for mining near other bat hibernacula near the New River Gorge National River Park. A worthwhile endeavor might be a collaborative effort between OEB, the permittee, NPS, FWS, and OSM on effects of surface blasting on endangered bat populations. It is assumed this project would be one to two years in length.

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3) “Vibrations from Blasting”: 2000. D. Siskind. International Society of Explosives Engineers. Pages 77, 78.

4) “Effect of Seismic Blasting on Hibernating *Myotis Sodalis* and Other Bats”: 1975. R. Myers, Ph. D.

5) vibra-tech engineers incorporated: “Germany Valley Limestone, Inc.”. 1985. G. A. Foster. Page 3

6) “Glen Park Hydroelectric Project, Supplemental Report, Article 34, Indiana Bat Monitoring Requirements”: 1984. J. Besha, P.E. Pages 5, 9

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9) “Blast Vibration Effects Upon a Deep Injection Well and the Reduction of Ground Vibration Over Depth”: 1994. J. A. Straw and J. P. Shinko, Jr. Page 36

10) “Vibration Characteristics on Surface and in Underground Openings from Opencast Mine Blasting”: 2006. P. K. Singh and M. P. Roy. The Journal of Explosives Engineering. Page 18

Jim Ratcliff is the program Manager for the West Virginia DEP Office of Explosives and Blasting (WVOEB). He started with the WVOEB in January 2002. He is responsible for conducting surface mine blasting research for the state. He serves as a blasting expert for the agency and is manager and instructor over the WV Surface Mine Blaster Certification program. He has 25 years of mining experience serving in various positions in the operations and engineering aspects of the industry. He holds a BS Degree in Mining Engineering from West Virginia Institute of Technology.

Surface Mine Blasting Effects on Underground Bat Habitat

Presented by Jim Ratcliff, WVDEP,
Office of Explosives and Blasting

Concerns with blasting on a West Virginia surface mine and impacts on possible bat hibernaculum.

- 2006 permit issues on a proposed 16 acre surface coal mine permit, located in Fayette County, WV near New River Gorge, National Park Service (NPS).
- Abandoned underground coal mine with extensive works in the Fire Creek seam below the surface mine.
- NPS and US Fish & Wildlife raised concerns that the old underground mine works potentially harbored endangered Indiana bats, because they were documented in area.
- Surface mine was located on private property, however the mine portals of the old mine works were located on park property.

Surface Mine Background Information

- This proposed surface mine involved reclaiming an old pre-law high wall on abandoned surface mine site.
- The surface mine was in the final stages of the permitting process when issues arose.
- Permit was appealed with protection of the bats the key issue at underground mine.

Species of endangered bats in West Virginia that were a concern in area

- Indiana (Myotis sodalis)
- Virginia big-eared (Corynorhisus townsendii virginianus)

Agencies involved and concerned about blasting near bat hibernaculum

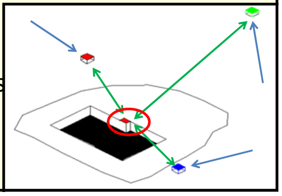
- National Park Service (NPS)
- Fish and Wildlife Service (FWS)
- Office of Surface Mining and Reclamation (OSM)
- West Virginia Dept of Environmental Protection - Office of Explosives and Blasting (WVDEP/OEB)

Blast Ground Vibrations - Basics

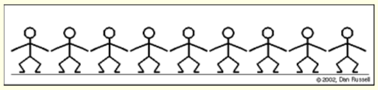
- Ground Vibrations from a blast are a function of the **amount of explosives used per delay** and,
- the **distance** from the blast to a specific structure.
- Vibrations have a **frequency** component resulting from the delay interval between charges.
- Blast vibration is characteristic of a **particle oscillation**, back & forth across a central position, much like a cork floating in a ocean wave.
- The **wave decays or dissipates with distance** or with disruption of the transference medium.

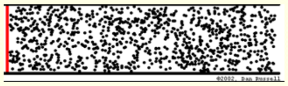
What are the Most Important Parameters in Evaluating Blasting Effects?

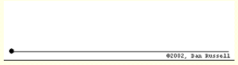
- Location of the blast
- Location of the compliance structure(s)
- Distance between the structure(s) and blast
- Charge weight per delay
- Shot Confinement
- Type of blast
- Geological characteristics



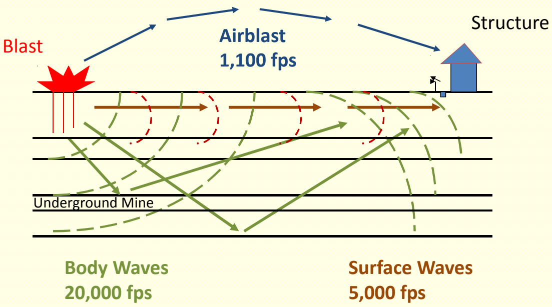
Examples of vibrations, particle waves traveling through a medium







Vibration Energy



Scaled Distance Equation or PPV

WV and Federal law stipulate minimum ***scaled distance factors*** and use of a ***scaled distance formula*** to be used for the protection of structures.

OR

Monitor the blast vibration with a **blasting seismograph at the structure** to insure the blast vibrations do not exceed the allowable limits, measured in peak particle velocity (PPV)

Scaled Distance Equation

$$\boxed{W} = (\boxed{D} / \boxed{SD})^2$$

Where,

W = Maximum weight explosive per 8ms delay (lbs)

D = Distance from the blast to structure (ft)

SD = Scaled Distance (factor)

Ground Vibration Criteria

Distance	SD	PPV (ips)
0 - 300	50	1.25
301 - 5000	55	1.00
5001 - greater	65	0.75

For perspective, the blast plan used the agreed limit of **0.3 ips** (inches per second) for the portals and SD formula for the underground bat hibernaculum.

Examples Using Scaled Distance Formula for Max. Weight Explosives

$$\mathbf{W = (D/SD)^2}$$

$W = (295 \text{ ft} /50)^2 =$ ☐ lbs/delay

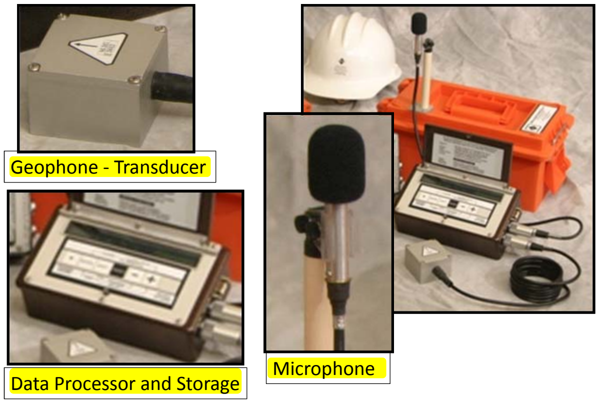
$W = (1100 \text{ ft} /55)^2 =$ ☐ lbs/delay

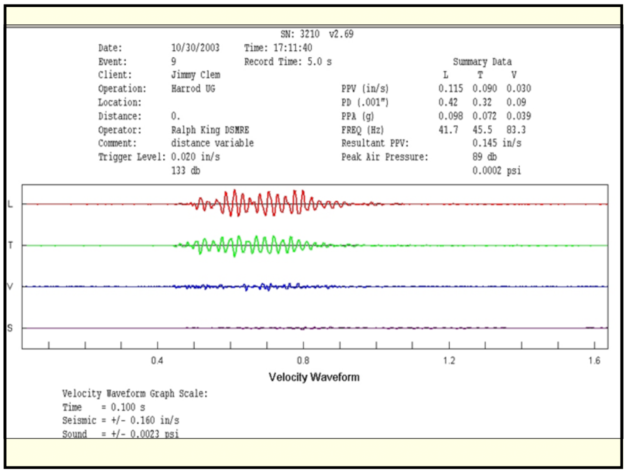
$W = (5010 \text{ ft} /65)^2 =$ ☐ lbs/delay

Parameters Affecting Charge Weight per Hole

- Borehole Diameter
- Borehole Height
- Type of Explosive
- Density of Explosive
- Amount of Stemming/Decking

Blasting Seismograph

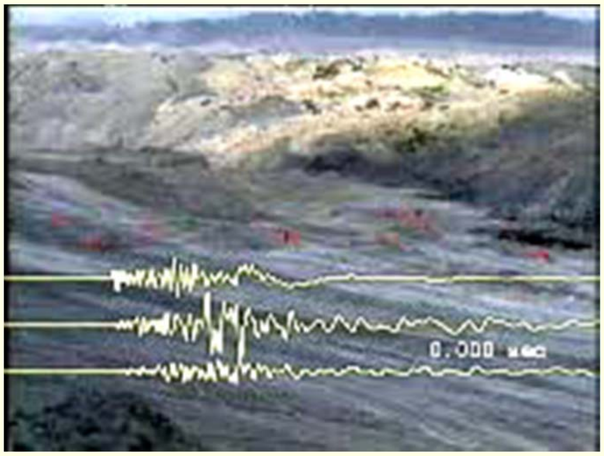


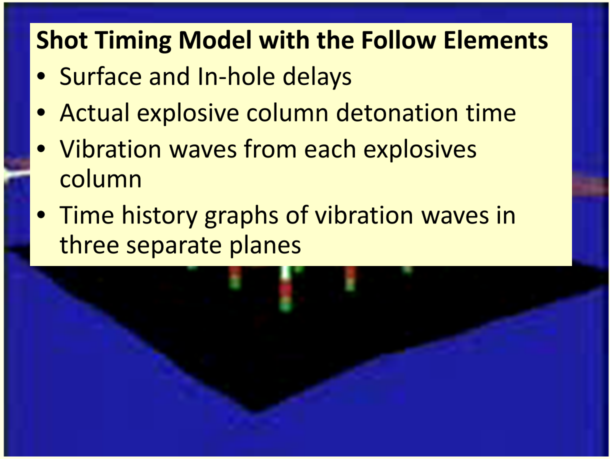


```
                         SN: 3210  v2.69
Date:          10/30/2003   Time: 17:11:40
Event:         9            Record Time: 5.0 s                    Summary Data
Client:        Jimmy Clem                                       L      T      V
Operation:     Harrod UG                   PPV (in/s)         0.115  0.090  0.030
Location:                                  PD (.001")         0.42   0.32   0.09
Distance:      0.                          PPA (g)            0.098  0.072  0.039
Operator:      Ralph King DSMRE            FREQ (Hz)          41.7   45.5   83.3
Comment:       distance variable           Resultant PPV:            0.145 in/s
Trigger Level: 0.020 in/s                  Peak Air Pressure:        89 db
               133 db                                                0.0002 psi
```

Velocity Waveform

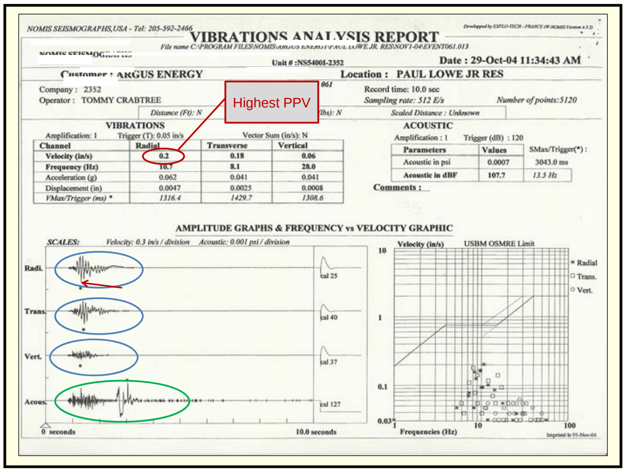
```
Velocity Waveform Graph Scale:
Time    = 0.100 s
Seismic = +/- 0.160 in/s
Sound   = +/- 0.0023 psi
```





Shot Timing Model with the Follow Elements

- Surface and In-hole delays
- Actual explosive column detonation time
- Vibration waves from each explosives column
- Time history graphs of vibration waves in three separate planes



NOMIS SEISMOGRAPHS,USA - Tel: 205-592-2466

Developped by EXPLO-TECH - FRANCE (W-NOMIS Version 4.5.2)

VIBRATIONS ANALYSIS REPORT

File name C:\PROGRAM FILES\NOMIS\ARGUS ENERGY\PAUL LOWE JR. RES\NOV1-04\EVENT061.013

NOMIS SEISMOGRAPHS

Unit # :NS5400I-2352

Date : 29-Oct-04 11:34:43 AM

Customer : ARGUS ENERGY

Location : PAUL LOWE JR RES

Company : 2352

Operator : TOMMY CRABTREE

061

Record time: 10.0 sec

Sampling rate: 512 E/s

Number of points:5120

Distance (Ft): N

(lbs): N

Scaled Distance : Unknown

Highest PPV

VIBRATIONS

Amplification: 1 Trigger (T): 0.05 in/s Vector Sum (in/s): N

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.2**	**0.18**	**0.06**
Frequency (Hz)	**10.7**	**8.1**	**28.0**
Acceleration (g)	0.062	0.041	0.041
Displacement (in)	0.0047	0.0025	0.0008
*VMax/Trigger (ms) **	*1316.4*	*1429.7*	*1308.6*

ACOUSTIC

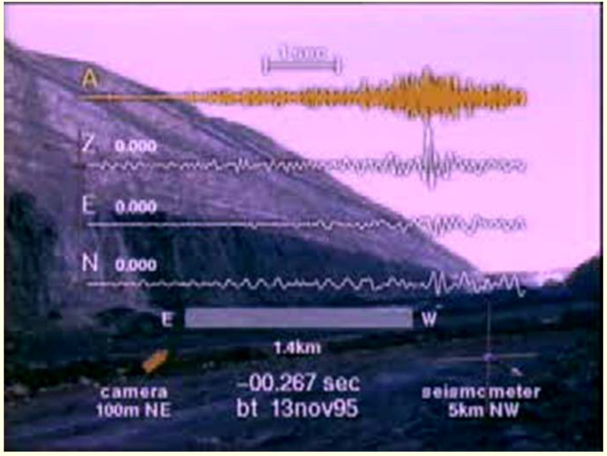
Amplification : 1 Trigger (dB) : 120

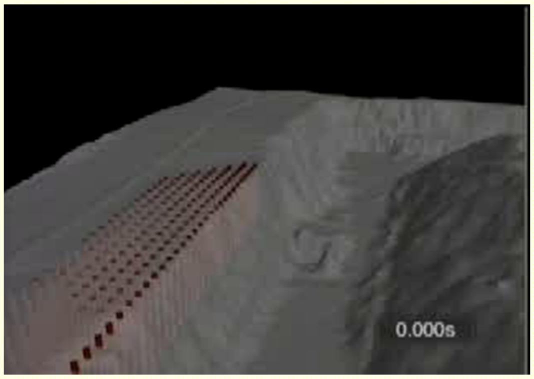
Parameters	Values	SMax/Trigger(*) :
Acoustic in psi	0.0007	3043.0 ms
Acoustic in dBF	**107.7**	*13.5 Hz*

Comments :

AMPLITUDE GRAPHS & FREQUENCY vs VELOCITY GRAPHIC

SCALES: *Velocity: 0.3 in/s / division* *Acoustic: 0.001 psi / division*

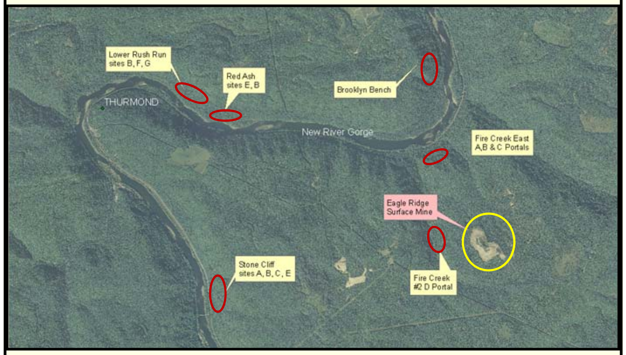




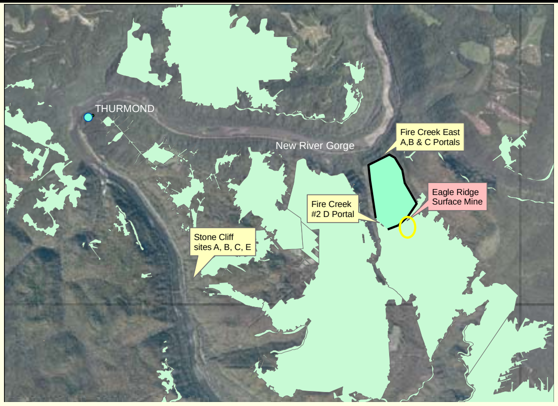
Blasting Vibration Concerns at the Proposed Surface Mine and Impacts on Bats

- Damage potential to mine portal entrances.
- Mine roof collapse adversely impacting bat habitat.
- Partial mine roof collapse disrupting air-flow.
- Vibrations disturbing hibernating bats resulting in energy loss and starvation.

General location of surface mine relative to the NPS boundary.

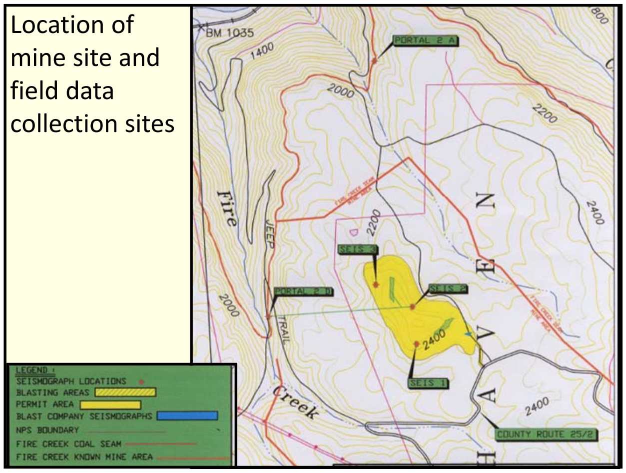


Eagle Ridge Mine and old mine portal locations that were being used by various species of bats based on 2002 and 2005 inventories, near the town of Thurmond and New River Gorge National River Park.



Existing mapping of Fire Creek old mine works.

Location of mine site and field data collection sites

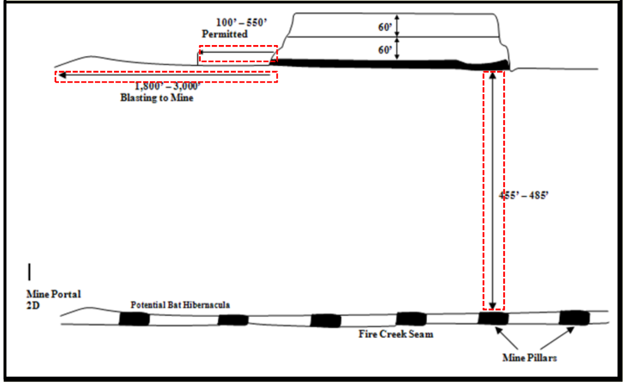


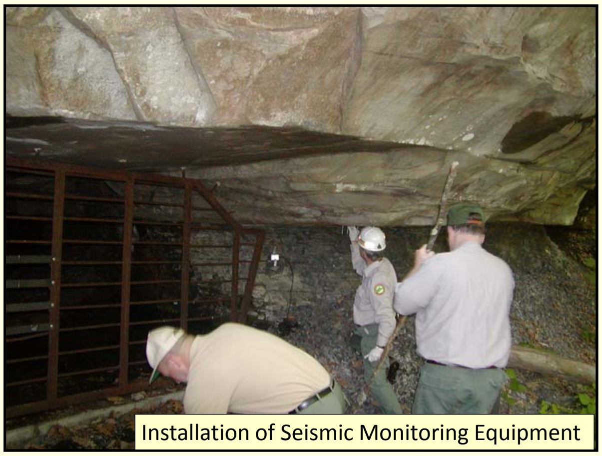
Bat Gate on Portal Entrance

View of Mine at Portal Opening

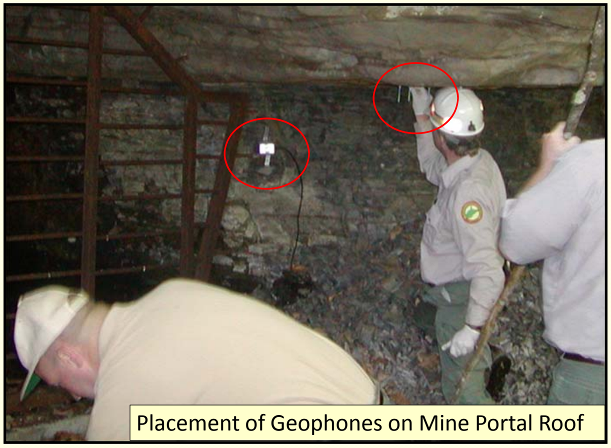
View of Mine at Portal Opening

Relationship of Fire Creek Mine to the Proposed Surface Mine

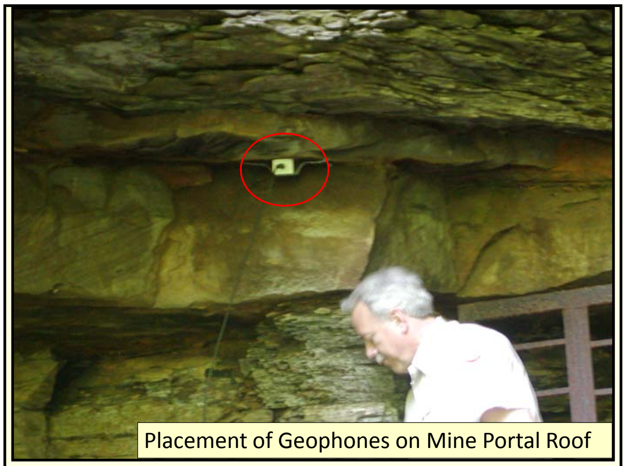




Installation of Seismic Monitoring Equipment



Placement of Geophones on Mine Portal Roof



Placement of Geophones on Mine Portal Roof

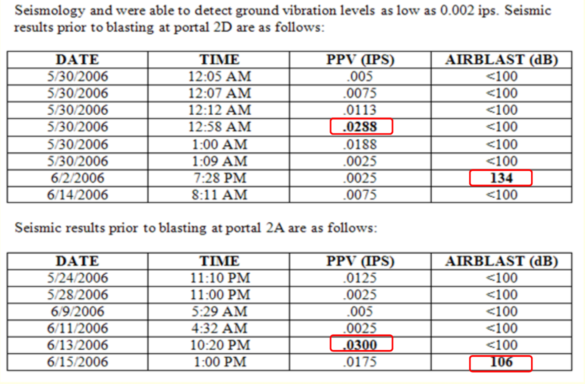
Geophone Bolted to Roof

Seismograph Locked to Bat Gate

Collection of Baseline Data

- Seismographs were put into place on May 24, 2006,
- Blasting did not begin until June 19, 2006.
- Baseline data was recorded to measure natural movement of the roof before blasting began.
- Low sensitivity seismographs able to detect ground vibration levels as low as 0.002 ips.
- Seismic data prior to blasting at portal 2D and 2A were recorded.

Baseline Data at Portal 2D and 2A



Seismology and were able to detect ground vibration levels as low as 0.002 ips. Seismic results prior to blasting at portal 2D are as follows:

DATE	TIME	PPV (IPS)	AIRBLAST (dB)
5/30/2006	12:05 AM	.005	<100
5/30/2006	12:07 AM	.0075	<100
5/30/2006	12:12 AM	.0113	<100
5/30/2006	12:58 AM	**.0288**	<100
5/30/2006	1:00 AM	.0188	<100
5/30/2006	1:09 AM	.0025	<100
6/2/2006	7:28 PM	.0025	**134**
6/14/2006	8:11 AM	.0075	<100

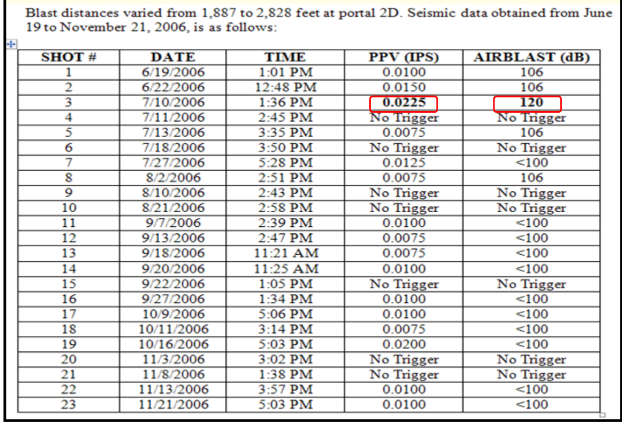
Seismic results prior to blasting at portal 2A are as follows:

DATE	TIME	PPV (IPS)	AIRBLAST (dB)
5/24/2006	11:10 PM	.0125	<100
5/28/2006	11:00 PM	.0025	<100
6/9/2006	5:29 AM	.005	<100
6/11/2006	4:32 AM	.0025	<100
6/13/2006	10:20 PM	**.0300**	<100
6/15/2006	1:00 PM	.0175	**106**

Blasting Plan for the Surface Mine

- OEB installed seismograph monitoring at two portal sites.
- Portal vibration limits not to exceed 0.3 ips.
- Abandoned Fire Creek U/G mine workings located 475 ft below the surface mine, will be considered a protected structure and protected by use of the Scaled Distance Formula.
- Continual monitoring at two portal sites for temperature outside and inside the mine openings.

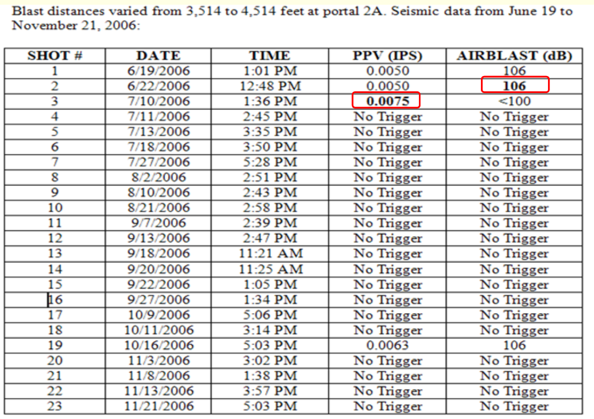
Portal 2D Seismograph Data - Blasting



Blast distances varied from 1,887 to 2,828 feet at portal 2D. Seismic data obtained from June 19 to November 21, 2006, is as follows:

SHOT #	DATE	TIME	PPV (IPS)	AIRBLAST (dB)
1	6/19/2006	1:01 PM	0.0100	106
2	6/22/2006	12:48 PM	0.0150	106
3	7/10/2006	1:36 PM	**0.0225**	**120**
4	7/11/2006	2:45 PM	No Trigger	No Trigger
5	7/13/2006	3:35 PM	0.0075	106
6	7/18/2006	3:50 PM	No Trigger	No Trigger
7	7/27/2006	5:28 PM	0.0125	<100
8	8/2/2006	2:51 PM	0.0075	106
9	8/10/2006	2:43 PM	No Trigger	No Trigger
10	8/21/2006	2:58 PM	No Trigger	No Trigger
11	9/7/2006	2:39 PM	0.0100	<100
12	9/13/2006	2:47 PM	0.0075	<100
13	9/18/2006	11:21 AM	0.0075	<100
14	9/20/2006	11:25 AM	0.0100	<100
15	9/22/2006	1:05 PM	No Trigger	No Trigger
16	9/27/2006	1:34 PM	0.0100	<100
17	10/9/2006	5:06 PM	0.0100	<100
18	10/11/2006	3:14 PM	0.0075	<100
19	10/16/2006	5:03 PM	0.0200	<100
20	11/3/2006	3:02 PM	No Trigger	No Trigger
21	11/8/2006	1:38 PM	No Trigger	No Trigger
22	11/13/2006	3:57 PM	0.0100	<100
23	11/21/2006	5:03 PM	0.0100	<100

Portal 2A Seismograph Data - Blasting



Blast distances varied from 3,514 to 4,514 feet at portal 2A. Seismic data from June 19 to November 21, 2006:

SHOT #	DATE	TIME	PPV (IPS)	AIRBLAST (dB)
1	6/19/2006	1:01 PM	0.0050	106
2	6/22/2006	12:48 PM	0.0050	**106**
3	7/10/2006	1:36 PM	**0.0075**	<100
4	7/11/2006	2:45 PM	No Trigger	No Trigger
5	7/13/2006	3:35 PM	No Trigger	No Trigger
6	7/18/2006	3:50 PM	No Trigger	No Trigger
7	7/27/2006	5:28 PM	No Trigger	No Trigger
8	8/2/2006	2:51 PM	No Trigger	No Trigger
9	8/10/2006	2:43 PM	No Trigger	No Trigger
10	8/21/2006	2:58 PM	No Trigger	No Trigger
11	9/7/2006	2:39 PM	No Trigger	No Trigger
12	9/13/2006	2:47 PM	No Trigger	No Trigger
13	9/18/2006	11:21 AM	No Trigger	No Trigger
14	9/20/2006	11:25 AM	No Trigger	No Trigger
15	9/22/2006	1:05 PM	No Trigger	No Trigger
16	9/27/2006	1:34 PM	No Trigger	No Trigger
17	10/9/2006	5:06 PM	No Trigger	No Trigger
18	10/11/2006	3:14 PM	No Trigger	No Trigger
19	10/16/2006	5:03 PM	0.0063	106
20	11/3/2006	3:02 PM	No Trigger	No Trigger
21	11/8/2006	1:38 PM	No Trigger	No Trigger
22	11/13/2006	3:57 PM	No Trigger	No Trigger
23	11/21/2006	5:03 PM	No Trigger	No Trigger

Blast Monitoring Results by OEB for Surface Mine near NRG area

- The OEB monitoring recorded a maximum ground vibration of .0225 ips.
- The maximum blast vibration level of 0.30 ips was not exceeded at the portal.
- The use of "scaled distance formula" was very conservative blast design criteria to protect the portal openings.
- For perspective, a earlier U/G study recorded people walking 6 ft from geophone produced vibrations at levels of .055 ips.

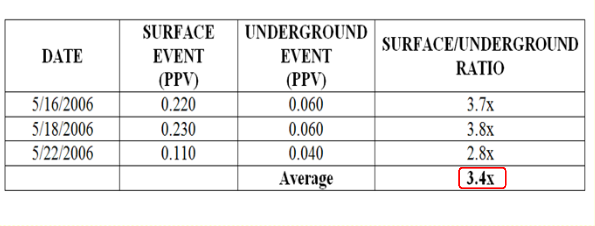
Comparison of Underground vs. Surface Geophones at Active U/G Mine

- Other ongoing OEB research during the same time looked at the relationship between *surface* and *subsurface ground* vibrations.
- Research was conducted at an active underground mine, with overlying active surface mine.
- There was an existing seismograph being used as a compliance point in an active underground mine.
- OEB established a surface monitoring point directly above this existing underground geophone.
- Monitoring at this location from May thru June 2006, resulted in only three events recorded.

Surface Mine Geophone Installation

Deep Mine Geophone Installation

Underground vs. Surface Geophone Data

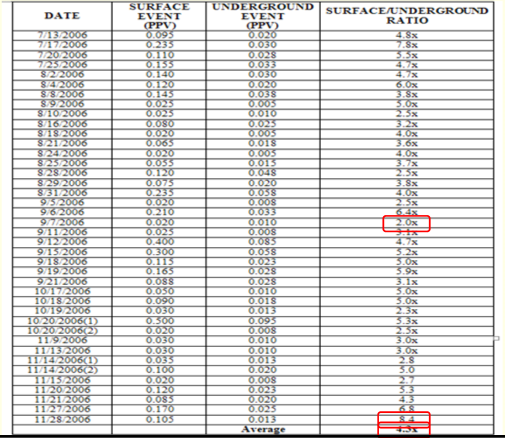


DATE	SURFACE EVENT (PPV)	UNDERGROUND EVENT (PPV)	SURFACE/UNDERGROUND RATIO
5/16/2006	0.220	0.060	3.7x
5/18/2006	0.230	0.060	3.8x
5/22/2006	0.110	0.040	2.8x
		Average	3.4x

Underground vs. Surface Geophone

- With only 3 events recorded, and
- Mining was progressing away from the seismographs.
- New surface and underground geophone location was established.
- Surface blast vibrations were recorded from July thru November 2006.

Underground vs. Surface Geophone Data, Site 2



DATE	SURFACE EVENT (PPV)	UNDERGROUND EVENT (PPV)	SURFACE/UNDERGROUND RATIO
7/13/2006	0.095	0.020	4.8x
7/17/2006	0.235	0.030	7.8x
7/20/2006	0.110	0.028	5.5x
7/25/2006	0.155	0.033	4.7x
8/2/2006	0.140	0.030	4.7x
8/4/2006	0.120	0.020	6.0x
8/8/2006	0.145	0.038	3.8x
8/9/2006	0.025	0.005	5.0x
8/10/2006	0.025	0.010	2.5x
8/16/2006	0.080	0.025	3.2x
8/18/2006	0.020	0.005	4.0x
8/21/2006	0.065	0.018	3.6x
8/24/2006	0.020	0.005	4.0x
8/25/2006	0.055	0.015	3.7x
8/28/2006	0.120	0.048	2.5x
8/29/2006	0.075	0.020	3.8x
8/31/2006	0.235	0.058	4.0x
9/5/2006	0.020	0.008	2.5x
9/6/2006	0.210	0.033	6.4x
9/7/2006	0.020	0.010	2.0x
9/11/2006	0.025	0.008	3.1x
9/12/2006	0.400	0.085	4.7x
9/15/2006	0.300	0.058	5.2x
9/18/2006	0.115	0.023	5.0x
9/19/2006	0.165	0.028	5.9x
9/21/2006	0.088	0.028	3.1x
10/17/2006	0.050	0.010	5.0x
10/18/2006	0.090	0.018	5.0x
10/19/2006	0.030	0.013	2.3x
10/20/2006(1)	0.500	0.095	5.3x
10/20/2006(2)	0.020	0.008	2.5x
11/9/2006	0.030	0.010	3.0x
11/13/2006	0.030	0.010	3.0x
11/14/2006(1)	0.035	0.013	2.8
11/14/2006(2)	0.100	0.020	5.0
11/15/2006	0.020	0.008	2.7
11/20/2006	0.120	0.023	5.3
11/21/2006	0.085	0.020	4.3
11/27/2006	0.170	0.025	6.8
11/28/2006	0.105	0.013	8.4
		Average	4.5x

During OEB Research, the Following Relevant Information was Found

- Maximum blasting vibrations to maintain roof integrity had been previously established.
- Dr. Dave Siskind evaluated nine separate studies from the United States, India, and South Africa for U/G mines.
- Major failure such as roof collapse and pillar failure would require vibrations greater than about 12 in/s.
- In a few cases loose rib material was dislodged at vibration levels of about 1.2 to 5 in/s.
- Low-level vibrations, certainly below 1.0 in/s, have been found to be totally harmless to underground workings.

In Closing

- Need to continue to evaluate blasting vibration levels in Appalachian U/G mines for both miners and bats.
- Continued vibration research at bat habitat areas like Hellhole and others have been overshadowed with other concerns like disease.
- There is a need for bat vibration sensitivity data.
- OEB is on the Web at www.dep.wv.gov/dmr/oeb

Reference Studies for Continued Information

- Temperature, humidity, and airflow levels generally determine how far bats migrate underground for hibernation.
- Temperatures need to range from 37° to 43° F and have an average relative humidity of 87%.
- Only two references could be found that documented distances that hibernating bats were found underground.
- The first was a report written by Dr. Richard F. Myers, in 1975 titled "Effect of Seismic Blasting on Hibernating *Myotis Sodalis* and Other Bats".[4] Dr. Myers' winter study in east-central Missouri determined that several bat clusters were found anywhere from the cave entrance to 500 feet inside the limestone cave.
- The other reference was from a 2005 winter bat survey performed at Greer Lime's Hellhole Cave in Pendleton County, West Virginia. The study revealed that bats had migrated up to 614 linear feet from the limestone cave opening.
- Discussions with Alan Hicks, biologist with the New York State Department of Environmental Conservation, revealed that endangered bats migrated up to 2,300 feet in abandoned iron ore mines in New York.

References on levels of blasting vibrations that would disturb hibernating bats?

- Little has been published on vibration levels that might awaken bats during their hibernation period.
- In 1975 Richard F. Myers, simply states that the bats were not disturbed at 0.02 inches per second. It was noted in the same report that four people walking within 6' of the geophone produced levels of 0.055 inches per second, not causing any disturbance.
- "Glen Park Hydroelectric Project", a study conducted in Watertown, New York, by James A. Besha P.E., involved the video taping of bats using infra-red lights during a period from January to May, 1985. All blasts were monitored at the cave entrance and peak levels of up to 0.20 inches per second were recorded. … This more relevant data tends to indicate that 0.20 inches per second as recorded at the cave entrance, is a more practical lower limit since it has been shown to cause no disturbance to the Watertown bats.
- A habitat of *Myotis* is located in the Jamesville area near Syracuse in a limestone formation that has been under continuous quarrying activity by the Allied Chemical Corp. since 1920. This quarrying activity involves blasting of all types. Loading limits of 200 pounds of explosive per delay as close as 1,000 feet from the caves during the winter are common. Observers have recorded PPV of 0.05 ips 1,400 feet from the blast site. The habitat is located 1,000 feet from the quarrying operation, thus seismic velocities are certainly higher at the caves. It is extrapolated that the PPV at the caves is no less than 0.25 ips. There has been no decrease in the population at Jamesville since observations began in 1969. Hicks recent observations since 1977 have found increasing number of bats."[6]

ACTIVE MINING RECOVERY OPPORTUNITIES:
BOONE NORTH NO. 3 SURFACE MINE

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Abstract

In the summer of 2005, a pregnant female Indiana bat (*Myotis sodalis*) was captured in the Bull Creek area of Boone County, West Virginia. This was the first of three female Indiana bats captured during an endangered species bat survey for Boone North No. 3 Surface Mine. Bats were radiotagged and tracked to five separate roost trees. Exit counts were conducted to determine colony size. The primary roost tree (40 – 50 bats) was located along a ridge top that forms the boundary between Boone and Kanawha counties and is the southern border of the Kanawha State Forest. These findings prompted the opening of formal consultation with the United States Fish and Wildlife Service and subsequently the establishment of a 2-mile radius buffer zone around the primary roost tree. We will examine how these events have affected Boone North No. 3 Surface Mine and other surface mines within the buffer zone. We will examine the permanently established conservation and protection efforts by mining companies in the area as well as document the ongoing plans to continue the protection and enhancement of the Indiana bat population in the Bull Creek area.

Introduction

The Indiana bat (*Myotis sodalis*) was listed as endangered by the USFWS pursuant to the Endangered Species Preservation Act on March 11, 1967 (32 Federal Register 4001). Listing was warranted based primarily on large-scale habitat loss and degradation, especially at winter hibernation sites and significant population declines that continue.

Thirteen winter hibernacula (11 caves and two mines; Table 2) in six States were designated as Critical Habitat for the Indiana bat in 1976 (41 Federal Register 187). The only designated critical habitat in West Virginia is Hellhole Cave, a Priority II hibernacula located in Pendleton County, approximately 135 air miles from the action area. Hibernacula priorities I through III are based upon population sizes at the various sites. Priority I: hibernation sites with a recorded population >30,000 bats in a given survey since 1960 (although two of these sites currently have extremely low numbers of bats); Priority II: recorded population >500 but <30,000 bats in a given survey since 1960, and Priority III: <500 bats (USFWS 1983).

Despite the protection of approximately half of the known major hibernacula (Currie 2002), range-wide population declines continue. In the last fifteen years, appropriately constructed bat gates have been correctly installed in caves, allowing for protection of hibernating bats and restoration of the microclimate. Although most of these efforts were completed by 1990 and resulted in some recolonization of traditional hibernacula, there have not been corresponding overall population increases (Clawson 2002).

Land use practices have been identified as a suspected cause in the decline of the Indiana bat, particularly because habitat in the Indiana bats' maternity range has been changed dramatically from pre-settlement conditions in the following ways: the vast majority of old-growth forests have been harvested and remaining forests are fragmented to varying degrees; fires have been suppressed; prairies have been replaced with agricultural systems; native plants have been replaced with exotics, and diverse plant communities have been simplified. These changes can have profound effects through factors such as loss of suitable roosting habitat caused by the removal of large trees and by a reduction of the diversity and abundance of insects on which the Indiana bats prey (USFWS 1983; Kurta and Murray 2002; Kurta et al. 2002; McCracken 1988; Racey and Entwistle 2003).

The action area is located within a region underlain by coal deposits and, therefore, is subject to past, present, and future mining activities. In 2003, a number of federal agencies and the WVDEP published a Draft Programmatic Environmental Impact Statement (EIS) on mining/valley fills in Appalachia (U.S. Environmental Protection Agency 2003). The EIS study area included the coalfields of Appalachia in eastern Kentucky, southwest Virginia, southwestern West Virginia and a small portion of Tennessee, covering an area of over 12.2 million acres. Studies conducted for the EIS anticipated significant impacts to aquatic and terrestrial habitats as a result of mining activities.

Existing and projected (10-year) future impacts are expected to total 2,400 miles of streams and 2,200 square miles of land, or 11 percent of forested habitat in the Appalachian coalfields region. Although this entire area is considered potential summer (maternity) habitat for the Indiana bat, the only confirmed maternity sites occur adjacent to the project area that is the subject of this consultation and a second area also located in Boone County, West Virginia.

Study Area

While overall West Virginia is 78 percent forested (USDA 2004), Boone County is the most heavily mined county in the state (West Virginia Coal Association, 2010). Boone County is in the southern part of West Virginia (Figure 1), and is centered in one of the major coal districts of the State. Over 10,000 acres of surface mining was permitted in the county between 2000 and 2005 (West Virginia Coal Association, 2010). The Raven Crest Contracting, LLC, Boone North No. 3 Surface Mine (BN3) (Project Area) can be found on the United State Geological Survey (USGS) Racine quadrangle map, 7.5-minute series in Boone County, West Virginia (Figure 2). A significant amount of surface mining is concentrated around the Racine quadrangle and there are several adjacent surface mines found in the vicinity of the Project Area.

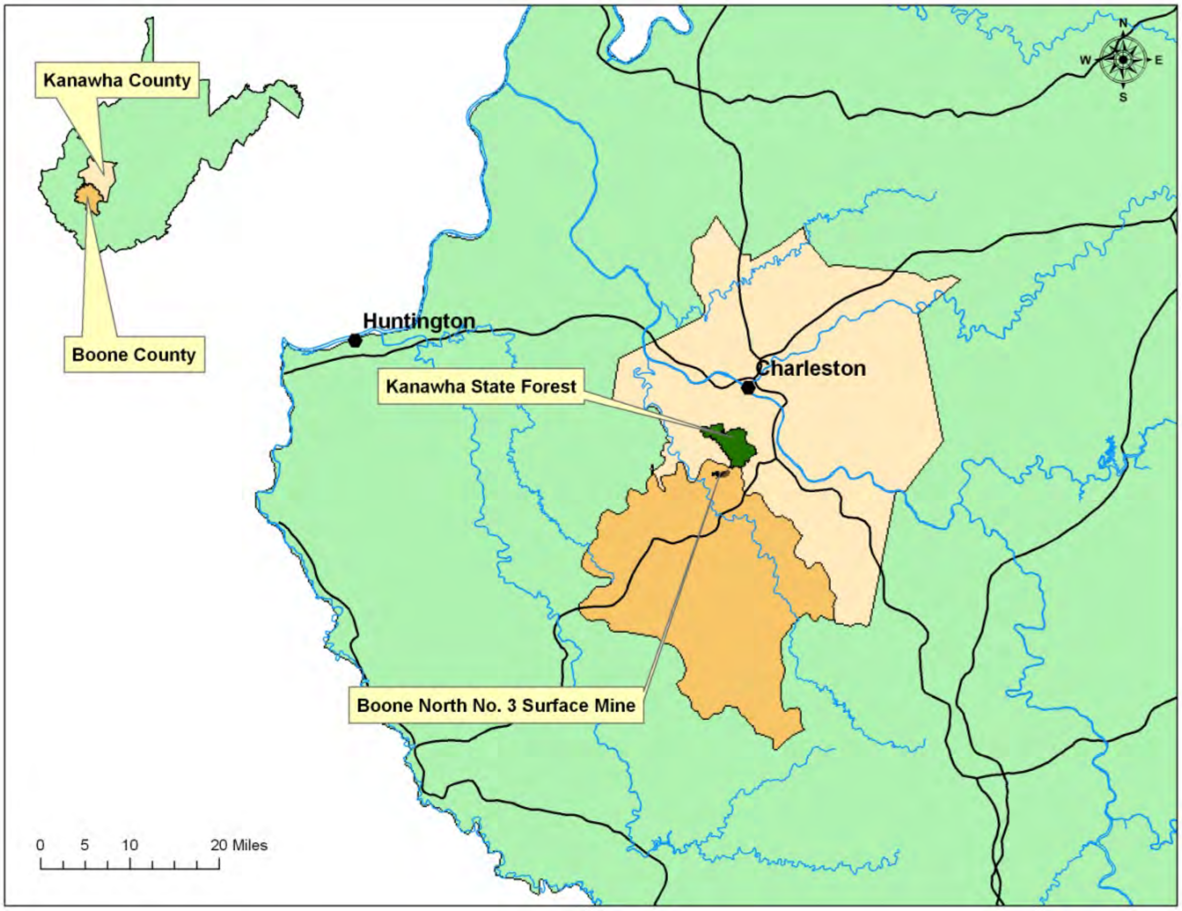

Figure 1. General location of Boone North No. 3 Surface Mine in Boone County, West Virginia.

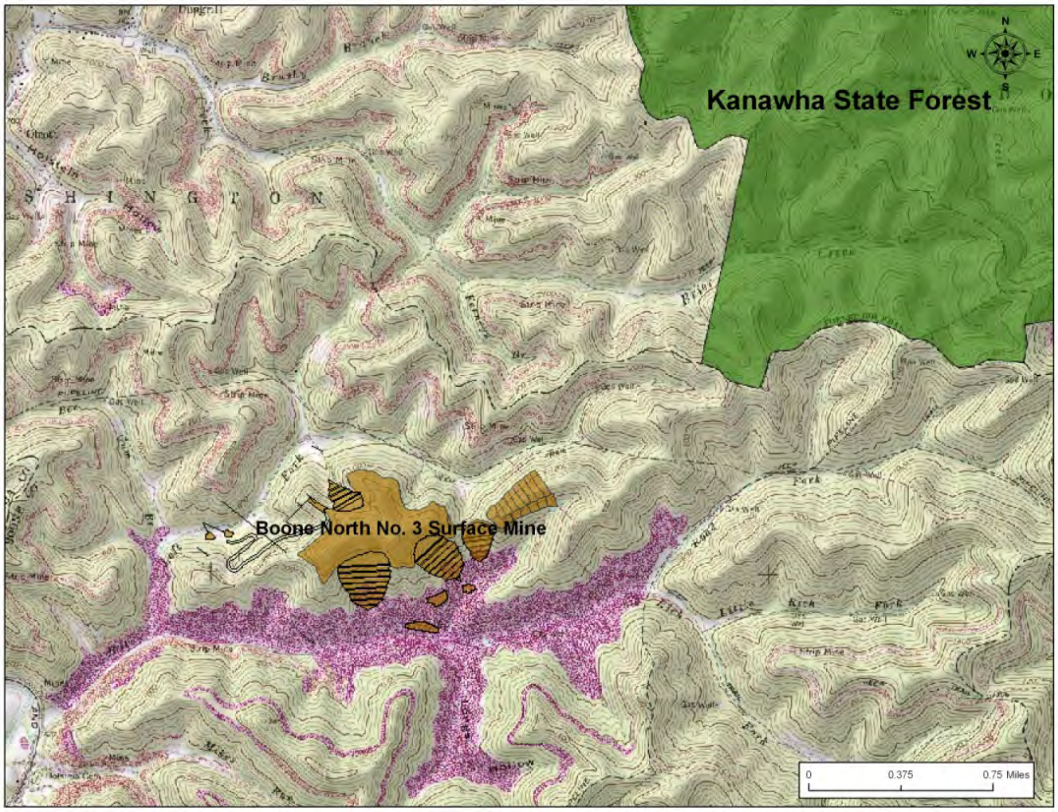

Figure 2. Location of Boone North No. 3 Surface Mine and its proximity to the Kanawha State Forest.

Background/History

2005

During the routine environmental survey for endangered bats required for the permitting of coal mining projects, three pregnant female Indiana bats (*Myotis sodalis*) were captured in areas adjacent to the BN3. All three bats were fitted with transmitters with frequencies in the 151 MHz range; these transmitters were less than 5% of the bat's body weight. Tracking was conducted for the life of the transmitter (until the transmitter was groomed off and located, or did not move for three or more days). A total of five roost trees were located. An area equal to 0.10 hectare circular plot around each roost tree was characterized to determine percent ground cover, mid- and understory closure, and percent canopy cover. Roost trees were also identified to species (2 - Shagbark hickory (*Carya ovata*), 2 - Pine (*Pinus* sp.), & 1 – White oak (*Quercus alba*)), diameter at breast height, and height of each individual roost tree was determined.

Exit counts were conducted at various times on all roost trees and it was determined that one tree served as the primary maternity roost tree (*Pinus* sp.) with exit counts of over 40 bats. This was only the second Indiana bat maternity colony to be discovered in West Virginia. This primary maternity roost tree located along the southern border of the Kanawha State Forest was the center point of a two-mile buffer zone established by the United State Fish and Wildlife Service (USFWS). With the establishment of this buffer zone, any activity falling within its radius was immediately subject to initiation of formal endangered species consultation with the USFWS. Boone North No. 3 Surface Mine fell within this radius and the events that follow are the results of those initial meetings with the USFWS (Figure 3).

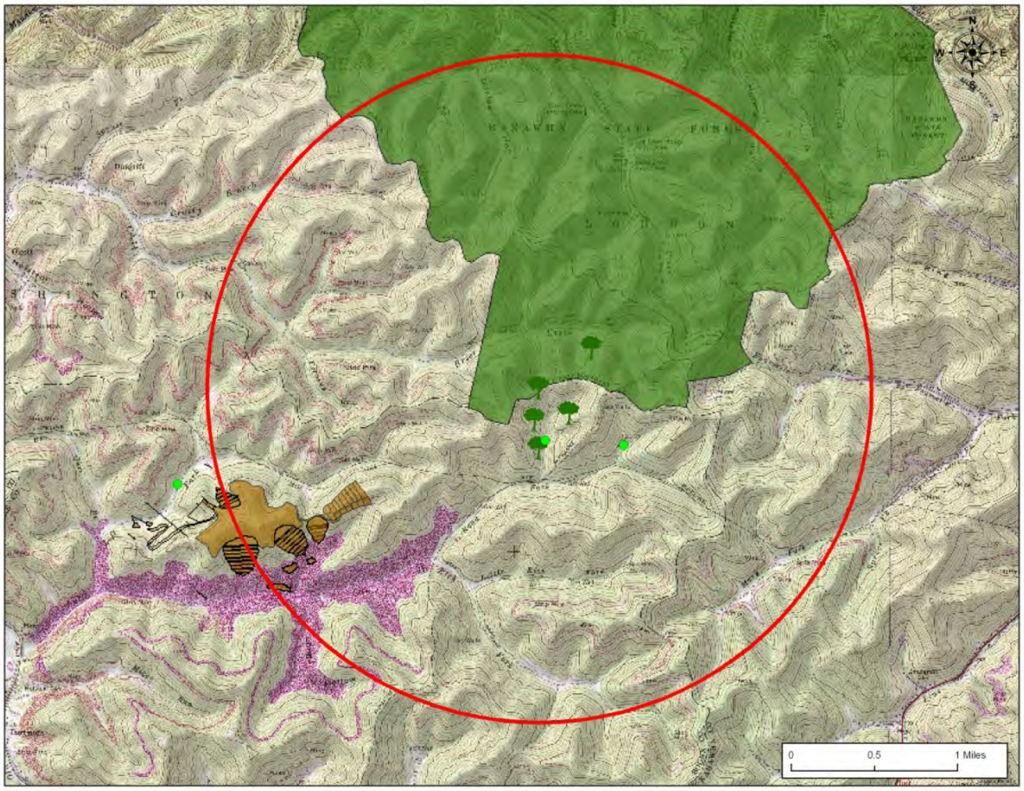

Figure 3. Location of roost trees, Indiana bat (*Myotis sodalis*) capture sites, and the US Fish and Wildlife Service two mile buffer zone centered on the primary maternity roost tree.

2006

With the capture of a female Indiana bat and the location of a maternity roost in the summer of 2005, a Biological Assessment (BA) (CMLI, 2006) with a formal protection and enhancement plan was required by the West Virginia Department of Environmental Protection (WVDEP) and the USFWS. The BA established a base line with what was currently known about Indiana bats in the area. It also documented and examined current and future mining projects within the buffer zone in an effort to provide the best possible picture of what impacts may be affecting this population. Conservation measures set forth in the BA are as follows:

- Establish a preservation area surrounding the primary roost tree approximately 433 acres in size (Figure 4).
- Establish 100-foot riparian buffer zones along Left Fork of Bull Creek and Bull Creek extending to the Big Coal River to maintain as much Indiana bat foraging area as possible (Figure 4).
- To conduct tree-clearing activities between November 15 and March 31. During these time periods, bats are expected to be in hibernation and should not be present on site.
- Implement a post-mining re-vegetation plan that will prevent erosion, provide future travel corridors, foraging areas, and include trees known to be used by Indiana bats.
- Minimize impacts to the bats by a phased-mining process, in which areas are reclaimed as the mining process moves from west to east across the project area.
- Set up a joint monitoring partnership between the Property owner and the Kanawha State Forest. Monitoring should extend a minimum of two years beyond the life of the project.

The summer of 2006 began the first year of the annual monitoring with the capture of an additional pregnant female Indiana bat. She was tracked to a previously located roost tree.

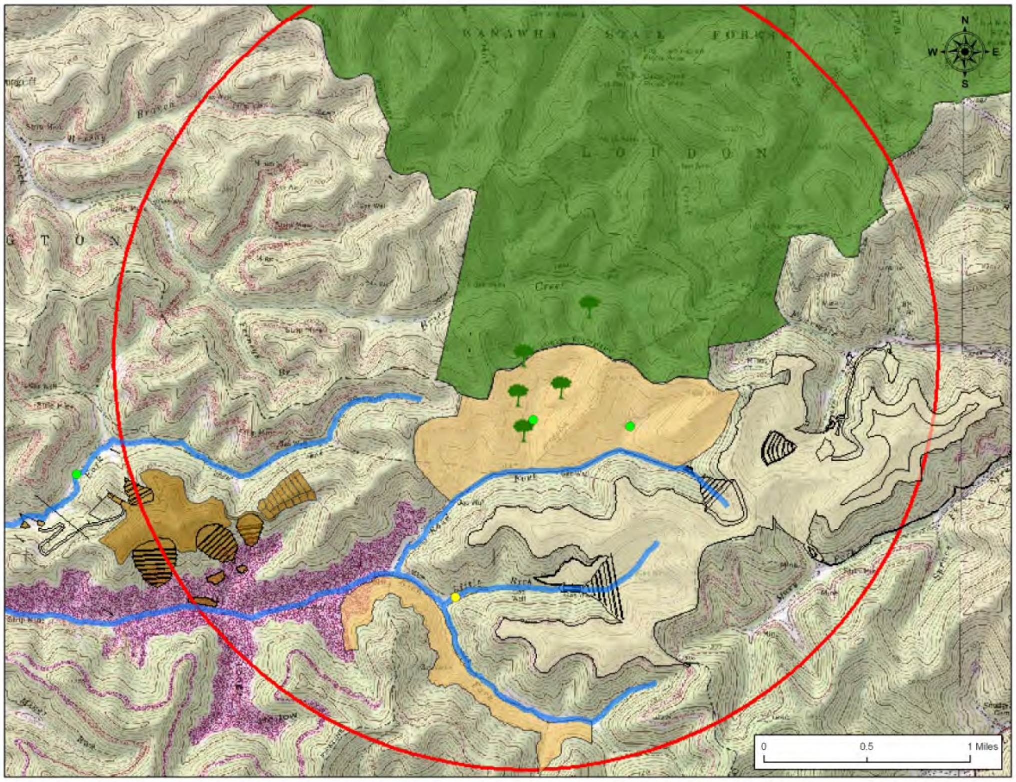

Figure 4. Location of the 2006 Indiana bat capture site (yellow dot) and conservation measures established in the Biological Assessment.

2007

Two thousand and seven (2007) proved to be a year of learning and re-evaluation of the conservation measures that had been established and how those measures will be applied and managed. We were provided with several challenges this year that forced an examination of how the conservation efforts could be better implemented and how information was disseminated to the public, as well as interagency personnel. This was truly a learning year for all involved with this project.

The original BA had to be amended (Amendment No. 1) in order to account for 15 acres that were logged outside of the designated timber cutting season (November 15 – March 31). This incident also required a change in the statement of how BN3 would impact the Indiana bats in the area from “not likely to adversely affect” to “may likely adversely affect.” An Incidental Take Statement (ITS) was now required to be added to the BA. The fifteen acres that were removed were a younger forest type with dense midstory that minimizes bat flight corridors (Burford and Lacki 1995; Erickson and West 1996) and with limited snags. Although it may not have represented prime foraging and roosting habitat (Figure 5), it is important to note when it was lost, during the early summer when bats are still replenishing themselves from winter hibernation (Barclay and Harder 2003) and establishing roosting sites.

This was also the summer that we discovered that a gas company had constructed a road and were drilling a gas well in the center of the preservation area (Figure 5). The gas well site was less than 100 meters from the primary roost tree. This presented an interesting challenge in that the gas company had all the required permits but somehow had not been informed that they were in a protected area and were in close proximity to an endangered species maternity colony. After being informed of the situation, the gas company did suspend all activities until late in the fall and early winter when the bats had migrated to hibernation sites. All work in the area was completed before the bats returned in the spring. This incident prompted a more open interaction between interagency offices and demonstrated the need for better lines of communication between agencies, the public, and companies that might have interests in and around the preservation area.

Prichard Mining Company, Inc. (PMC) elected to assume presence of Indiana bats on their Fourmile Fork Surface Mine, which is almost entirely located within the two-mile buffer zone (Figure 5). PMC as part of their protection and enhancement plan did the following: added 135 acres to the preservation area, installed 20 – two-chambered, rocket style bat boxes (Figure 6) and established funding to support the annual monitoring as prescribed in the original BA.

The annual monitoring in the area did not produce any Indiana bat captures from sites where Indiana bats had been previously captured. No additional sites were surveyed this year.

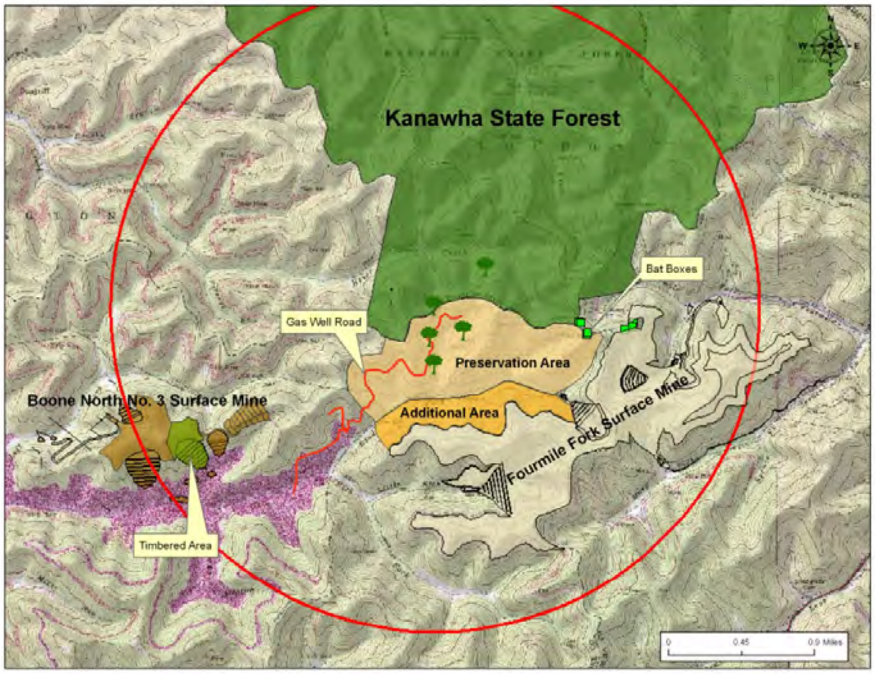

Figure 5. Location of area where timber was removed, road was constructed by gas company into Preservation Area, additional area added to preservation area, Fourmile Fork Surface Mine, and bat boxes.

Figure 6. Example of the two-chambered, rocket style bat boxes installed by Prichard Mining.

2008

Due in part to the events that occurred in 2007, this year proved to be the year that we intensified our efforts to manage and protect this population of Indiana bats. This year could also be called a rebuilding year in that every effort was made to inform all interested parties of the conservation efforts that are/were ongoing in the area. Raven Crest Contracting added a small, 15-acre area to BN3 (Figure 7). The additional area did not require any additional documentation and all previously established conservation measures remained in place.

During 2008, it was discovered that four of the five roost trees had fallen, including the primary maternity roost tree. There had been several severe storms during the winter and early spring, and after examination it was determined that all downed roost trees had been lost through natural causes. After several discussions with the WVDEP and USFWS, it was decided that every effort possible must be made to capture an Indiana bat and document that they were still in the area. Mist net surveys were conducted at 30 sites throughout the preservation area and the Kanawha State Forest (Figure 7). Netting was done following the established guidelines in the Indiana Bat Draft Recovery Plan (USFWS 2007). A single juvenile female was captured outside the normal netting season in the Kanawha State Forest. This bat was not fitted with a transmitter due to the lateness of the capture date and that bats in the area are typically moving to hibernation sites. The capture of this juvenile female did provide intuitive information on the status of Indiana bats in the area. From this capture we can draw the conclusion that there is still a viable reproductive population of Indiana bats existing in the area.

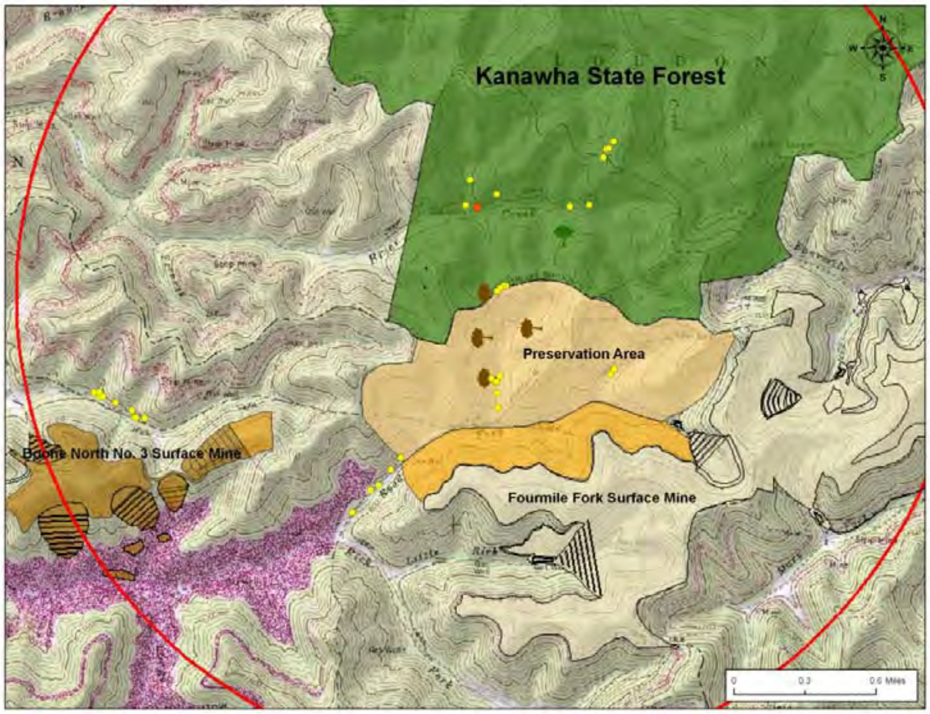

Figure 7. Location of additional mist net survey sites (yellow dots) and late season Indiana bat capture site (red dot).

2009

Raven Crest Contracting, LLC proposes to add an additional 45 acres to the Boone North No. 3 Surface Mine project. This addition requires an amendment to the original BA (Amendment No. 2) with an updated ITS. This amendment requires a more detailed Protection and Enhancement Plan with additional conservation measures. The WVDEP also requests a letter of commitment to the conservation measures from Raven Crest Contracting, LLC. This request of a formal letter that acknowledges the conservation measures and a statement of commitment to them are unique in that it had not been done previously. To their credit, Raven Crest stepped up and agreed to provide the WVDEP with a letter acknowledging their continued commitment to the conservation and long term protection of the Indiana bat in the area. As part of the newly updated Protection and Enhancement Plan, Raven Crest elected to install 10 two-chambered, rocket style bat boxes in the preservation area in areas where Indiana bats had been previously captured and adjacent to fallen original roost trees (Figure

8). Raven Crest also agrees to construct small (<4 meter diameter) wildlife ponds in upland areas to be part of the mining reclamation adjacent to the preservation area.

Penn-Virginia and Raven Crest elect to post signs in and around the preservation area to provide information that the area is protected because of endangered species and all activities are restricted without written permission.

During the annual monitoring, a single female Indiana bat was captured in early June. This female was captured in the Kanawha State Forest at the 2008 capture site. A radio transmitter was applied and the bat was tracked for the duration of the battery life (10 days) but was never located.

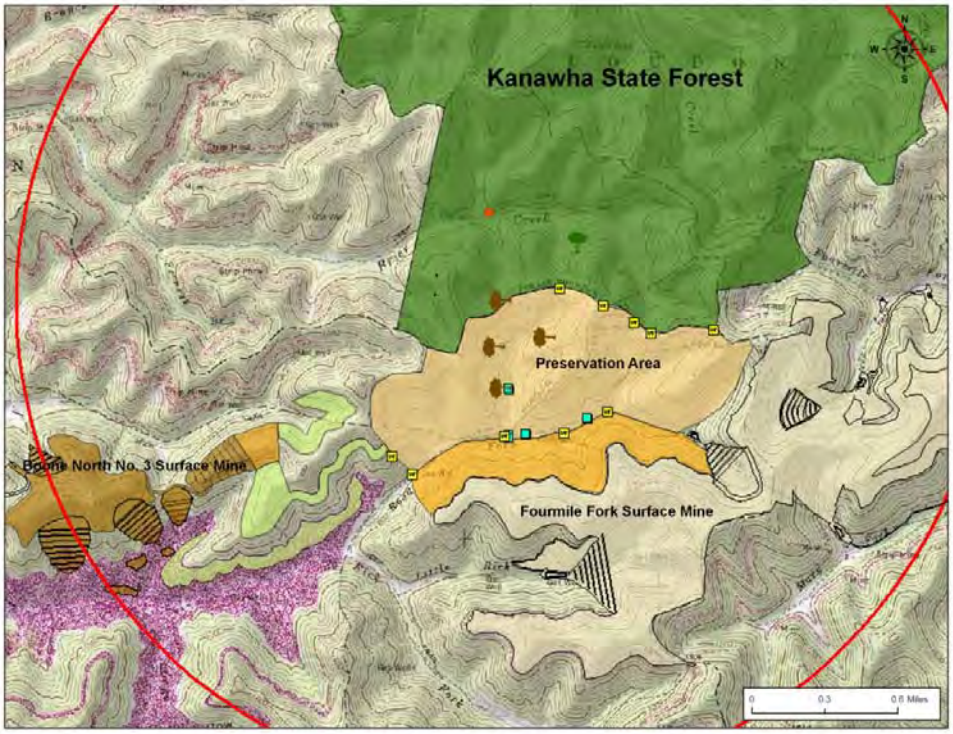

Figure 8. Location of the additional 45 acres (light green) to be added to Boone North No. 3 Surface Mine, bat boxes (blue green squares), Preservation Area signs (yellow squares with "w"), and Indiana bat capture location (red dot).

2010

Routine visual examination of the 30 bat boxes revealed nine of the 20 installed by Prichard Mining and four (4) of the ten (10) installed by Raven Crest had bats occupying them during the summer of 2010 (Figure 9). Exit counts were not conducted because visual inspections only had one or two bats in the occupied boxes. There was no effort made to capture any of the bats in an effort to minimize any disturbance that would cause bats to abandon the roost boxes. If bats return next year, acoustic surveys will be conducted to determine species present. If these surveys prove to be inconclusive, attempts will be made to capture the bats for positive identifications.

This year also marked the final year of the annual monitoring as prescribed in the original BA. No Indiana bats were captured during this year's netting effort.

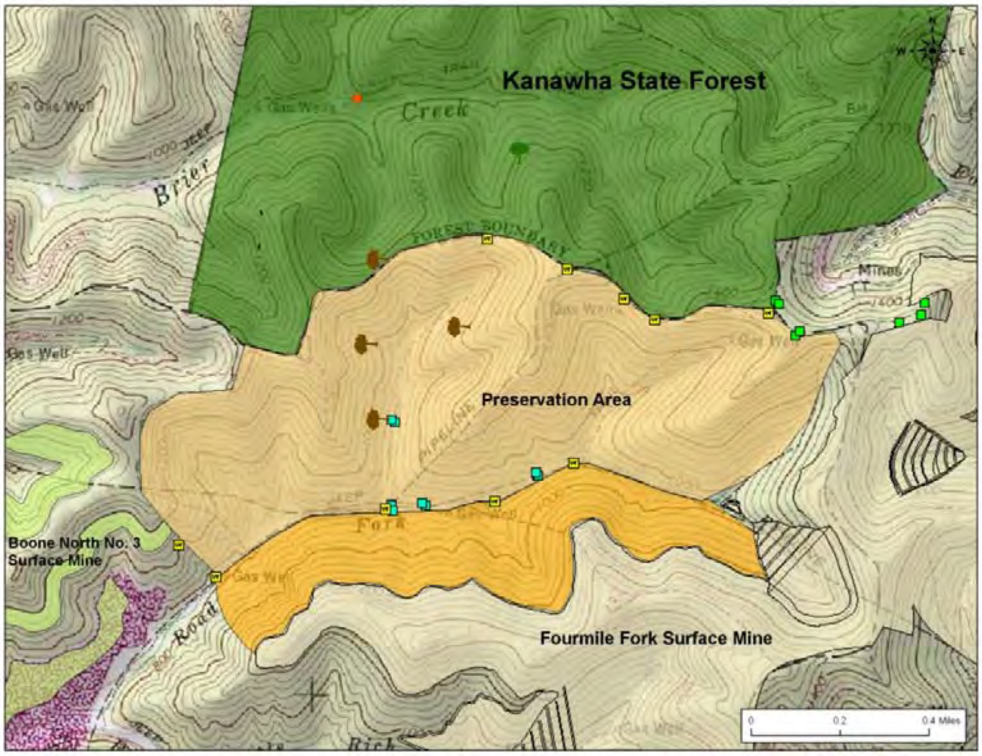

Figure 9. Nine of the 20 bat boxes installed by Prichard Mining and four of the 10 installed by Raven Crest were occupied by bats during the summer of 2010.

Recovery Opportunities

This project demonstrates in many ways just what can be accomplished when there is an atmosphere of mutual trust, understanding, cooperation, and willingness to explore unique management ideas. The level of cooperation and willingness to accept conservation measures specific to bats demonstrated by Penn-Virginia, Raven Crest, and Prichard Mining truly reflects a positive image of the mining community. These companies chose to see this as an opportunity to become a pro-active partner in the conservation efforts of this population of Indiana bats. This positive attitude allowed the author and agency personnel the ability to approach this work as a manageable challenge rather than having to deal with it as a problem.

Penn-Virginia took the first step by setting aside 433 acres of land that fully enclosed the majority of the roost trees as a preservation area. Although there were some early communication issues, this served as a major component of the conservation and protection plan. Creating a preservation area where activities are more limited and controlled allows for more diverse conservation and management opportunities. Prichard Mining then followed by adding 135 acres to the preservation area established by Penn-Virginia, bringing the total protected area to 568 acres. This additional acreage completely encloses the headwaters of Road Fork, the area where the original captures were made.

Prichard Mining and Raven Crest also installed 30 two-chambered, rocket-style bat boxes within and adjacent to the preservation area. The placement of bat (roost) boxes by Prichard Mining and Raven Crest on active mining sites and adjoining areas had not been done in West Virginia prior to this project. Raven Crest also took the same proactive approach by installing bat boxes in areas where previously discovered roost trees had been lost. As previously stated, 13 of the 30 bat boxes had bats occupying them during the summer of 2010.

Penn-Virginia, Prichard Mining, and Raven Crest all agreed to provide funding for the continued monitoring of the Indiana bats in the area. This funding provided for five years of additional surveys, radio transmitters for tracking, and production and installation of signs identifying the area and its use restrictions to be posted around the boundaries of the preservation area.

Summary and Discussion

This project began with what many in the mining industry fear the most: finding an endangered species on or adjacent to the mining project area. To make matters worse, several roost trees and a major maternity colony (2nd in the state) were also discovered. There are many in the mining industry that would see this as a worst case scenario and do all they could to make it go away. That's where this project takes a dramatic turn. Instead of attacking this as a problem and working to make it disappear, Penn-Virginia, Prichard Mining, and Raven Crest took a pro-active approach and elected to become partners in the conservation and management of this population of endangered bats. By taking a more positive approach, these mining companies set a new standard on what could be done to protect a neighboring (endangered) species and still mine coal. Although surface mining has a dramatic effect on the landscape, if more companies were willing to go the distance on management and protection, the impacts on the habitat could be minimized and mitigated so that wildlife (in this case, bats) can still exist in close proximity to working mining operations.

Acknowledgements

There are several different individuals and groups that must be thanked without whose diligence, attention to detail, cooperation, and willingness to think outside the box, this project would never have been realized. I would like to thank Jeremy Jackson and Shane Prescott for their work on the initial stages of this project. I would also like to thank the following mining companies and land owners for their willingness to listen and work with a bunch of biologists on the continued protection and recovery of the Indiana bat: Penn-Virginia Resource Partners, L.P.; Raven Crest Contracting LLC, and Prichard Mining Company, Inc. I would also like to thank the previously mentioned companies for the funding to conduct the annual monitoring and implementation of the conservation measures. Thanks to the West Virginia Department of Environmental Protection, West Virginia Division of Natural Resources, and the United States Fish and Wildlife Service for their advisement and encouragement in developing unique conservation measures specific to the project area, for not only Indiana bats but all bats in the area. Last, but by no means least, I would like to thank Compliance Monitoring Labs, Inc. for the freedom and understanding to devote the time and resources that this project required. Specifically, James Browning, Josh Justice, Josh Richards, Chris White, Lee Williamson, and numerous field technicians whose help on many nights of mist netting and daytime radio tracking on this project could not have been done.

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J.D. Wilhide holds the senior biologist position at Compliance Monitoring Labs, Inc. (CMLI) in West Virginia. During the five years he has been at CMLI, his bat work has included mist netting, research in foraging, home range, roost preference and location, the placement and monitoring of numerous bat houses and, as always, keeping a lookout for the endangered Indiana bat. He has extensive knowledge working in many areas of biology and the wildlife ecology fields, specializing in bat ecology. Having over twenty years experience and numerous publications related to said fields, he has worked extensively with several endangered bat species in Arkansas, Mississippi, Tennessee, and West Virginia. In 2005, he was involved in the initial discovery of the Indiana Bat (maternity) colony in the Bull creek area of Boone County, West Virginia; he continues to monitor and oversee this endangered colony. He has worked with State and Federal agencies together with the full cooperation and support of the land owner and several mining companies to ensure the continued protection of the Indiana bat colony in the Bull Creek area.

Active Mining Recovery Opportunities:

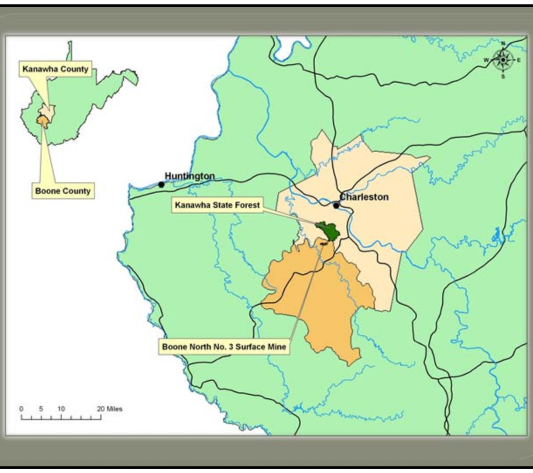
Boone North No. 3 Surface Mine

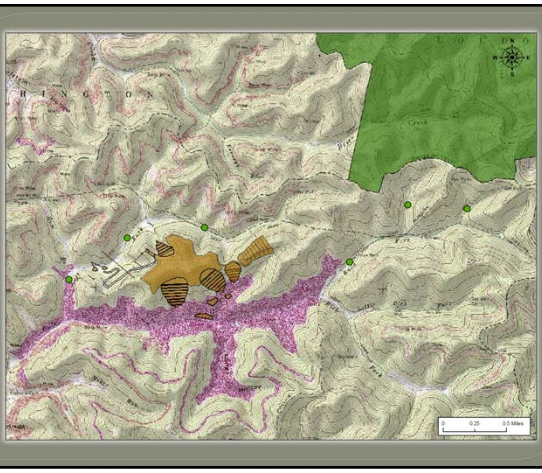
J. D. Wilhide
Mammalogist / Bat Ecologist
Compliance Monitoring Labs Inc.

PROTECTING BATS AT COAL MINES?

BACKGROUND / HISTORY

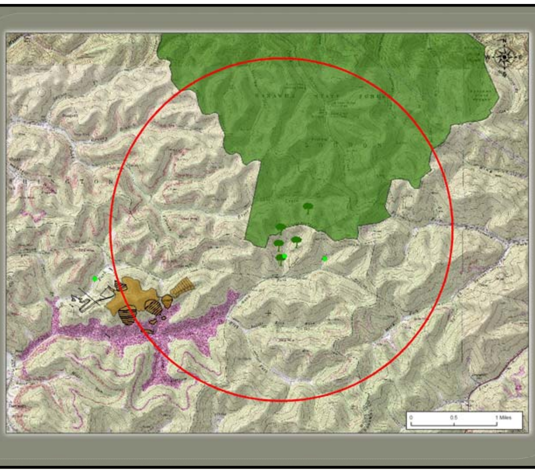
Raven Crest Contracting, LLC
Boone North No. 3 Surface Mine
Boone County, West Virginia





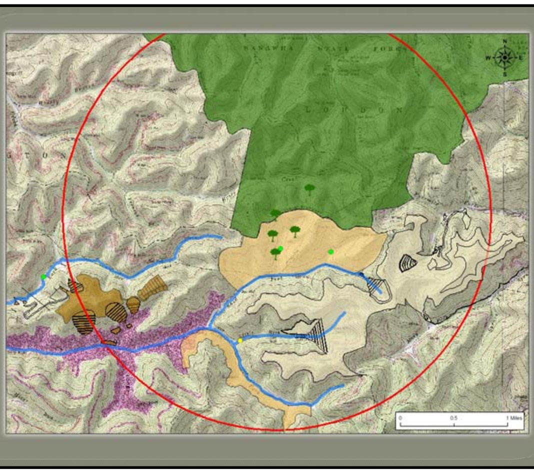
2005

- 3 Female Indiana Bats
- 5 Roost Trees
- Exit Counts 5 – 49 bats
- Establishment of 2 mile Buffer Zone



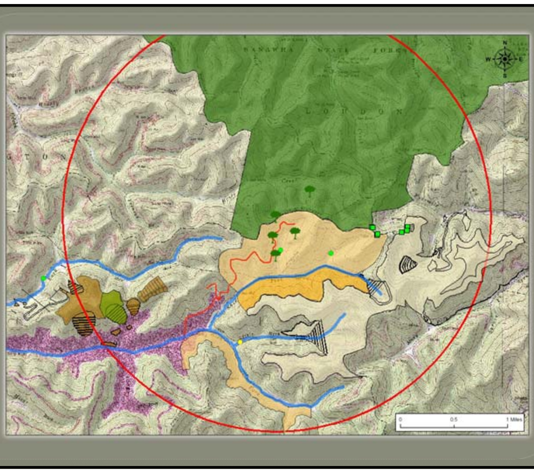
2006

- Raven Crest Contracting, LLC
  - Biological Assessment (BA)
    - Protection and Enhancement plan
      - Riparian Buffer Zone
      - Establish Preservation Area (433 ac)
      - Annual Monitoring
- Female Indiana Bat captured
  - No new roost trees (using existing roost)



2007

- Prichard Mining Company, Inc.
  - Assumes presence of Indiana Bats
    - Protection and Enhancement Plan
      - Installs 20 bat boxes
      - Additional 135 acres added to Preservation Area
      - Funding for annual monitoring
- Raven Crest Contracting, LLC
  - Amendment No. 1 to original BA
    - Incidental Take Statement
    - Logging out of season
- Gas well road into Preservation Area within 100 m of primary roost tree
- No Indiana Bat captures

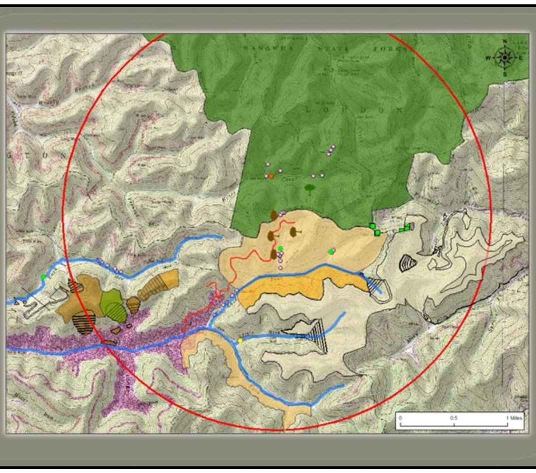


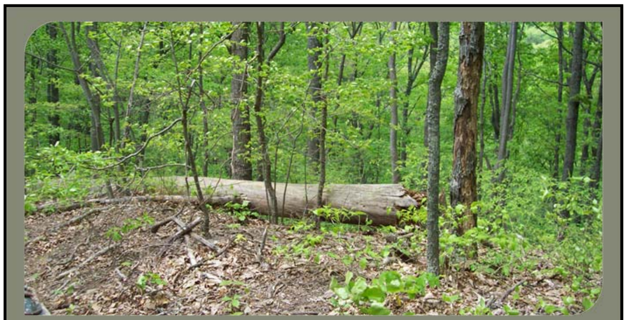
Prichard Mining Company, Inc.

- 20 two chambered rocket style bat boxes installed during the Fall and Winter 2007 – 2008.

2008

- Roost Trees
  - 4 of 5 original trees fallen from natural causes
- Kanawha State Forest
  - 1 Female Indiana bat captured (late season)
- Raven Crest Contracting, LLC
  - Addition of 25 acres to Boone North No. 3





4 of 5 Roost Trees have fallen:

Primary Roost Tree

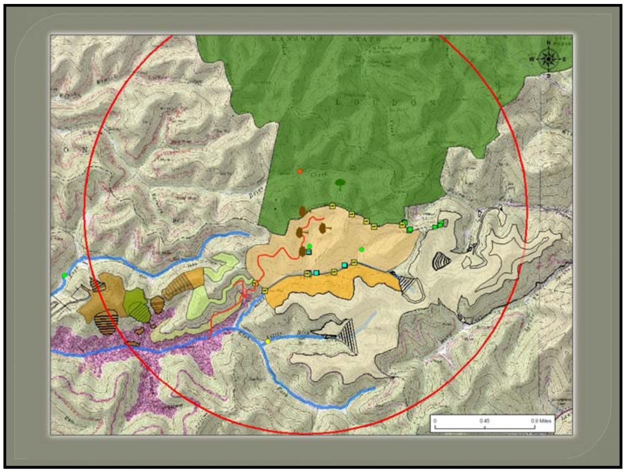
Exit counts:
2005 - 40+ bats
2006 - 20 bats
2007 – No counts
2008 -Tree on ground

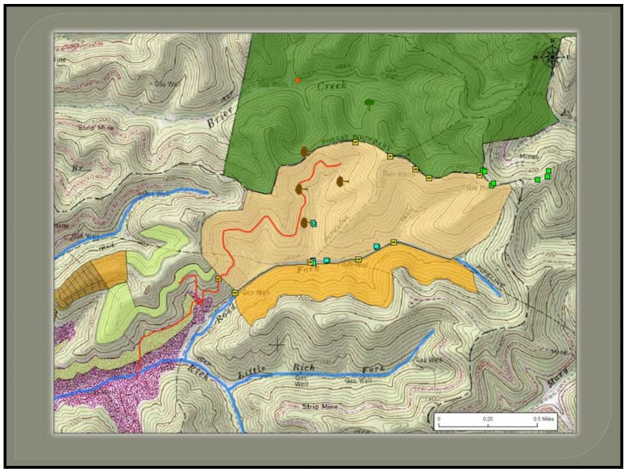
Secondary Roost Tree

Exit Counts:
2005 – 38 bats
2006 – no bats
2007 – no count
2008 – tree on ground

2009

- Kanawha State Forest
  - Female Indiana bat captured
    - Same location as in 2008
- Raven Crest Contracting, LLC
  - Amendment No. 2 to original BA
    - Addition of 45 acres to Boone North No. 3
  - New Protection and Enhancement Plan
    - Letter of commitment to conservation measures
    - Installation of 10 bat boxes
    - Wildlife ponds
    - Signs for Preservation Area (Bull Creek Wildlife Preservation Area)



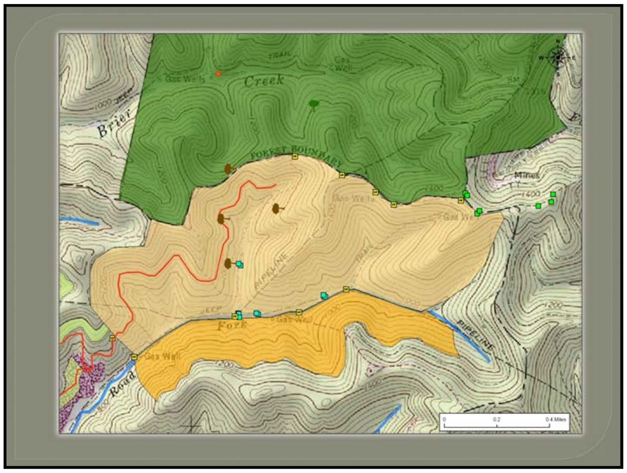


Bull Creek Wildlife Preservation Area Signs

Installed Fall and Winter 2009/2010

2010

- Raven Crest Contracting, LLC
  - 4 of 10 bat boxes have bats
  - Final year of Annual Monitoring (BA 2005)
- Prichard Mining Company, Inc.
  - 9 of 20 bat boxes have bats
- No Indiana Bat Captures



Recovery Opportunities

- Annual monitoring of populations
- Avoidance of established roost trees
- Bat Boxes
- Preservation Areas
- Post mining tree planting
- Tree harvesting
- Wildlife Ponds

- Challenges not Problems
- Partners in conservation

Funding and Support

- Penn-Virginia Resource Partners, L.P.
- Raven Crest Contracting, LLC
- Prichard Mining, Inc.
- WV Department of Environmental Protection
- WV Division of Natural Resources
  - Wildlife Resources Section
  - Parks and Recreation Section
- U. S. Fish and Wildlife Service
- Compliance Monitoring Labs, Inc.

Acknowledgements

- James Browning
- Jeremy Jackson
- Josh Justice
- Shane Prescott
- Josh Richards
- Chris White
- Lee Williamson
- Numerous field technicians

QUESTIONS??

Indiana Bat roosting under power pole bracket. Arrow pointing to transmitter antenna.

West Virginia Department of Environmental Protection – Office of Abandoned Mine Lands (WVDEP/AML) Preservation Efforts of Potential Bat Habitat

Robert Rice
West Virginia Department of Environmental Protection
Office of Abandoned Mine Lands

Abstract

Since entering into a programmatic agreement with the Fish and Wildlife Service in 2008, the WV DEP Office of Abandoned Mine Lands has preserved approximately 75 mine openings with bat friendly closures. Many of these openings were in a state of collapse and due to the quick actions of the DEP, they are now stable. Due to the age and rock structure of many portals it is not uncommon for mine openings to be open today and completely sealed by rock collapse tomorrow.

Unlike limestone cave entries, mine entries are often in shale or severely fractured sandstones making the entries more susceptible to freeze and thaw cycles. Therefore, standard bat gates are not always the most appropriate method for sealing mine entries. The WV DEP has elected to use bat gates constructed in culverts as the common method for sealing mine entries. By utilizing gates constructed in culverts to seal portals, the areas prone to collapse can be stabilized. Additionally, by installing gates constructed in culverts, the highwall or faceup can also be backfilled without restricting reclamation.

As the WV DEP moves forward in its efforts to preserve potential bat habitat, it has become clear that current construction constraints have limited our ability to preserve potential habitat to the best of our ability. Currently, construction of bat gates is limited to summer months only in an attempt to prevent disturbance to hibernating bats. By allowing the installation of bat gates constructed in culverts throughout the year, we would be preserving portal entries that could become completely collapsed by the time the spring construction season starts. However, the WV DEP is aware of the detrimental effects that disturbing hibernating bats can have. Can the installation of bat gates constructed in culverts be done in a manner that will not be detrimental to hibernating bats?

Preservation Efforts

Since entering into a programmatic agreement with the U.S. Fish and Wildlife Service in 2008, the WVDEP/AML has preserved approximately 75 mine openings with bat friendly closures. Many of these openings were in a state of collapse and due to the quick actions of the WVDEP/AML, they are now stable. Due to the age and rock structure of many portals, it is not uncommon for mine openings to be open today and completely sealed by rock collapse tomorrow.

Unlike limestone cave entries, mine entries are often in between shale or severely fractured sandstones making the entries more susceptible to freeze and thaw cycles. Therefore, standard bat gates are not always the most appropriate method for sealing mine entries. The WVDEP/AML has elected to use culvert bat gates as the common method for sealing mine entries.

Culvert gates allow for reclamation to better resemble the original contour of the landscape. This is due to the ability to backfill the highwall, which is necessary to establish the estimated original contour. Additionally, by backfilling highwalls, AML is also eliminating the health and safety hazards associated with the highwalls.

Culvert gates stabilize the shales that are frequently associated with the strata above and below WV coal mines, thus, better preserving the mine entries. Mine openings, associated with AML sites, can come and go with the seasons. These openings will close and open without warning during freeze/thaw periods and during heavy rain events which could trap hibernating bats or allow for drastic changes in air flow (collapsed openings are permanently stabilized with modified mine seals).

Culvert gates can be installed with much less risk to contractors. By installing culvert gates, excavators can be used to maneuver the culvert into place rather than having workers drill and weld within the mine entry. Additionally, the gate can be assembled in a controlled environment such as a workshop and hauled to the worksite for the equipment operator to install.

Culvert gates are cheaper to install than typical AML mine seals or wet-seals. The vast majority of AML mine entries have drainage associated with them due to historic mining practices. Without pumps to remove water, the easiest way to drain water from a mine was to mine up dip and let the water flow out. The mine seal must accommodate drainage or the mine seal becomes a dam and creates an underground impoundment that could potentially blowout. Wet-seals consist of excavating the entrance down to the coal pavement, installing bulk heads, risers, drains, clay seals, and stone bedding. A typical mine seal is comparable in cost to a culvert bat gat. Both culvert bat gates and wet-seals allow for water to flow freely from the mine workings. However, by assuming presence, AML is able to skip the costly portal surveys and install bat gates.

Currently, construction of bat gates is limited to summer months only in an attempt to prevent disturbance to hibernating bats. By allowing the installation of culvert bat gates throughout the year, we would be preserving portal entries that could become completely collapsed by the time the spring construction season starts. However, the WVDEP/AML is aware of the detrimental effects that disturbing hibernating bats can have. Can the installation of culvert bat gates be done in a manner that will not be detrimental to hibernating bats? This question was asked during the 2010 OSM Forum “Protecting Threatened Bats at Coal Mines” to the speakers and audience.

The general consensus was that construction could happen during the winter under special circumstances if extra precautions were taken to prevent disturbance. The WVDEP/AML is currently working with various state and federal agencies to determine when winter installation would be acceptable and what precautions should be met for winter installations.

Robert Rice has been employed by the WV Department of Environmental Protection Office of Abandoned Mine Lands since 2006. Part of his duties include being a planner with the WV DEP is to delineate where mine portals are located that need to be sealed in a bat friendly manner and acquire the environmental clearances to do such. He has been previously employed by Sanders Environmental from 2001-2004 as a team leader for Sanders Environmental, conducting mist net & harp trap surveys, constructed bat gates, and tracked captured Indiana bats utilizing telemetry. He contracted to conduct mist net surveys on the Monongahela National Forest in 2002. In 2000, he was on loan from Sanders Environmental and assisted Cal Butchkowski, with the PA Game Commission, at Canoe Creek State Park on an Indiana Bat maternity colony telemetry project.

PENNSYLVANIA BAT GATING EFFORTS

Calvin M. Butchkoski
Pennsylvania Game Commission
Harrisburg, Pennsylvania

Abstract

In Pennsylvania, the seven hibernacula with the highest interior bat counts are mines; four of these harbor the federally endangered Indiana bat (*Myotis sodalis*). The hibernaculum with the highest bat count has evidence of both coal and limestone extraction. Eighty-seven percent of bats tallied in Pennsylvania hibernacula are in mines. Of the abandoned coal mines where safe interior counts cannot be conducted, at least 3 have very significant bat populations as evidenced through live-trapping, use of bat detectors, and mortality outside the mines after they were affected by White-nose Syndrome (WNS). Because bats have adopted abandoned mines as primary overwintering habitat, management of mines as hibernacula is a priority. Pennsylvania has approximately 75 gated hibernacula on record; they include 42 abandoned coal mines, 18 other mines (limestone, iron, clay), and 15 limestone caves. All 42 coal mines were gated by the Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation or the U.S. Department of Interior, Office of Surface Mining Reclamation and Enforcement (OSM). Gates are installed for a variety of reasons that include: a significant hibernating bat population; gating may be more cost effective than backfilling; or engineering requires that an opening be maintained (for drainage, etc). Gate design takes 3 basic factors into account: 1) to exclude humans for safety and to minimize disturbances to bats-gate must be robust and easily repairable if vandalized; 2) the gate must incorporate proven designs that allow bats to fly through; and 3) the gate(s) and entrance area must provide for the natural air flow in and out of the mine so that the interior environment is not degraded. With the spread of WNS, which causes significant mortality of hibernating bats, providing more hibernacula for smaller populations may be a management option, especially if WNS is found to be most severe in hibernacula with high densities of bats. Mines may also offer more environmental variables (i.e. colder, drier sections) to buffer WNS impacts. Now more than ever, hibernacula management and protection must be emphasized.

Introduction

In the mid-1980's, the Pennsylvania Game Commission (PGC) entered a partnership with the OSM and the Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation (BAMR) to conduct bat surveys at coal mine openings scheduled for reclamation. Bat use of abandoned mines is well documented (Altenbach and Pierson 1995; Altenbach et al. 2001; Ducummon 2001; McAney 1999; Tuttle and Taylor 1998; Tuttle and Kennedy 2002). The volume of surveys needed was more than PGC staff could accomplish; shortly thereafter BAMR began awarding contracts to private environmental companies to survey mine portals for the presence of bats. The contracted company must obtain a special-use permit from the PGC to do the surveys. The permitting process requires reporting to the PGC and the data is preserved in a netting/trapping database. Due to dangerous interior conditions, surveys of coal mines are done using harp traps, mist nets, and acoustics at entrances to sample the species and abundance at a site. Survey results may require gating and/or consultation with the PGC when bats are captured; otherwise the site can be reclaimed. Sometimes sites or the entire landscape surrounding the sites are too dangerous or unstable to provide for a gate. In these cases, closures occur during the summer months using exclusion techniques (Sherwin and Foss 2004) where possible. In Pennsylvania, surveys are conducted in spring (April 10 through May 10) and fall (September 15 through October 31).

Gating and Modifications

Gates are installed for a variety of reasons that include: a significant hibernating bat population; gating may be more cost effective than backfilling; or engineering requires that an opening be maintained (for drainage, etc). Gate design takes 3 basic factors into account: 1) to exclude humans for safety and to minimize disturbances to bats-gate must be robust and easily repairable if vandalized; 2) the gate must incorporate proven designs that allow bats to fly through; and 3) the gate(s) and entrance area must provide for the natural air flow in and out of the mine so that the interior environment is not degraded.

Pennsylvania has 75 gated hibernacula on record. They include 42 abandoned coal mines, 18 other mines (limestone, iron, and clay) and 15 limestone caves. Approximately 900 bat surveys (netting/live-trapping) have been done at 600 coal mines sites of which ~280 had bat captures and 205 sites had 10 or fewer bats captured. Not all gated coal mines have been surveyed. In some cases, BAMR and OSM find that it is more efficient to gate a site with no surveys conducted.

Three coal mines (all in the anthracite region) have documented Indiana bat (*Myotis sodalis*) use. Another limestone mine of which portions have coal extraction (bituminous) is also an Indiana bat hibernaculum. The 7 hibernacula with the highest interior counts (~5,000 to ~90,500 bats) are mines (non-coal). Through live-trapping, at least 3 coal mines rival these 7 in bat activity during spring/fall.

When a gating project involves earth–moving, preserving air flow within the tunnels is always a concern (Fig. 1). In some cases, earth-moving can provide better habitat (Fig. 2).

In many cases during reclamation projects, there is heavy equipment involved and modifications can be easily achieved with correct planning. The same holds true with extensive tunnels if they are mapped with elevations indicated. Gating the upper entrances with bat-friendly designs (Tuttle and Taylor 1998) while closing lower elevation openings to prevent the escape of cold air, can create exceptional hibernation environments for bats in some cases.

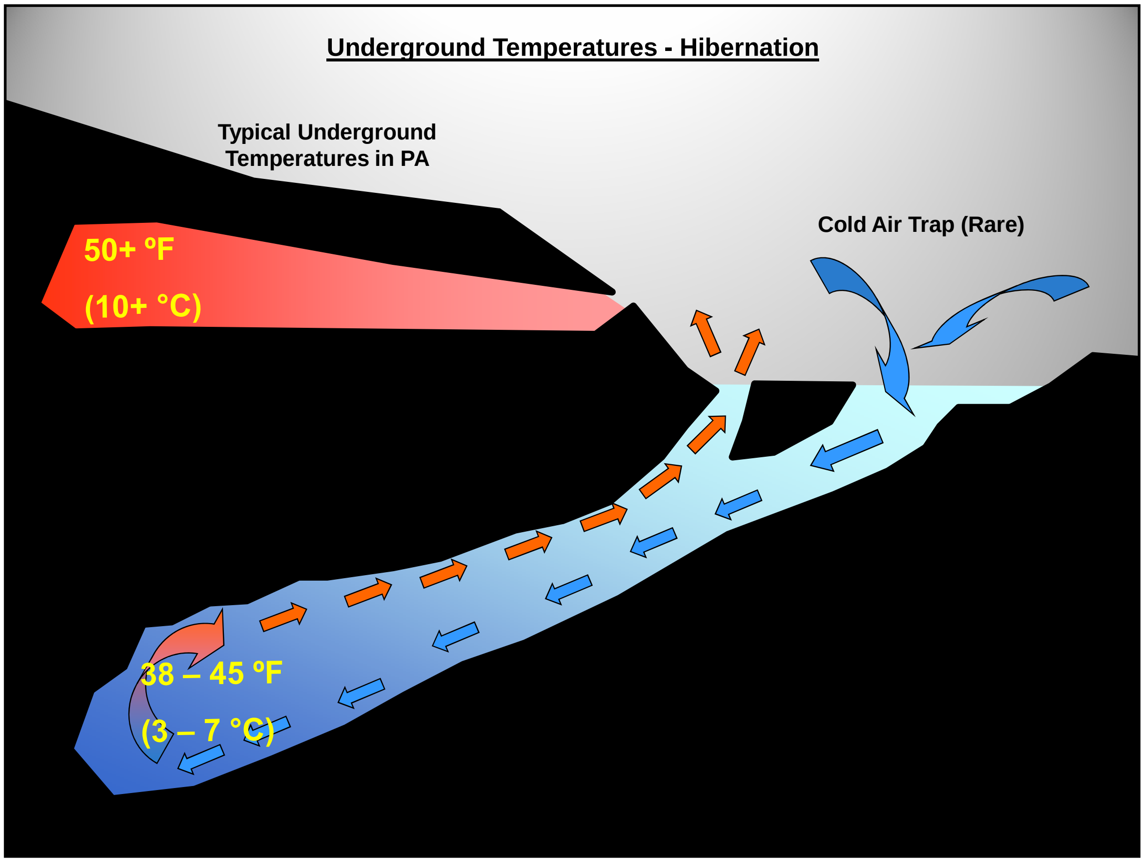


Figure 1. Temperatures of 3º-7º C are considered optimum for Indiana bat hibernacula (Tuttle and Kennedy 2004). These temperatures require a cold air trap where cold air flows into a site while warm air rises and vents out, resulting in some cold air being trapped within the lower tunnels to achieve the aforementioned temperatures.

Figure 2. Existing large tunnels on state land needed to be closed for safety reasons. Fill was blasted and pushed into 3 openings. Two gated openings at the top provided an exchange of air and allowed cold air to drop into the lower portions of the mine. The next winter, Indiana bats were found in the site for the first time.

Bat White-Nose Syndrome Considerations

White-nose Syndrome (WNS) is an emerging disease affecting bats in hibernacula that can result in 2-year population declines in excess of 75% (Blehert et al. 2008). In Pennsylvania and elsewhere in the northeast, some hibernacula have experienced a 99% decline (Frick et al. 2010). A newly described fungus, *Geomyces destructans* (Gargas et al. 2009), is the probable infectious agent. Two Pennsylvania abandoned coal mine sites with large numbers of bats were found due to WNS. These were previously unidentified bat hibernacula. Local residents reported the sites and investigations found extensive mortality at the entrances with bat carcasses layered in the snow pack. Nine abandoned coal mines have documented WNS infections and all coal mines in the northeast coal region of Pennsylvania are likely already infected. Some common bat species may experience extensive declines as time of exposure continues to impact populations, leading to the possibility of extirpation or extinction (Frick et al. 2010).

However, WNS is a new emerging disease and much remains to be learned:

- Do affects increase as bat density increases?
- Do environmental factors within hibernacula play a role (cold and dry versus wet and warm)?
- What is the etiology of WNS?
- What is the ecology of *Geomyces destructans*?
- Will there be survivors?

Recently WNS has been found in France (Puechmaille et al. 2010) with no apparent mortality. It is possible that the fungus has been present in Europe for a long time and bats may have developed immunity. If this is the case, there may be hope for survivorship.

With the spread of WNS, providing more hibernacula for smaller populations may be a critical management option, especially if WNS is found to be most severe in hibernacula with high densities of bats. WNS research is focused on sites that number in the hundreds to thousands of bats; little or no monitoring is being done at hibernacula with 1 to 100 bats. In Pennsylvania, of ~300 sites with interior hibernacula counts of 1 or more bats, ~230 have tallies of <100 bats. Eventually, when monitoring of these small hibernacula begins, extra care will be needed to prevent WNS contamination.

Mines likely offer a variety of environmental conditions (i.e. colder, drier sections) that may minimize the impacts of WNS. Pennsylvania mines also offer many small hibernacula where 10 or fewer bats are captured in netting/live-trapping surveys. In the past, emphasis for preservation and management of hibernacula focused on sites with significant bat populations and those with species of concern. Researchers and managers should now begin management of sites once considered insignificant with just a few common species. Now more than ever, hibernacula management and protection must be emphasized for all species and sizes of populations. Once considered insignificant, some smaller sites may turn out to be critical refugia with regard to WNS.

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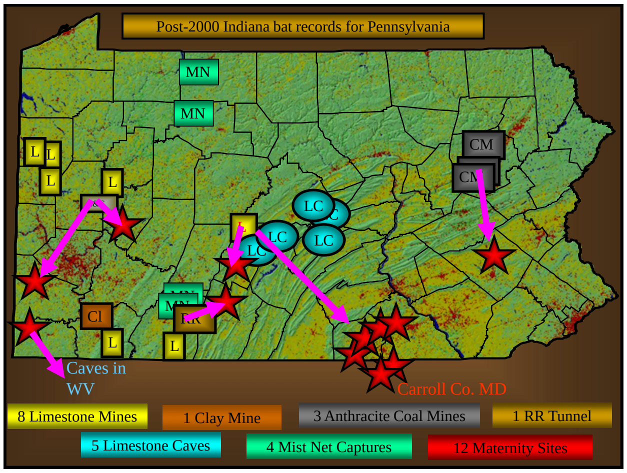
Calvin Butchkoski began his career with the Pennsylvania Game Commission in June of 1982 as a Wildlife Technician for the Bureau of Wildlife Management. His early assignments focused on collecting population and habitat data on upland and forest game species and waterfowl. In the early 1990s, he specialized in non-game mammals and birds. Now a Wildlife Biologist in the bureau's Wildlife Diversity Division, he is best known for his expertise on Pennsylvania's bats and on the Allegheny woodrat, insight gained through many years of extensive field research. PGC research using radio telemetry to study the habits, habitat, and migration of the federally endangered Indiana bat has earned national attention. Allegheny woodrat studies include documenting their statewide distribution, researching their habitat requirements, and developing management strategies.

Son of an Indiana County coal mining and farming family, Butchkoski grew up familiar with the great outdoors and with time spent underground. A hunter and fly-fisherman since his youth, he is now also an enthusiastic whitewater kayaker and mountain biker. After earning an associate's degree in Wildlife Technology from the Pennsylvania State University, Dubois Campus, he spent three years in the United States Marine Corps. While stationed in Annapolis, he continued classes at the University of Maryland. After being honorably discharged, he spent over three years with the Bucktail Council, Boy Scouts of America, as ranger at Camp Mountain Run near Penfield, Clearfield County.

Pennsylvania Bat Gating Efforts



Pennsylvania hibernacula surveys are conducted and evaluated by Pa. Game Commission staff or in the case of most coal mines, by the Department of Environmental Protection (BAMR) and the Office of Surface Mining. Often times these relate to complaints.
BAMR regularly contracts private sources for bat surveys of problem areas.

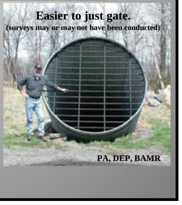
Sites may be gated for several reasons which include:


Significant bat numbers found within


Significant bat activity during swarms (bat detectors)


Significant bat captures (Trapping/Netting)

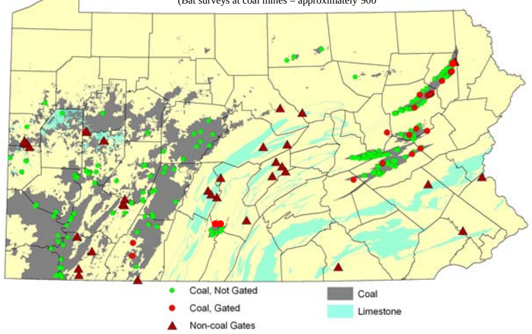

Documentation of endangered or threatened species.


Easier to just gate.
(surveys may or may not have been conducted)
PA, DEP, BAMR

Eighty-seven percent of bats tallied in Pennsylvania hibernacula are in mines

Pennsylvania has approximately 75 gated hibernacula on record; they include 42 abandoned coal mines, 18 other mines (limestone, iron, clay), and 15 limestone caves.

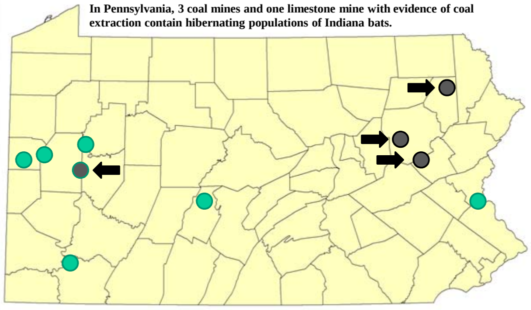
Distribution of gated sites and bat surveys of coal mine openings.
(Bat surveys at coal mines = approximately 900



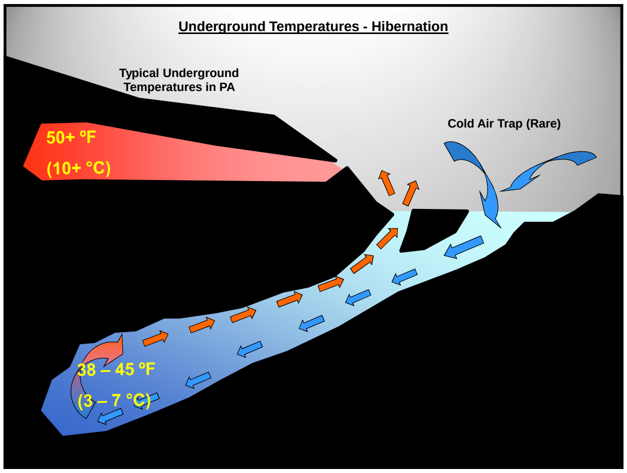
The 7 hibernacula with the highest interior counts are mines - one of which has documented coal extraction.

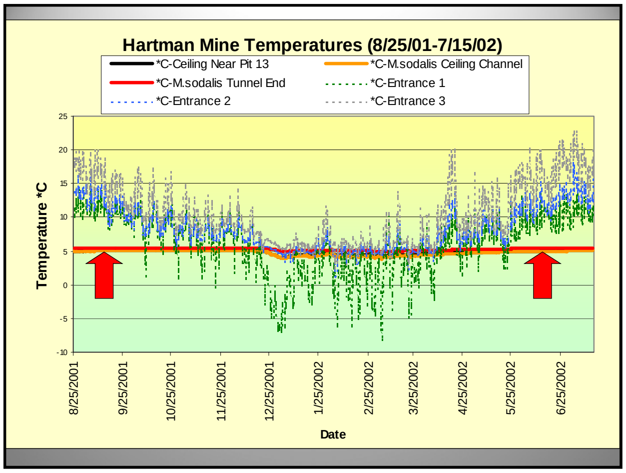
Through trapping, at least 3 coal mines rival these 7 in bat activity.

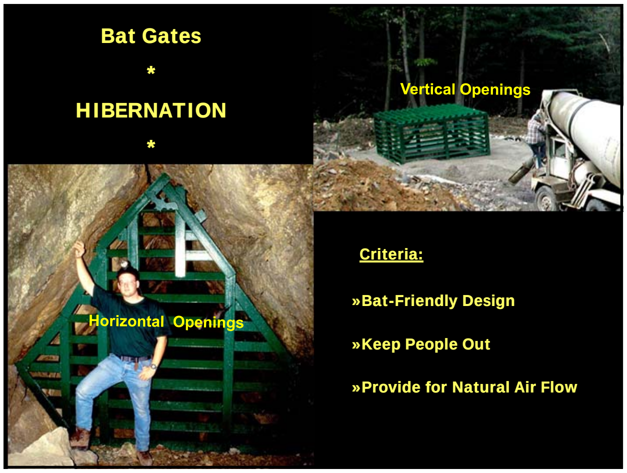
In Pennsylvania, 3 coal mines and one limestone mine with evidence of coal extraction contain hibernating populations of Indiana bats.



Underground Temperatures - Hibernation







Bat Gates

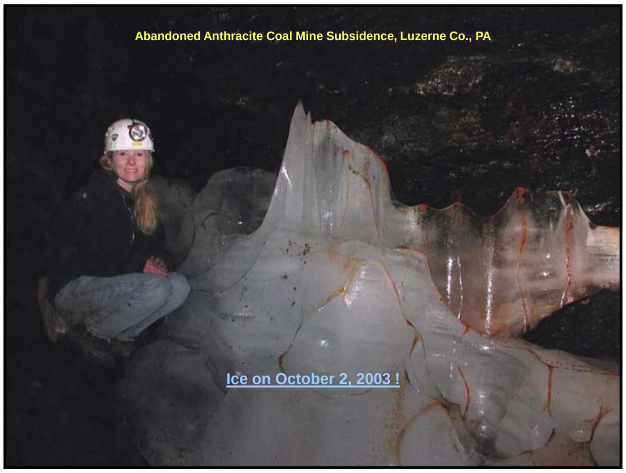
*

HIBERNATION

*

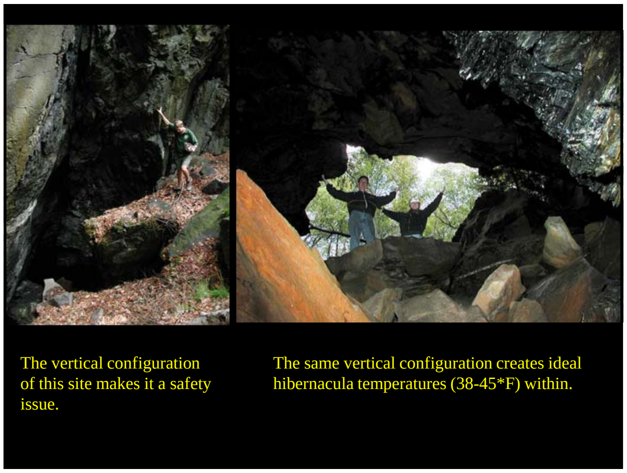
Criteria:

- »Bat-Friendly Design
- »Keep People Out
- »Provide for Natural Air Flow



Abandoned Anthracite Coal Mine Subsidence, Luzerne Co., PA

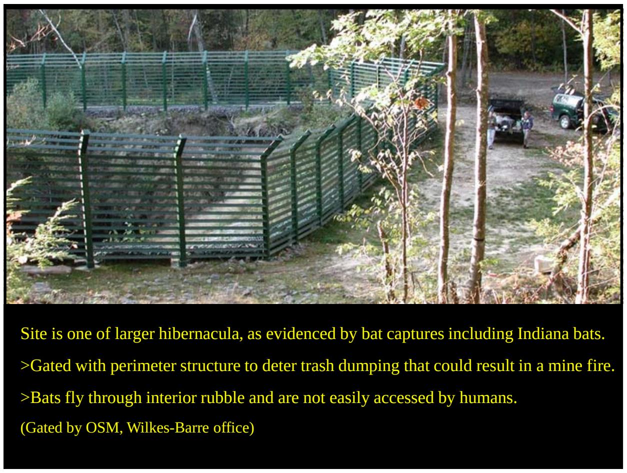
Ice on October 2, 2003 !



The vertical configuration of this site makes it a safety issue.

The same vertical configuration creates ideal hibernacula temperatures (38-45*F) within.

Site has significant visitation by public with illegal dumping and campfires within the mine.



Site is one of larger hibernacula, as evidenced by bat captures including Indiana bats.

>Gated with perimeter structure to deter trash dumping that could result in a mine fire.

>Bats fly through interior rubble and are not easily accessed by humans.

(Gated by OSM, Wilkes-Barre office)

Casparis Mine - Entrance modifications to improve bat habitat and keep people out.

Need: Cold Air Dam

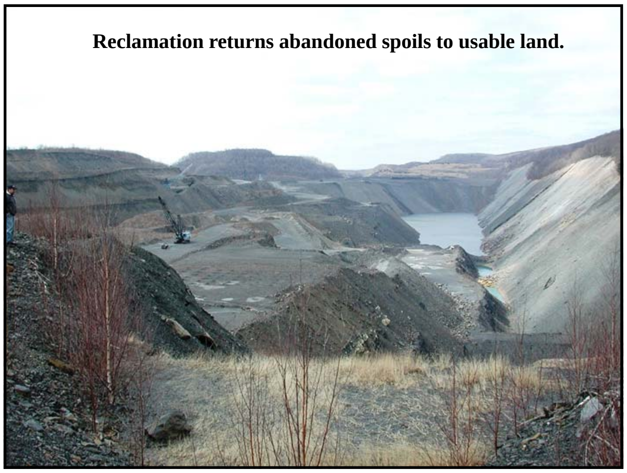
To stop the loss of cold air.

Summer 2005

Additional fill was pushed from surface above.

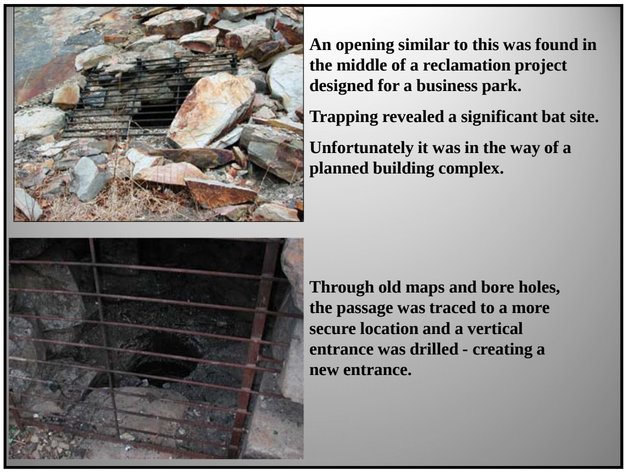
Foreground was blasted to throw debris into openings.

Other-species management considerations included providing rock habitat within mine for the Allegheny woodrat.
(state threatened)



Reclamation returns abandoned spoils to usable land.

Sometimes the land use is compatable with maintaining bat habitat …but sometimes it just doesn't work out.

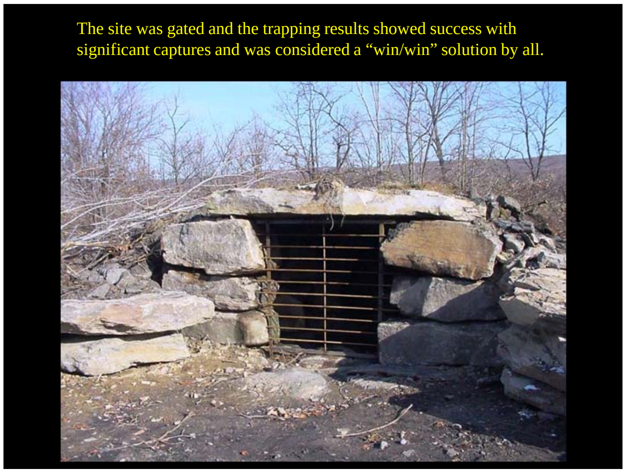


An opening similar to this was found in the middle of a reclamation project designed for a business park.

Trapping revealed a significant bat site.

Unfortunately it was in the way of a planned building complex.

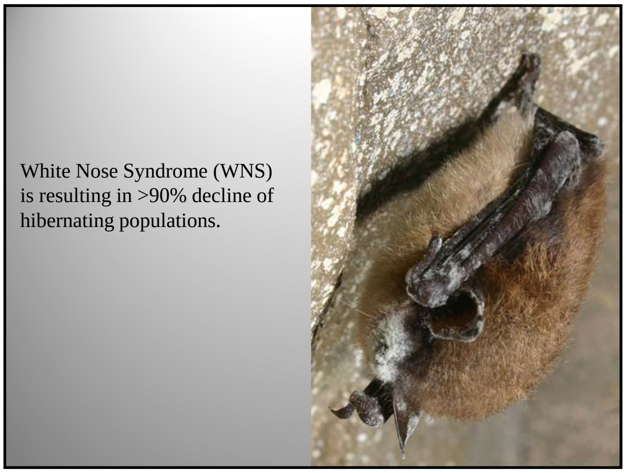
Through old maps and bore holes, the passage was traced to a more secure location and a vertical entrance was drilled - creating a new entrance.



The site was gated and the trapping results showed success with significant captures and was considered a “win/win” solution by all.

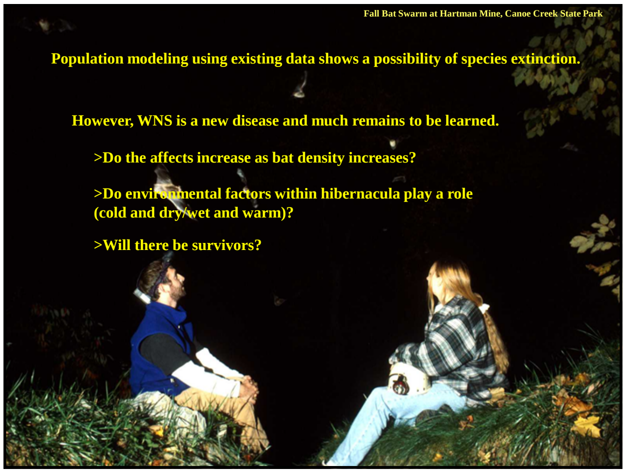
As the business park expanded, the opening was moved again by the developer without consulting biologists. The relocated opening is now in the middle of an open lot and very few bats use it.

However, this exercise does illustrate the potential for creation of new openings - as a last resort of course.



White Nose Syndrome (WNS) is resulting in >90% decline of hibernating populations.

With the spread of WNS, which causes significant mortality of hibernating bats, providing more hibernacula for smaller populations may be a management option, especially if WNS is found to be most severe in hibernacula with high densities of bats. Some mines may also offer a variety of environmental conditions (i.e. colder, drier sections) that buffer the impacts of WNS.



Fall Bat Swarm at Hartman Mine, Canoe Creek State Park

Population modeling using existing data shows a possibility of species extinction.

However, WNS is a new disease and much remains to be learned.

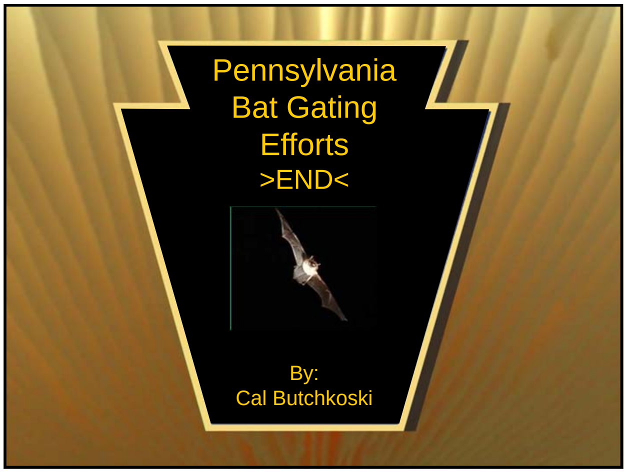
>Do the affects increase as bat density increases?

>Do environmental factors within hibernacula play a role (cold and dry/wet and warm)?

>Will there be survivors?

NEED:

Now more than ever, hibernacula (both large and small) management and protection must be emphasized for *all species*.



Pennsylvania Bat Gating Efforts

>END<

By:
Cal Butchkoski

MICROCLIMATE RESEARCH TO SUPPORT ENDANGERED SPECIES OF BATS IN HELLHOLE AND SCHOOLHOUSE CAVE AND TECHNOLOGICAL ADVANCEMENTS IN MONITORING SYSTEMS

Mike Masterman, Anvesh Singireddy, and Shana Frey
Extreme Endeavors
Philippi, West Virginia

Abstract

Extreme Endeavors has been working under contract with Greer Lime to monitor the environment of Hellhole and Schoolhouse Caves to protect one of the largest hibernacula and roosting sites of endangered species of bats. In this sixth year, we have developed and are continuously improving a cave monitoring system that records microclimate data which has redefined how the underground environment is viewed. We will present the system used to produce this data and some novel results that detail what drives the underground conditions that house the endangered bats.

The undertaking of precise and accurate data collection from environments such as these caves located in Pendleton County, West Virginia required significant electronics research and development and with the technological advancements made, the monitoring potential is unlimited in the future. The future technology available to researchers will be presented and discussed.

Introduction

Greer Lime is the largest limestone producer in West Virginia. The company provides a valuable resource that is used to treat drinking water and to save rivers and streams from acid mine drainage. While the need for limestone is clearly evident, so is the need to protect natural resources. A common objective for both mine operators and governmental regulators is the protection of these valuable resources around the mine.

Under permit by the West Virginia Department of Environmental Protection, Greer Lime must monitor the environments of Hellhole and Schoolhouse Caves because of the Endangered Species Act. Both Hellhole and Schoolhouse Caves have significant numbers of endangered species of bats hibernating and roosting at their respective sites. The question that surrounded this agreement was how an adverse impact to the underground environment is defined and what mechanism created the irregularity.

In 2004, Extreme Endeavors was contracted by Greer Lime to provide environmental monitoring in accordance with its DEP permit. Development of a data collection system that had to be created specifically for this application, taking into account the austerity and general conditions of the target environments is what makes this project more advanced than the great majority of environmental monitoring projects.

To compound the environmental issues associated with conservation and mining, very little knowledge is available as to why bats select certain locations to hibernate and other locations to roost. To complete the daunting task of providing a highly precise monitoring system, while providing the resulting data in such way that it would be accessible from anywhere in the world through the internet, Extreme Endeavors designed the ‘Cave Monitoring System.’ Since then, it has continuously worked to expand the research to provide the greatest benefit for the wildlife, not only in this particular instance, but as a whole.

Cave Monitoring System

The driving challenges were to withstand the harsh cave environment while remaining precise and reliable. The development started with a small module that samples temperature, pressure, and light. The sampling of air pressure incorporated a Micro Electro Mechanical System (MEMS) based sensor that was developed as an altimeter for precise missile guidance and provides an accuracy and precision of .002 PSI. The temperature sensor utilized a 1 Kilo-Ohm platinum element and provides a precision of .01 Degrees Fahrenheit. The data from these sensors is collected and stored on an on-board 64MB memory chip. These electronics are enclosed in an air/water tight aluminum box (Figure 1).

Figure 1. Cave Monitor Sensor.

Schoolhouse Cave is outfitted with a sensor package on the surface and another positioned some 600 linear feet underground, centered in a passageway that is regarded as the hibernacula of Virginia Big Ear bats. These locations are shown in Figure 2. The modules in this cave are referred to as Mod11 on the surface and Mod12 inside the cave.

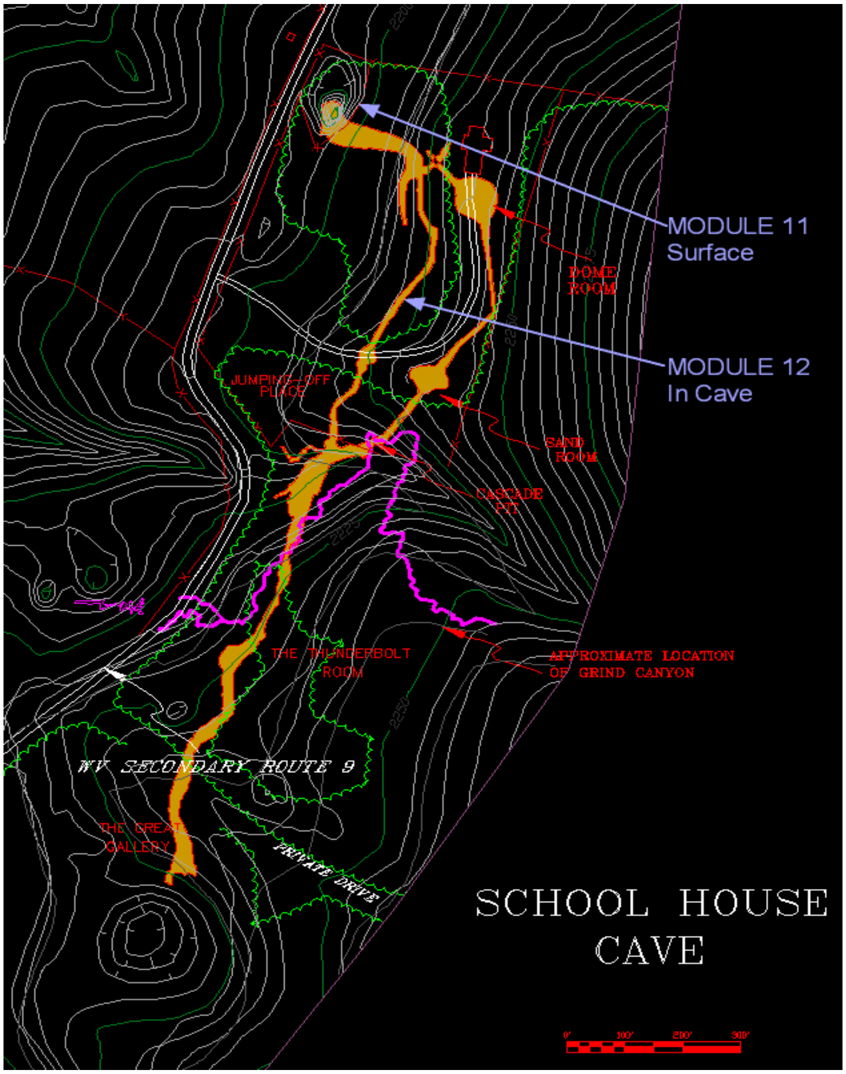


Figure 2. Sensor Location in Schoolhouse Cave.

As shown in Figure 3, Hellhole has a total of four sensors. The surface sensor (Mod21) is located next to the fence line, out of the sun, and just inside the sinkhole. The interior sensors are located in three different areas: in the passageway to the

Shipp Room (Mod22), also referred to as the Triple Dome Location; in the corkscrew passage that leads to the southern extension of Hellhole Cave (Mod23); and in the Hellhole Lower Sodalis site (Mod24).

All the modules in each cave are connected to a surface module which acts as a gateway between the radio system and the modules. The data from the caves transmitted from the entrance of the caves to a repeater station located on a mountain top (Figure 4). From there the signal is relayed down to the base station at Greer Lime's scale house using a 900MHz radio system with 128-bit encryption. At the scale house, a Linksys router is used to connect the 'Cave Monitoring System' to the Internet.

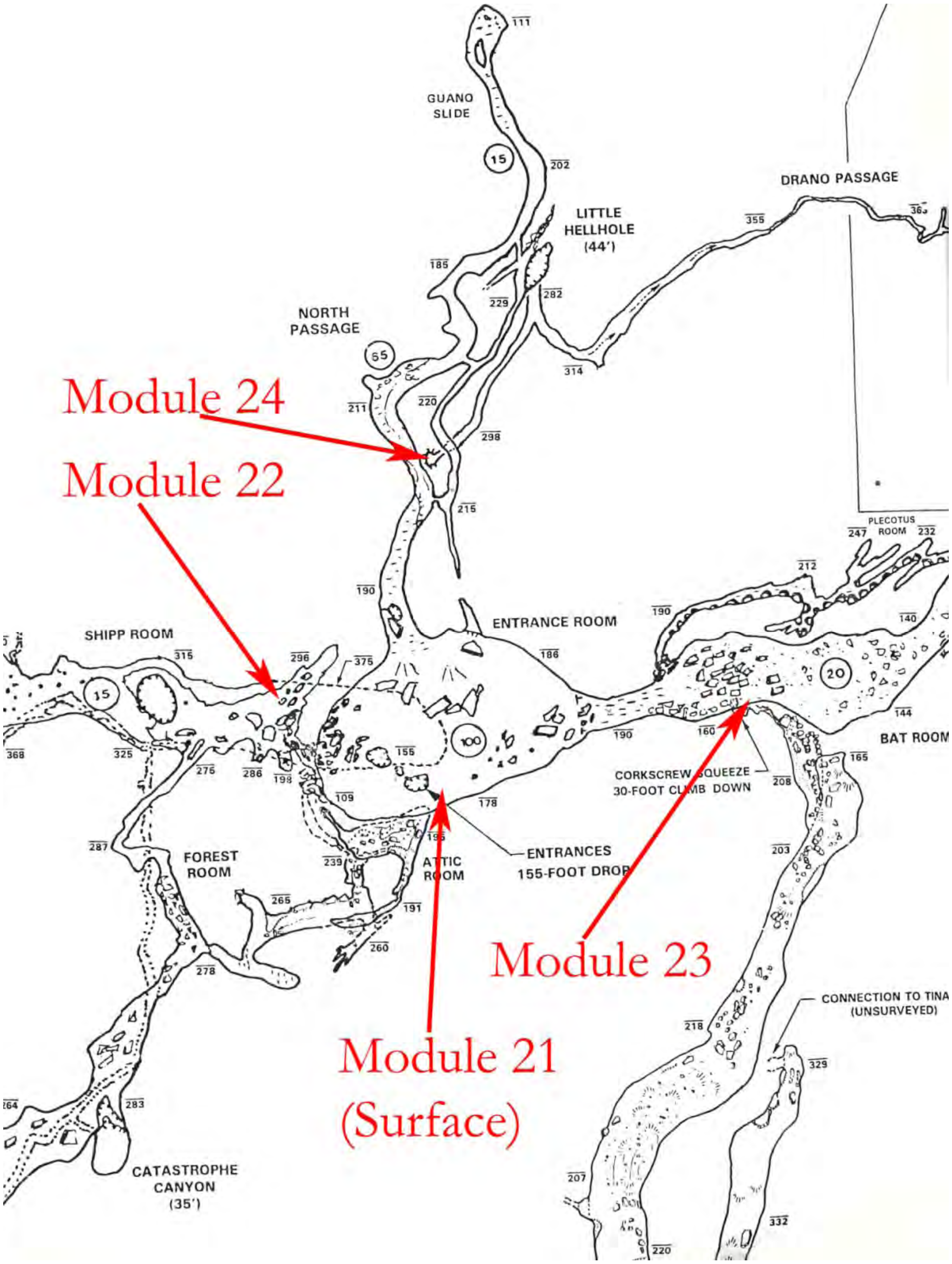


Figure 3. Sensor Locations inside Hellhole Cave.

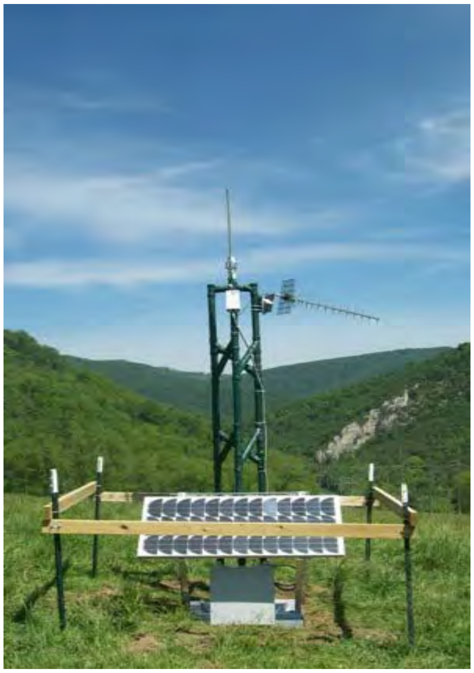


Figure 4. Portable Repeater System.

Temperature Data Results

Data logged at the Hellhole and Schoolhouse Caves is downloaded weekly via a secure internet connection. This data is processed using the proprietary MATLAB code that analyzes the temperature trends and fluctuations of the cave passages. Changes in environmental conditions are compared to the daily, monthly, and annual trends recorded during previous years and are documented in a project plan. What makes this approach feasible is how Extreme Endeavors has defined its approach to temperature monitoring, viewing the cave temperature as a dynamic and ever changing system.

Figure 5 shows the difference in the quality of the sensor system developed by Extreme Endeavors versus the standard sensors used by current regulatory agencies. Extreme Endeavors is using the advanced sensor system to analyze the micro-environment and perform advanced analysis of the dynamic temperature cycle a cave goes through on both short and long time frames.

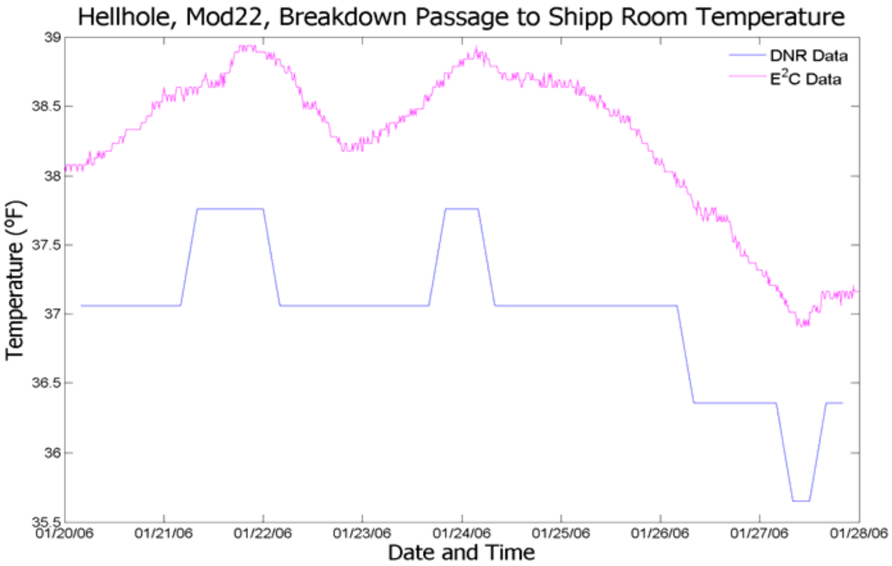


Figure 5. Extreme Endeavors Data versus Regulatory Agencies Data.

While most people understand seasonal temperature variations that occur in a cave passage from winter to summer, as shown in Figure 6, closer analysis shows that the cave passages also undergo various environmental factors that affect the daily microclimate as well. If we take a discrete Fast Fourier Transform to look at the data in the frequency domain, we will find that every passageway being monitored displays daily, twice daily, and three times daily temperature changes. The discrete FFT of Hellhole is shown in Figure 7.

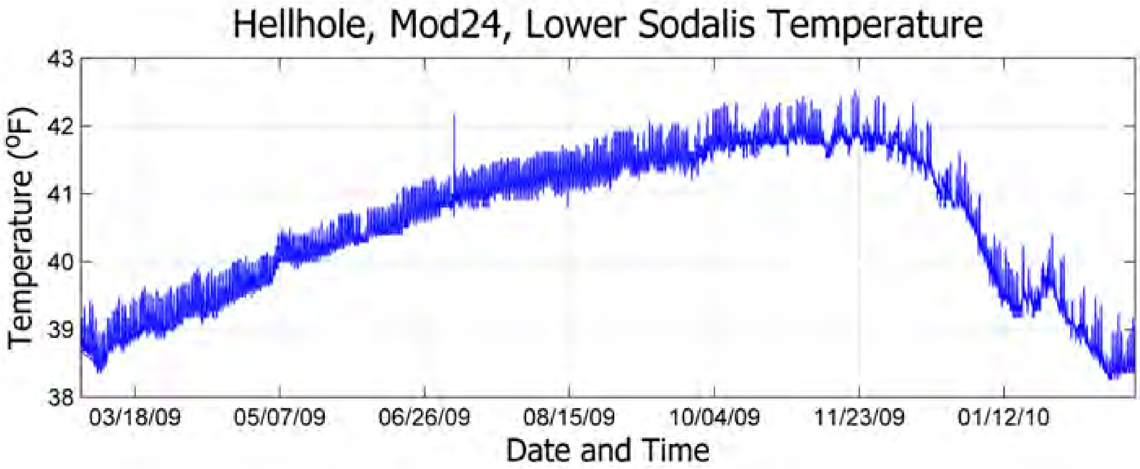


Figure 6. Annual Variation in Temperature for Lower Sodalis Site Temperature.

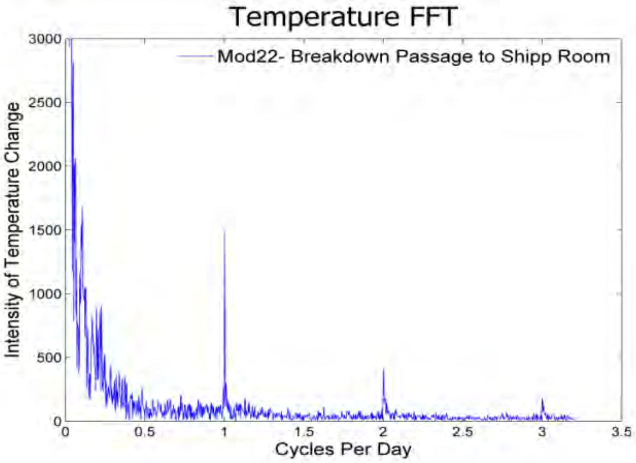


Figure 7. Mod22 Fast Fourier Transform of Temperature Data.

To better understand the environment of a cave, we have to determine what drives that environment. First, we can easily see the variations in daily external air pressure causing changes in the cave by pushing and pulling air from different passages of the cave. However, the temperature in the cave has been shown to be affected by water levels present in various locations. At the Lower Sodalis site in Hellhole, for example, we found that daily temperature variations increased drastically then subsided after a large rainfall. The passageway behind the Lower Sodalis site is normally sealed with water, but when the water levels become sufficiently low, the passageway is opened up. This allows air to flow and thereby changes the environment of the passage. When heavy rainfall then occurs, it seals the passage back up, returning it to what we view as the normal operating condition.

It should also be noted that for the last two years the Mod24 passage has remained fairly stable in its temperature and that snowfall data is needed to properly summarize the groundwater levels. In the two winters since we saw large daily temperature cycles inside of Hellhole, the amount of snowfall has been increasing. When the snow melts, it raises the water levels underground and keeps the passageways behind the Lower Sodalis site closed off from air movement.

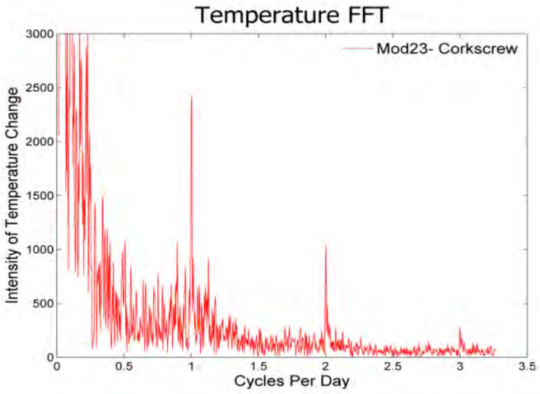


Figure 8. Mod23 Fast Fourier Transform of Temperature Data.

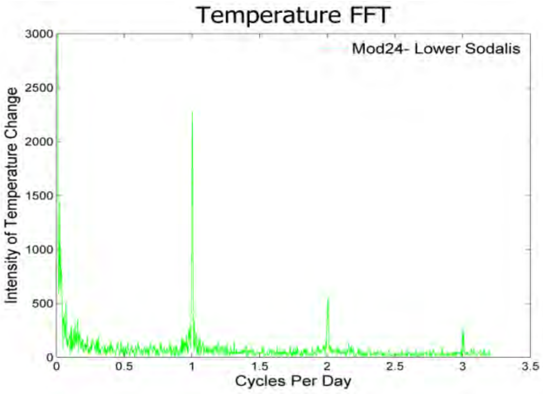


Figure 9. Mod24 Fast Fourier Transform of Temperature Data.

Most of Hellhole and other caves in the region are notably warmer than the Lower Sodailis site. In order to have these cooler temperatures, there must be a heat sink that is absorbing the warmth inside this passage. As heat energy reaches the heat sink, it can be absorbed in a similar manner to the way sponges absorb water. Heat enters an object, warming it. The longer the object is exposed to the heat source, the more heat it absorbs. It should also be noted that this passage shows less interaction with the outside environment than the other passageways we have been analyzing. A change in air pressure outside can change the temperature elsewhere in the cave by as much as four or five degrees, whereas the Lower Sodailis region would only experience half a degree temperature change. Less airflow from the blocked passage, therefore, forces other factors to dictate what controls the temperature.

What we have seen in January of 2010 is that the Lower Sodailis site inside the cave reacts to temperature changes outside more than it would from higher temperature changes outside the cave in March of 2010. The difference noted is that in March there were several feet of snow on the ground. It is hypothesized that as the snow melts, the water is close to 32 degrees and it runs into the ground, providing a cooler heat sink than water that has been underground for a long period of time.

From the last year it is evident that the snow fall, its melting, and outside temperatures all play critical roles in the microclimate of the Lower Sodailis site. The exact interaction between air pressure, outside temperature, precipitation and water levels is still unknown, but it is evident from this data that all contribute to setting up the microclimate of the Lower Sodailis site.

Additionally, the data from the past several years show the temperature of the Lower Sodailis site has slightly dropped in the previous three years. On average it is almost one degree cooler; however, weather data has shown that the snow fall has been increasing over the last three years. Since the snow fall and run off from melting affect the short term climate of this passage, we can assume that it has a long duration effect. This also makes sense from a practical standpoint. During heavy snow melt from the Rocky Mountains, the rivers run extremely cold. As the run off finishes in late July/August, the rivers warm up. This is no different than the snow melt in Appalachia where water draining underground from snow melt is cooler than that of normal rain water and, once the water supply is cooled, it affects the microclimate of the cave, bringing the average temperature down.

Air Pressure Data Results

Air pressure plays a key role in the underground environment and monitoring systems. Many times it is noted that the changing air pressure outside will drive the conditions inside the cave. The data in Figure 10 demonstrates the relationship between the air pressure data recovered from the inside and the outside of the cave. There is a significant difference between the levels of air pressure inside and outside the cave because of the altitudinal difference from the entrance of Hellhole. Figure 10 demonstrates, however, that changes in air pressures do occur inside the cave in a pattern relative to what happens outside. By removing the DC components from the data, filtering the signal and zooming in on the data, we produce Figure 11, which shows that the pressure inside the cave is changing before the pressure outside the cave. By applying a Fast Fourier Transform of the data, we obtain Figure 12, which demonstrates the frequencies of changes in air pressure that occur at each module located inside and outside of Hellhole Cave. Figure 13 utilizes the units of cycles per day and clearly shows changes on the order of once per day and twice per day.

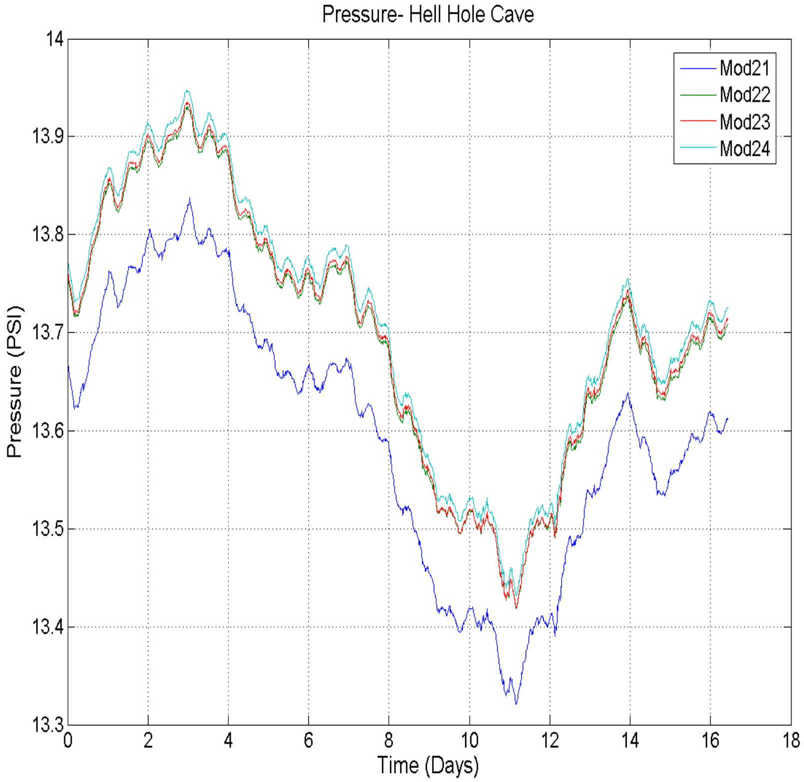


Figure 10. Pressure inside and Outside of School House Cave.

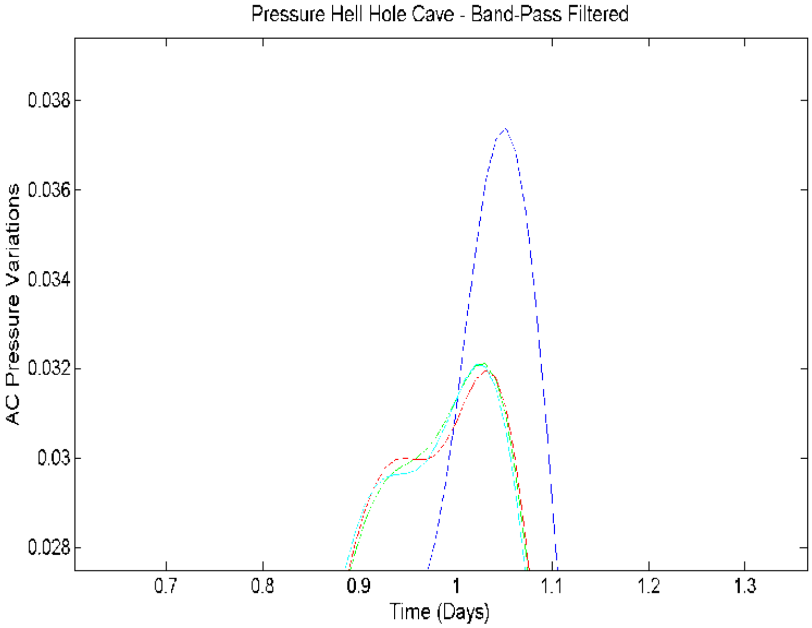


Figure 11. Close Up of Filtered Air Pressure.

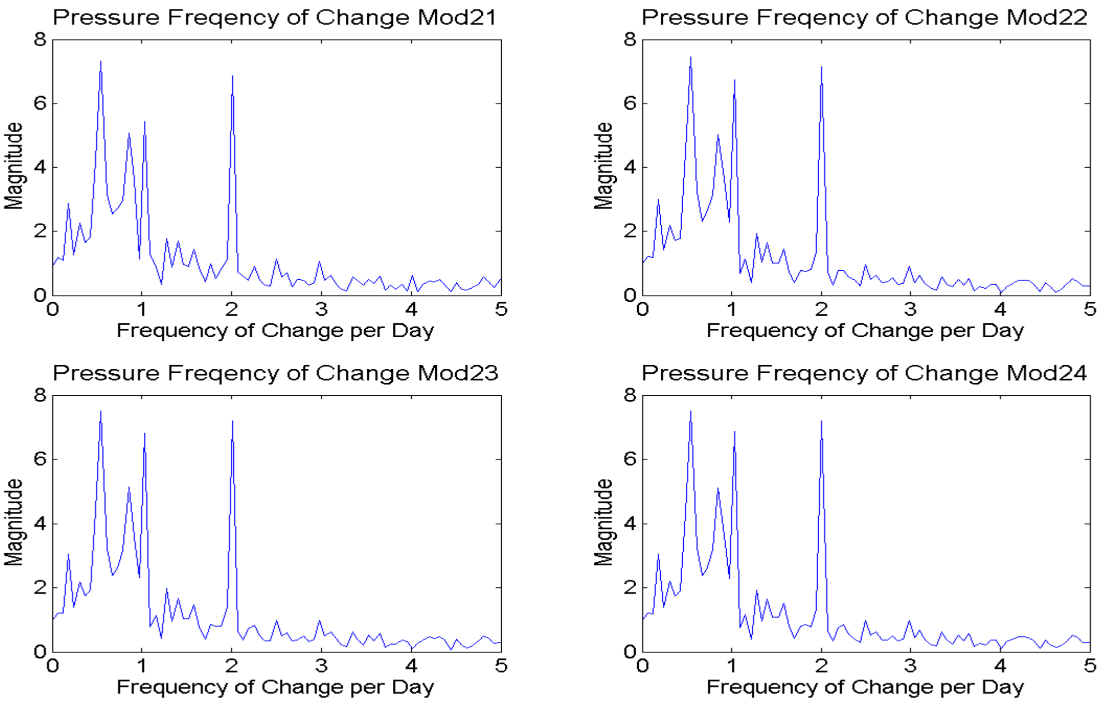


Figure 12. The frequencies of change in air pressure that occur at each module located inside and outside of Hell Hole Cave and outside of Hellhole Cave.

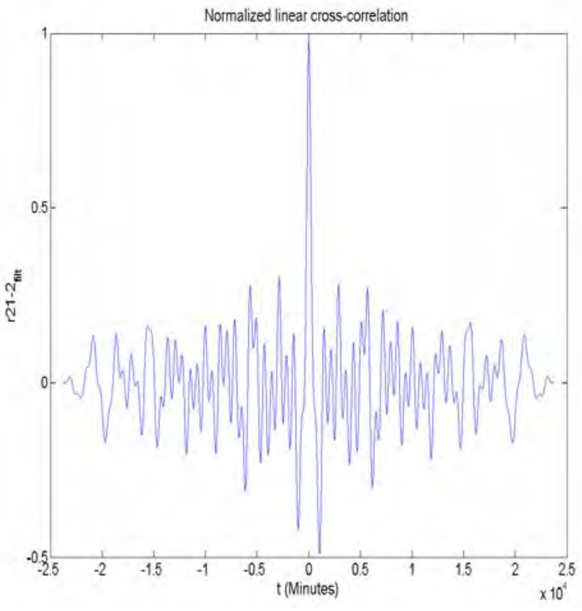


Figure 13. Correlation between the air pressures outside and inside the cave.

Taken in October, 2004, the correlation between the air pressure outside and inside the cave is shown in Figure 14, with the peak zoomed in on Figure 15. The sample rate of the data is once every 15 minutes, which is not precise enough to show the time delay in the correlation of data, hence further research is required utilizing the SMART system operating at a sample rate of one minute. However, this information shows that the change in the air pressure just outside of the cave does drive the change that occurs within the cave. This effect is currently under investigation and is being researched since most methane explosions within mines are correlated to times of high barometric pressure. Our data has shown that when the air pressure dropped due to change in weather conditions, the leading and lagging effect that previously occurred desists.

The time delay is critical to the environment because it is a measure of how much the outside environment will affect environment inside the cave. The amount of environmental effect can be changed from a variety of parameters including, but not limited to, the change in amount of passageway behind the sensors, the amount of passageway in front of the sensor, or additional passageways opened up from the outside environment into the cave.

In considering pressure effects, a caver opening a small hole from six inches in diameter to 2 foot in diameter so that they can crawl through it, can greatly affect the air flow through a passageway and change the overall condition of the passage. This pressure change affecting the environment is exactly what happed as described above when the passageway behind the Lower Sodailis site drained and then refilled with water.

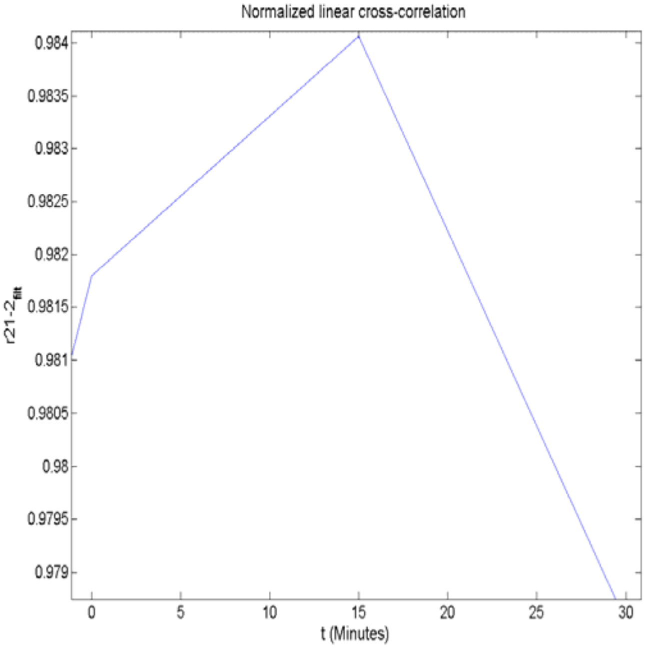


Figure 24. Cross Correlation Peak between inside and outside of cave.

Additional Research Involving the Partnership between Extreme Endeavors and Greer Industries

Low Frequency Sound

Extreme Endeavors worked under a Space Act Agreement with NASA Langley in the development, testing, and analysis of infrasonic sensor technology. Under the Innovative Partnerships Program, Extreme Endeavors and NASA Langley utilized a small, compact infrasonic sensor designed for the application of cave detection on Mars and for listening for movement inside an underground facility. Greer Industries provided testing facilities and provided supporting data to show how the movement of air in the cave correlates to the infrasonic sounds.

The issue that has restricted the use of infrasonic equipment in the past is the footprint size. Infrasonic systems have been known to provide low power-consumption solutions and, due to the excellent propagation characteristics of low frequency sound, these instruments could sense anomalies occurring at a considerable distance. The primary disadvantage of this technology is that most applications require wind sound filtering, with this filter approximately the area of a football field. Not only does this take a considerable amount of real estate but the construction and placement of the wind filter is a significant task that could take one to two days per system. Further, it must be operated on a large flat region and is thus not feasible for a remote area, such as a mountain crag, within a cave, or on a battlefield. The large size also limits the amount of sensors that can be placed, making triangulation difficult.

During this research, several different caves were monitored. Three infrasonic spectrums are presented in Figure 15. These particular three spectrums were chosen because they came from different sized entrances of caves.

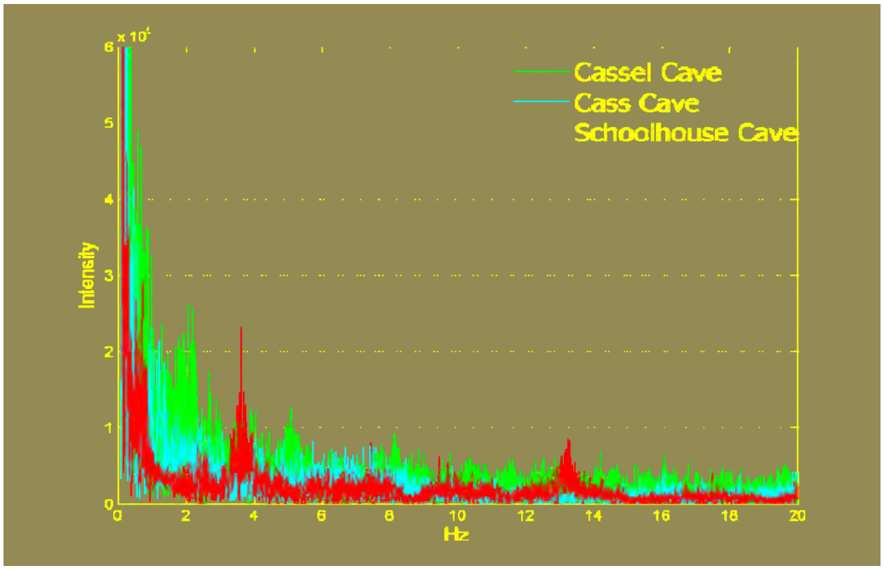


Figure 15. Infrasonic Spectrum of Cassel Cave, Cass Cave and Schoolhouse Cave.

From the data in Figure 13, we can conclude that infrasonic sound is emitted from caves and that this presents a viable means to detect and monitor entrances. The size of the entrance, extent of the cave, and its interior geometry contribute to the low frequency acoustical signature for the three cases presented in the chart and provide a couple of different general rules. The noise from two to five hertz appears to be dependent on the size of the entrance. Other factors may affect the readings, such as the waterfall at Cass Cave and the multiple entrances of Cassel Cave.

It should also be noted that the Schoolhouse Cave spectrum shows peaks of around 3.5 hertz and 13 hertz. This correlates to the spacing of the metal members of the gate covering the entrance. A literature search was performed to see how bats are attracted to caves and to date there have been no reliable conclusions as to how bats find caves. In addition, literature searches were conducted on the testing of bats' abilities to hear in the infrasonic range. It was found that most of the research was conducted with a bat's ability to hear extremely high frequency sounds. This research leads us to believe that if a bat can hear infrasound frequencies of sound (similar to a dog), that it could use this as a methodology to detect caves and underground facilities.

High Frequency Acoustical Monitoring

When Extreme Endeavors performed maintenance on the cave monitoring system on January 11, 2010, we noticed two bats flying around the entrance of Hellhole. Because this was out of the ordinary, the West Virginia Department of Natural Resources was notified within one hour of the sighting. It was later confirmed that Hellhole was infected with White Noise Syndrome. To assist in the research of WNS, Extreme Endeavors linked a sonar bat recording system through the wireless bridge around Greer Lime's Environmental Monitoring System so that bat acoustical sounds could be placed on a computer server anywhere in the world.

On March 5th, an acoustical monitoring system was secured to the fence around Hellhole, as shown in Figure 16. Power is supplied to this system by Greer Lime's cave monitoring system. When acoustical data is received, file transfer protocol is used to place the data on the server at the WVDNR in Elkins, West Virginia.

For the first few days of operation, in approximately 4 1/2 days' time, some 3.7 gigabytes of data have been transferred through the cave system. This data describes the acoustical recordings of bats flying out of Hellhole as a result of White-nose Syndrome. What is most impressive about this data collection is that it involves the monitoring of bat acoustics remotely in real time. Figure 17 shows the successful number of chirps recorded over a three-day time period through this system.

Figure 16: Acoustical Data Capture System at Hellhole Cave

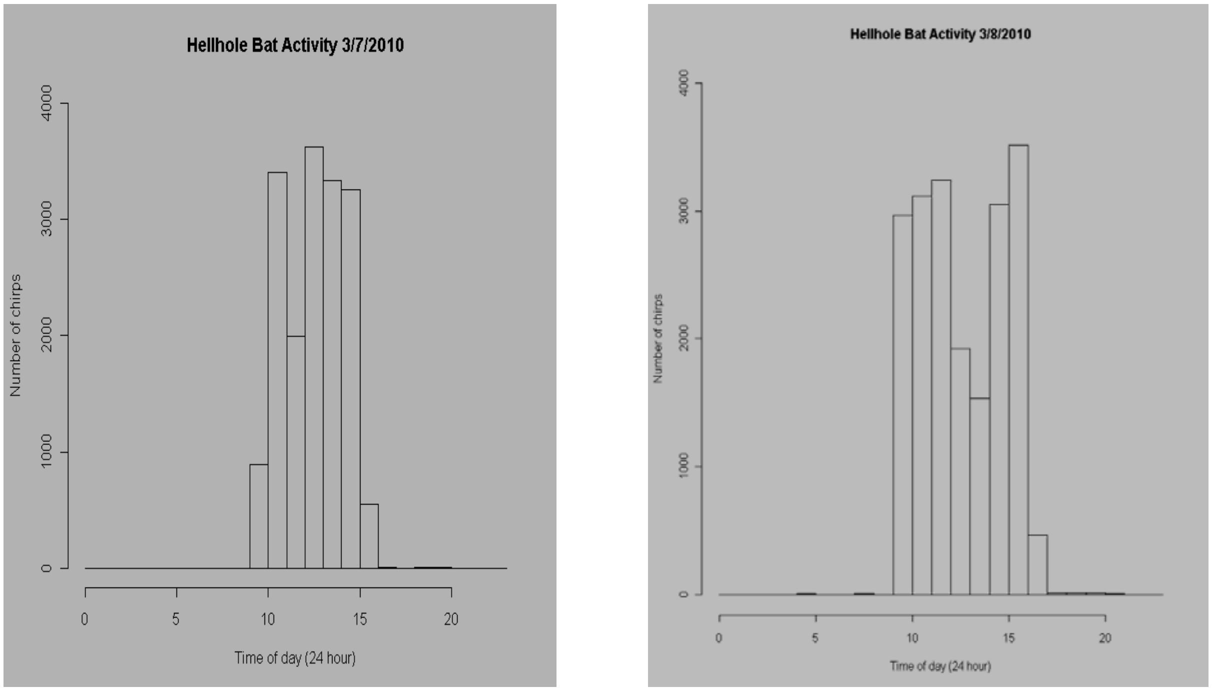


Figure 17. Bat Chirps Recorded in Real Time, Using Greer's Environmental Monitoring System.

Conclusion

During the past six years of monitoring, Extreme Endeavors has found no adverse impacts on the environment of the Schoolhouse and Hellhole Caves as a direct result of Greer Lime's mining operations. We have learned a considerable amount about the environments that the bats choose and the dynamics of the cave environment. These findings have not only benefited environmental research, but have provided information to help NASA explore and search for underground chambers on Mars and to assist our soldiers in the detection of underground facilities where enemy combatants may be hiding.

Microclimate Research to Support Endangered Species of Bats in Hellhole and Schoolhouse Cave and Technological Advancements in Monitoring Systems

Funding for this Work was Provided By Greer Industries/Greer Lime, Whose Commitment to the Environment Is Noted and Greatly Appreciated.

Technical Information Provided by Extreme Endeavors

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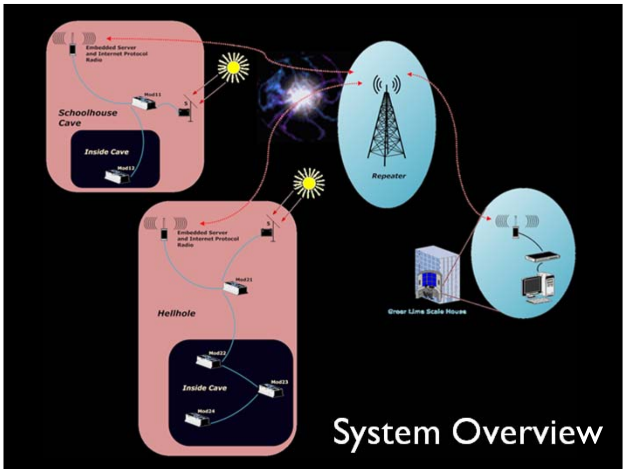
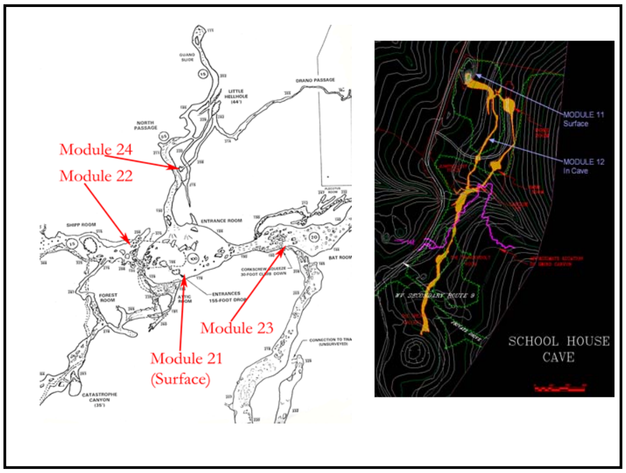
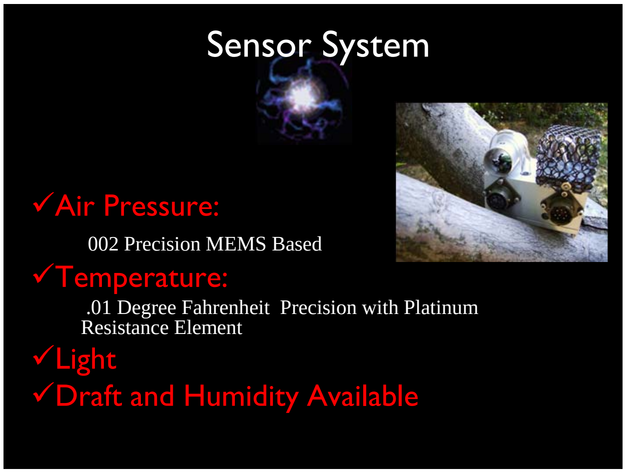
- Anvesh Singireddy: Lead Engineer , Extreme Endeavors
- Shana Frey: Chief Financial Officer, Extreme Endeavors



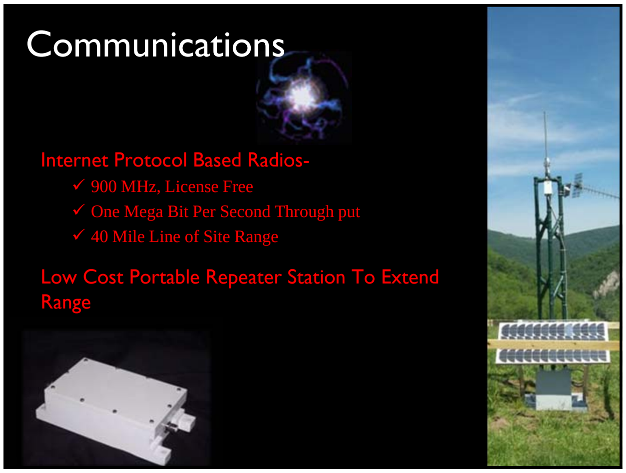
System Overview





Sensor System

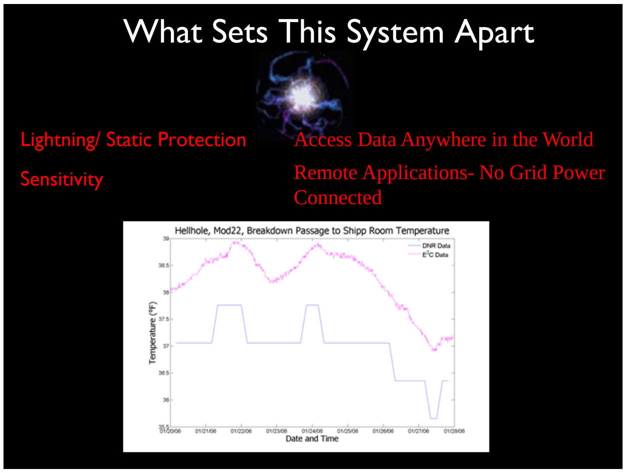
- ✓Air Pressure:
  - 002 Precision MEMS Based
- ✓Temperature:
  - .01 Degree Fahrenheit Precision with Platinum Resistance Element
- ✓Light
- ✓Draft and Humidity Available



Communications

Internet Protocol Based Radios-
- ✓ 900 MHz, License Free
- ✓ One Mega Bit Per Second Through put
- ✓ 40 Mile Line of Site Range

Low Cost Portable Repeater Station To Extend Range



What Sets This System Apart

Lightning/ Static Protection

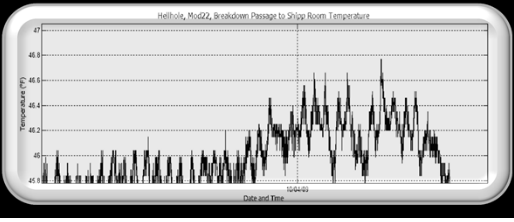
Sensitivity

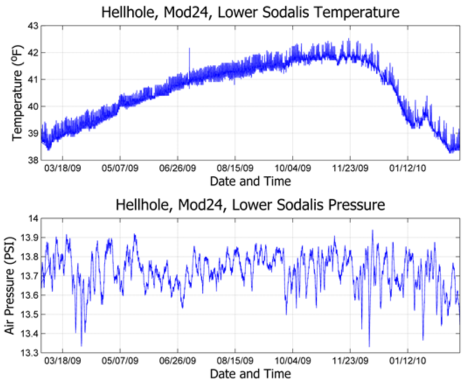
Access Data Anywhere in the World

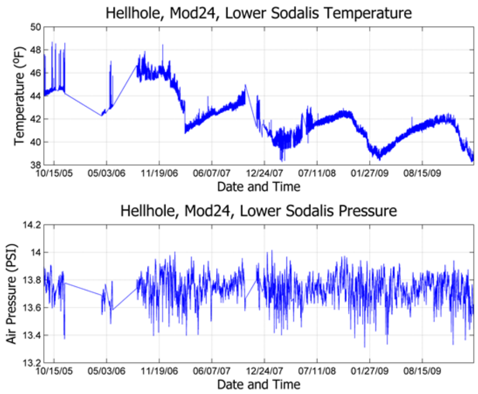
Remote Applications- No Grid Power Connected

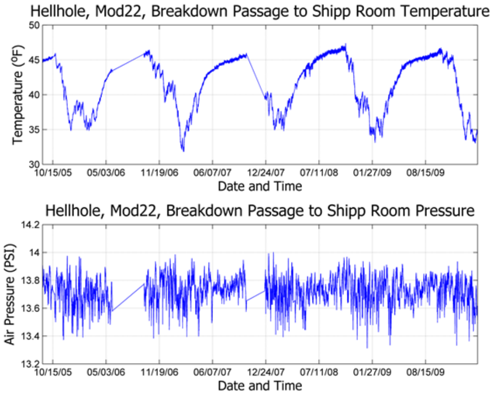
Temperature Recording Dependencies

- ✓ Temperature is a Very Dynamic Item in a Cave (Despite What Most Believe)
- ✓ We Can Obviously See Daily Temperature Changes with the Correct Sample Rate, Precision and Accuracy
- ✓ We Can Also See Temperature Change based on the Structure of the Cave

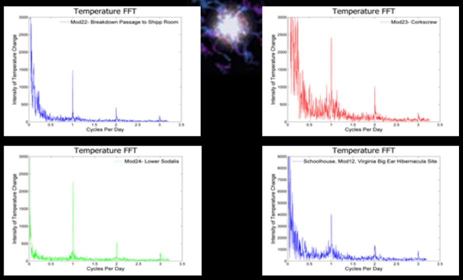








Detailed Analysis…

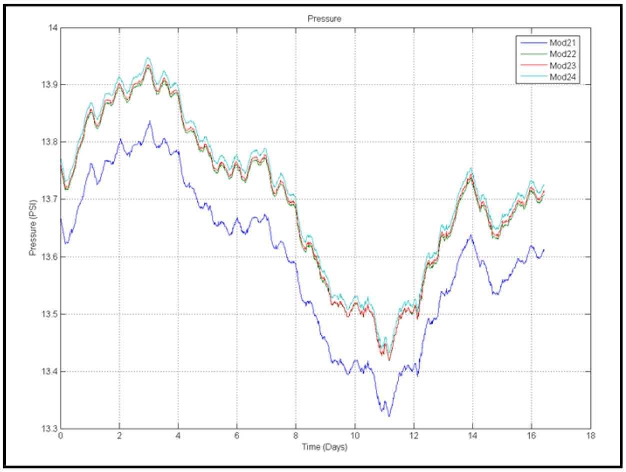


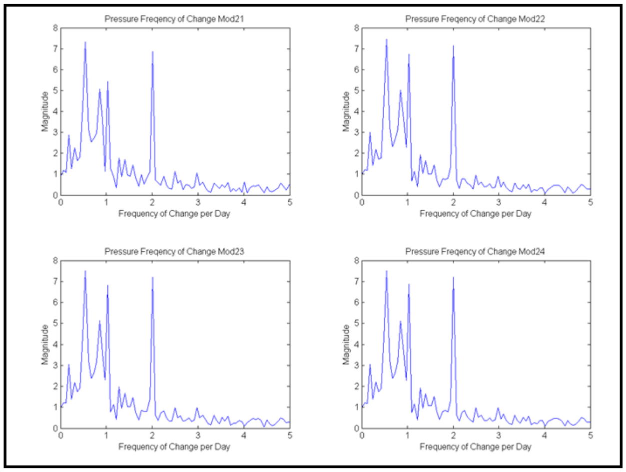
FFT shows Daily, Twice Daily and Three Times Daily Temperature Change

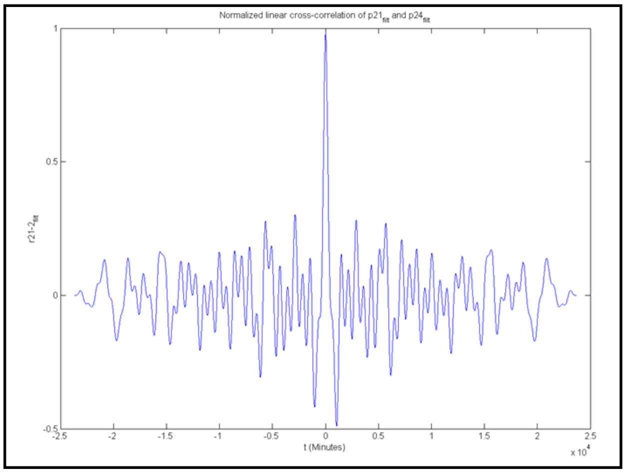
Air Pressure is One of the Key Elements that Drive the Cave Environment

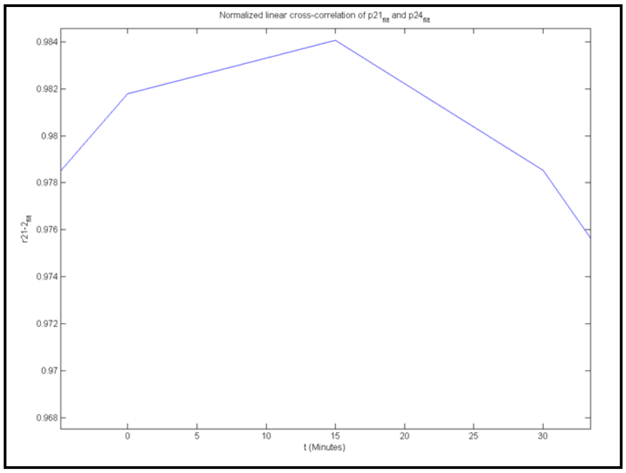
Air pressure is changed through

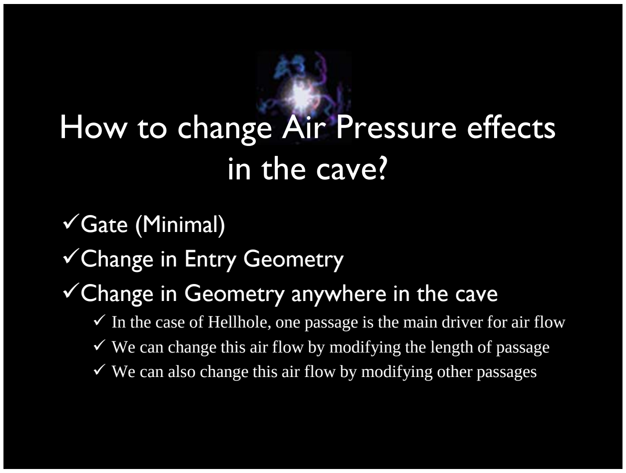
- ✓ Daily, Twice Daily and Three Times Daily swings
- ✓ Weather Patterns
- ✓ Changes to Cave Geometry





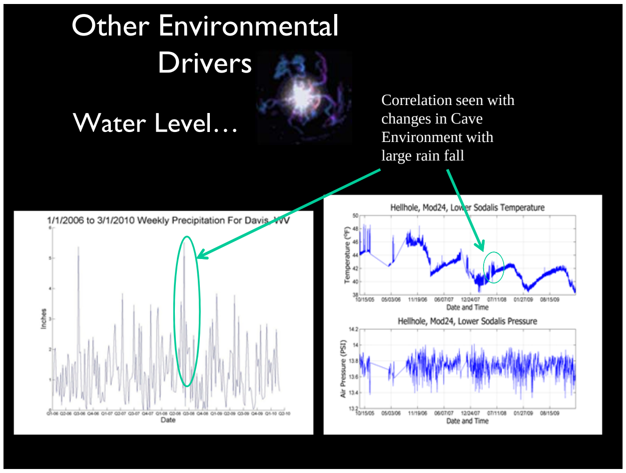






How to change Air Pressure effects in the cave?

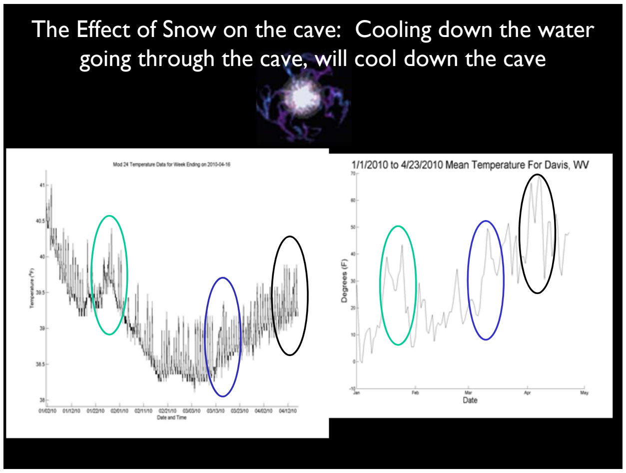
- ✓Gate (Minimal)
- ✓Change in Entry Geometry
- ✓Change in Geometry anywhere in the cave
  - ✓ In the case of Hellhole, one passage is the main driver for air flow
  - ✓ We can change this air flow by modifying the length of passage
  - ✓ We can also change this air flow by modifying other passages



Other Environmental Drivers

Water Level…

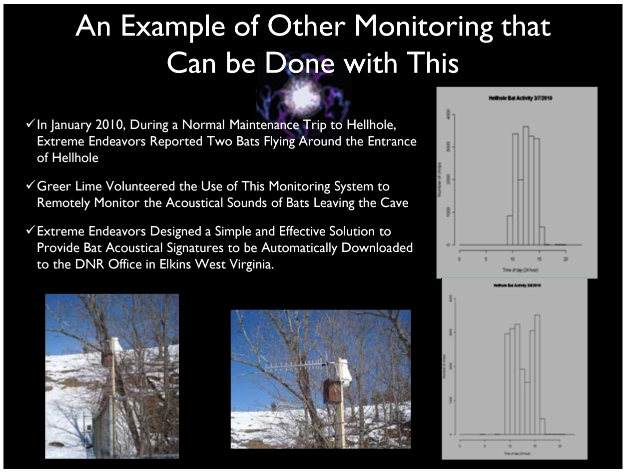
Correlation seen with changes in Cave Environment with large rain fall



The Effect of Snow on the cave: Cooling down the water going through the cave, will cool down the cave

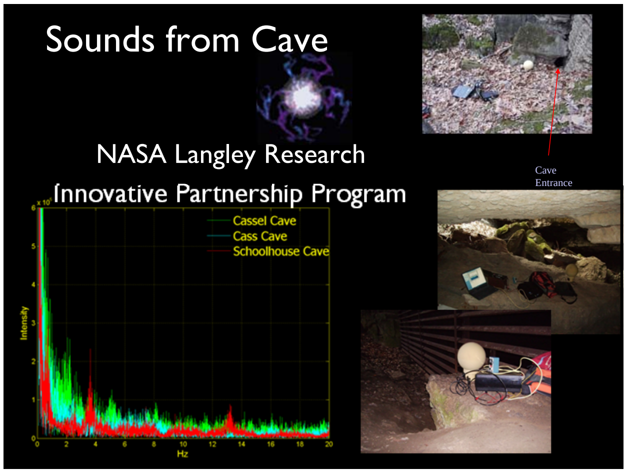
What the future will bring

- ✓ Remote Monitoring Is Available, More Information Available with Less Personnel Time
- ✓ As Sensor and Electronics Increase in Precision and Accuracy, We Will Continue to Learn More
- ✓ Cross Cutting Technology is Critical to Advancement



An Example of Other Monitoring that Can be Done with This

- ✓ In January 2010, During a Normal Maintenance Trip to Hellhole, Extreme Endeavors Reported Two Bats Flying Around the Entrance of Hellhole
- ✓ Greer Lime Volunteered the Use of This Monitoring System to Remotely Monitor the Acoustical Sounds of Bats Leaving the Cave
- ✓ Extreme Endeavors Designed a Simple and Effective Solution to Provide Bat Acoustical Signatures to be Automatically Downloaded to the DNR Office in Elkins West Virginia.



Sounds from Cave

NASA Langley Research

Innovative Partnership Program

What We Recommend

- ✓ Better Defined Monitoring and Remediation Requirements for Industry
- ✓ Praise for Industry that Supports the Environment
- ✓ Work to Understanding Industry Needs and be Able to Advise for an Environmentally Sound Solution
- ✓ Increased Precision and Accuracy in Monitoring by State and Federal Agencies

Session 5

RESEARCH EFFORTS AND RESEARCH NEEDS

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

Bats and Coal Mining: Big Picture Research Needs
Dr. David L. Waldien, Mylea Bayless and Michael Baker, Bat Conservation International, Austin, Texas

Bat Conservation and Energy
Christy Johnson-Hughes, U.S. Fish and Wildlife Service, Arlington, Virginia

Acoustic Monitoring and Sampling Technology
C. Ryan Allen, Shannon E. Romeling and Lynn W. Robbins, Department of Biology, Missouri State University, Springfield, Missouri

White-Nose Syndrome: An Overview of Ongoing and Future Research Needs
Dr. Thomas H. Kunz, Center for Ecology and Conservation Biology, Department of Biology, Boston, Massachusetts, Jeffrey T. Foster, Winifred F. Frick, A. Marm Kilpatrick, Gary F. McCracken, Marianne S. Moore, Jonathan D. Reichard, DeeAnn M. Reeder and Alison H. Robbins

Converting Abandoned Mines to Suitable Hibernacula for Endangered Indiana Bats
Dr. Timothy C. Carter, Ball State University, Muncie, Indiana and Bradley J. Steffen, BHE Environmental, Cincinnati, Ohio

BATS AND COAL MINING: BIG PICTURE RESEARCH NEEDS

David L. Waldien, Mylea Bayless and Michael Baker
Bat Conservation International
Austin, Texas

Abstract

Bats are the only mammals capable of true flight and many species travel large distances throughout the year to meet their biological needs. Conservation and management challenges of today, such as White-nose Syndrome (WNS), wind power development, forest harvest, mining, and urbanization occur at large spatial scales and require private landholders, state and federal land managers, conservationists, and researchers to think and act beyond the narrow scope of individual sites. The coal mining industry currently faces the challenges of operating under guidance associated with three endangered species of bats in the eastern United States (Indiana myotis [*Myotis sodalis*], gray myotis [*M. grisescens*], and Virginia big-eared bat [*Corynorhinus townsendii virginianus*]). Threats from WNS have already resulted in a proposed listing of two additional species (northern myotis [*M. septentrionalis*], eastern small-footed myotis [*M. leibii*]), and a third, the little brown myotis (*M. lucifugus*) has been proposed for a formal status review and emergency protection. Among other management needs, emerging large-scale research priorities include improved knowledge of 1) enhanced methods for monitoring bat colonies and populations that will allow data to be compared among sites and synthesized across sites, 2) movements of bats among key roost-sites and across landscapes, 3) the biologically important population subunits of a species, and 4) the cumulative impacts of emerging conservation and management threats to bats. It is important that researchers, managers, and conservationists look beyond their boundaries and specific projects to help ensure that high quality research is developed to truly address these needs at the correct scale. Collaboration among researchers, managers, and conservationists can ensure well designed research projects that provide defensible information from which to base daily and long-term management decisions for coal mining companies that also advance the conservation of bats and their habitat.

Introduction

As the only mammals capable of true flight (Kunz 2003), bats are fascinating yet feared, widespread yet cryptic, and their presence in any given area often goes undetected. Many bat species are protected by federal law, as economically and ecologically important insect predators, yet bats in many regions are often subject to persecution, and intentional or inadvertent disturbance. Many species of bats travel large distances throughout the year to meet their biological needs (Kunz 2003) and exhibit very low reproductive rates. Several North American bat species also congregate in large numbers in relatively few locations during overwinter hibernation (Kunz 2003, Tuttle 2003). These life history traits combine to make these species exceedingly vulnerable to sudden and rapid population declines (Tuttle 2003). Emerging conservation and management challenges of today, such as White-nose Syndrome (WNS), wind power development, forest harvest, mining, and urbanization occur at large spatial scales and require private and government land managers, conservationists, and researchers to think and act beyond specific sites. Currently, the coal mining industry faces the challenges of operating under guidance associated with three endangered species in the eastern United States (Indiana myotis [*Myotis sodalis*], gray myotis [*M. grisescens*], and Virginia big-eared bat [*Corynorhinus townsendii virginianus*]), and in 2010, as a direct result of the threat of WNS to the survival of hibernating bats, three additional species of bats (little brown myotis, *M. lucifugus*; northern myotis, *M. septentrionalis*; and eastern small-footed myotis, *M. leibii*) have been proposed for federal listing or emergency protection under the Endangered Species Act (Kunz and Reichard 2010, The Center for Biological Diversity 2010).

Counting Bats across Large Spatial Scales

Although bats can live relatively long lives, because they reproduce slowly and pups are nursed by their mothers they are vulnerable to rapid population declines (O'Shea et al. 2003). Bat populations have been monitored by various methods for more than 50 years, however, many of these methods result in significant biases and none of the current methods provide statistical estimates with associated measures of error that would allow valid comparisons among sites or within sites over time (Kunz 2003).

The most commonly applied technique for annual and biennial census efforts for bats that hibernate in known caves and mines involves mid-winter entry into hibernacula by teams of biologists, resulting in disturbance to the colony during a critical time of their annual life cycle (Tuttle 2003). The use of direct counting techniques has been augmented by the use of photography in recent years providing a mechanism for increased consistency and accuracy in bat census efforts (Meretsky et al. 2010).

Over the last decade, additional technology has been applied to the task of enumerating bats through thermal imaging (Sabol and Hudson 1995). This technique can provide reliable counts before and after the young of the year become volant, thus providing estimates of the number of young produced, but requires active, on-site human operation of the equipment.

Another recently employed technique for counting bats is represented by the GateKeeper beam-break system, developed by David Redell, Bat Ecologist with the Wisconsin Department of Natural Resources (Redell 2005, Redell et al. 2006). This system utilizes a set of paired infra-red beams which allow for the detection and recording of bat movement in both directions within user-defined time periods (Fig.1). This information can be recorded continually and uploads to a secure website through either the cell phone or satellite networks. Coupled with other techniques, the system can provide continuous statistically-valid population estimates.

Figure 1. The GateKeeper beam-break system installed on independent uprights at Wyandotte Cave, Crawford County, IN, (left) and on the gate at James Cave, Edmonson County, KY, (right). Both views are from inside the caves.

Despite these advancements in technology, further improved census methods, and innovative applications of new and old technologies remains a fundamental research need to improve our ability to more effectively monitor individual colonies of bats and obtain species-level population estimates from data obtained across the species range. Currently, most available methods still do not provide statistically comparable estimates among sites and are costly either in staff resources or equipment. Most methods provide information about one set of parameters (e.g. fecundity, overwinter survival, or behavior) but do not provide complete information. Because of the costs associated with employing each technique, resources are not commonly available to use multiple techniques at every site. Thus, comparing information among sites is difficult and the validity of synthesizing data gathered via different techniques from across a species range remains suspect. In addition, it is difficult to determine if changes in estimates at a single site are simply offset by changes occurring at other nearby sites reflecting no net change in the local population. Although bats are difficult to study, improving our census techniques would provide a critical tool for managing regional and local populations.

Tracking Movements of Bats across Large Spatial Scales

Most bats living in temperate climates are highly mobile and utilize seasonal movements as a means to survive during long periods of inclement weather (e.g., freezing temperatures) and reduced food availability or to access specific resources necessary for seasonal activity (e.g., high quality hibernation or maternity sites; Fleming and Eby 2003). These seasonal movements vary among and within species, but include short distance movements between summer and winter roosts, typically <50 km (e.g., Rafinesque big-eared bats [*Corynorhinus rafinesquii*]), regional migrants moving moderate distances seasonally, typically 100-500 km (e.g., little brown myotis, gray myotis, and Indiana myotis), and long distance migrants who can sometimes travel > 1,000 km between summer and winter roosts (e.g., red bat [*Lasiurus borealis*] and hoary bat [*L. cinereus*]; Fleming and Eby 2003). Individual bats not only move between summer and winter roosts, but they also typically share roosts with individuals coming from different geographically isolated roosts. For example, one winter roosting colony may be comprised of individuals from many different geographic areas. Band recovery data from a hibernating colony in Aeolus Cave, VT, demonstrates this behavior by documenting little brown myotis traveling in all directions to summer sites, including some sites up to 277 km (172 miles) away (Davis and Hitchcock 1965). The reverse is also true; bats from a single summer maternity colony may hibernate in several different winter roosts. During migration bats will temporarily occupy transient or swarming roosts further increasing the complexity of social behavior and gene flow in temperate North American bat populations (Fleming and Eby 2003). Clearly there are important research questions that must be answered in order to effectively manage regional bat populations.

Understanding the context of individual colonies within larger populations and the connections among summer and winter roosts is critical to managing long-lived and slow-reproducing bat species. More research is needed to reliably estimate regional trends in bat populations and interpret the effects of management actions on the landscape, recognizing that local studies may produce biased results without understanding the context in which local colonies contribute to a larger regional population. Without a clear understanding of seasonal bat movements, inferences about the effect of management actions on a particular colony of bats may be misleading. Kunz et al. (2009), in their review of research methods allude to this dilemma stating "Much of our current understanding of population trends in bats is based on observations of changes in colony size over time (Ellison et al. 2003). But because bat populations often consist of individuals distributed among different roosts, assessing changes in abundance at a single roost may lead to biased estimates of population trends (Sherwin et al. 2003, Sherwin and Altenbach 2004)". For example, bat counts in hibernacula may not reflect impacts from local summer management activities (e.g., timber harvest) simply because summer bat residents may migrate to other regions of the country to hibernate.

Because bats are highly mobile and most individuals migrate to some degree between summer and winter ranges, understanding their requirements during seasonal migration will be important to long term conservation of intact regional populations and healthy gene flow. For populations with historically contiguous distributions, barriers to movement (e.g. large breaks in suitable habitat) may isolate segments of the population or trigger changes in species diversity at any one site (Kunz et al. 2009).

Identifying Biologically Important Subunits of a Species

Most species have much broader distributions than what we observe simply based on the location of the species' largest roosts. While it's important to recognize the core of a species range and protect the largest roosts, for some species, like the endangered Virginia big-eared bat, there may be biologically distinct subpopulation units (Piaggio et al. 2009) worthy of special management consideration. Further, it may be that these dispersed smaller colonies can serve as refugia from threats such as emerging diseases or perturbations associated with different land management practices. For these reasons, the preservation of species in general should incorporate efforts to conserve the genetic diversity of a species across its range by focusing on regional subpopulations within recovery units (Piaggio et al. 2009). Peripheral roosts may be critical to maintaining a species in a rapidly changing landscape and additional information is needed on the role of smaller dispersed roosts in maintaining genetic diversity across the range of a species and the ability of bat populations to respond to unexpected events.

Understanding biologically important subunits should also include thinking more broadly about how we define local bat populations for research and management. For many species of bats, critical hibernation sites are not evenly distributed across the species range but often occur in proximity to one another. When this occurs, sites may need to be considered as members of 'hibernation complexes' and managed as such. Addition research to understand bat movements among hibernacula, both within and among seasons, will be important when managing each site within a hibernacula complex or when managing the entire complex as a biological subunit.

Estimating Cumulative Impacts of Multiple Threats

Bat populations may be impacted through the direct loss of underground roosts when old mines are removed from the landscape due to renewed coal mining (Sherwin et al. 2009) or harvest of the surrounding forest. In 2004, at an Office of Surface Mining Technical Interactive Forum, Vories and Harrington (2004) recognized the need for the coal states to evaluate cumulative impacts of coal mining on Indiana myotis. Unfortunately, in the 21st century, many species of bats are subject to multiple threats, in addition to coal mining, across their range in North America. White-nose Syndrome is an emerging fungal disease of hibernating bats that has killed over a million hibernating bats in the eastern United States and Canada since its discovery in New York in 2006 (Bat Conservation International 2009) and half of the species of bats in the United States and Canada are at risk from WNS. Further, in some regions of North America, wind-energy facilities are causing unprecedented fatalities of bats, especially of migratory tree-roosting species (Arnett et al. 2007, Arnett et al. 2008). Recreation and other disturbance in caves and mines have negatively impacted critical colonies of bats (Tuttle 2003) and both urbanization and timber harvest have directly removed vast areas of forest habitats throughout North America. These large-scale habitat perturbations not only result in the direct loss of roosts, they may also dramatically modify local foraging habitats, fragment landscapes and may disrupt local and regional migratory corridors. Bat populations and communities are a result of all of the factors that influence them and resource managers need to understand the cumulative impact of those threats and how they may interact to impact bats across spatial scales. Further research to understand the complexity of these combined effects could provide valuable tools for balancing the threats to bats with other resource management objectives.

Summary

The coal mining industry faces numerous conservation and management challenges today including WNS, wind power development, forest harvest, mining, and urbanization that are manifesting themselves over large spatial scales. Operational challenges have increased under federal guidance associated with three endangered species of bats in the eastern United States and with an increasing probability of more species being proposed for listing under the Endangered Species Act due to the threats of WNS. In this new environment, visionary managers must look beyond the boundaries of specific mine-project sites and manage for how local actions influence regional wildlife resources. Managers should work with researchers to develop and implement quality research for large-scale issues including understanding: 1) improved methods for monitoring bat colonies and populations to obtain data for comparison and synthesis across sites; 2) bat movement among key roost-sites and across landscapes; 3) biologically important population subunits of a species; and 4) the dynamics of cumulative impacts of emerging conservation and management threats, such as WNS and wind energy development, to bats. It is important that researchers, managers, and conservationists work together to help ensure quality research is developed that truly addresses the issues at the correct spatial and temporal scales.

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Dr. Dave Waldien is Vice President of Operations at Bat Conservation International. He joined BCI in 2004 and has led or supervised international conservation programs including work in Latin America and the Philippines. In the US, he has supervised the cave and mine conservation and management in the southwest and the eastern United States, including programming explicitly addressing the recovery of the Indiana bat. He is working with a team to restructure BCI's programs to embrace global conservation priorities at landscape scales. He received his MS in Forest Ecology from Oregon State

University in 1998 where he studied the roosting and foraging ecology of the long-eared *myotis* and his Ph.D. in Wildlife Ecology from Oregon State University in 2005 where he studied small mammal responses to forest management practices.

Bats & Mining:
Big Picture Research Needs

Dave Waldien, PhD , Bat Conservation International

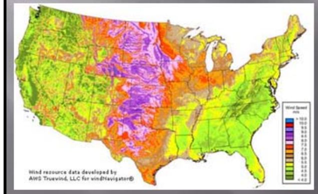
Michael Baker, Bat Conservation International

Mylea Bayless, Bat Conservation International

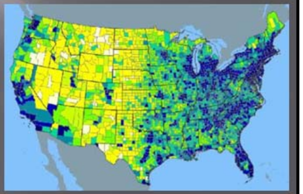
Conservation challenges of today require us to think and act beyond specific sites.

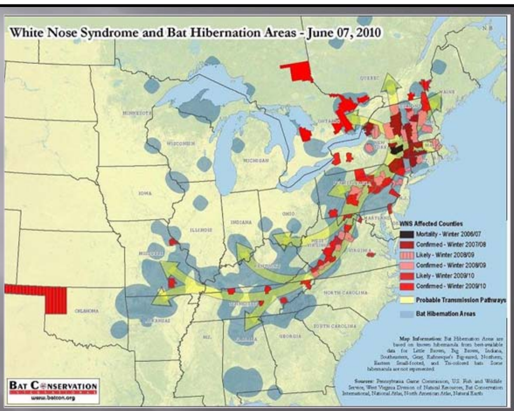
"Things" simply happen faster, at larger scales and are often connected to other "things"!

Wind Power Potential



Urban Areas



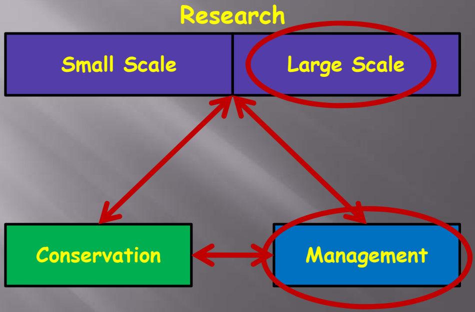


Mining and "Threatened" Bats

Indiana Bats
Gray Bats
Big-eared Bats

WNS – all hibernating species

WIND – tree bats



Research

Small Scale | Large Scale

Conservation

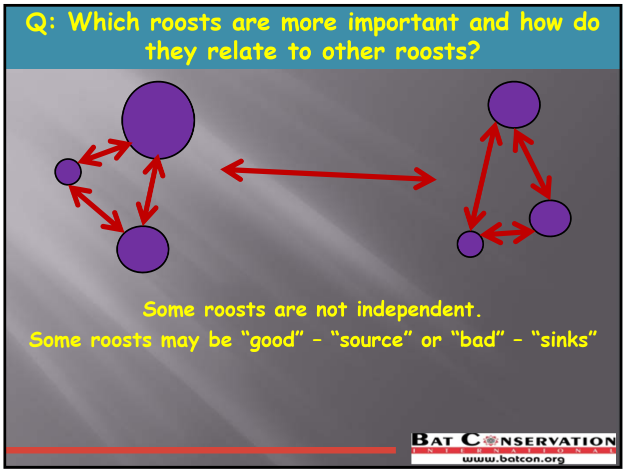
Management

Q: How do we count the bats?

Validated monitoring techniques applicable across a species range.

1. Beam-break
2. Visual counts
3. Photo counts
4. Thermal cameras
5. Other new technologies

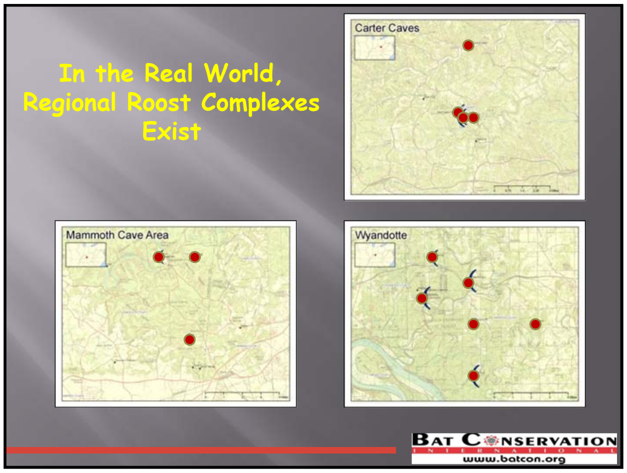
Critical that the methods lend themselves to site specific differences or that we understand how to defensibly integrate colony counts derived from different methods.



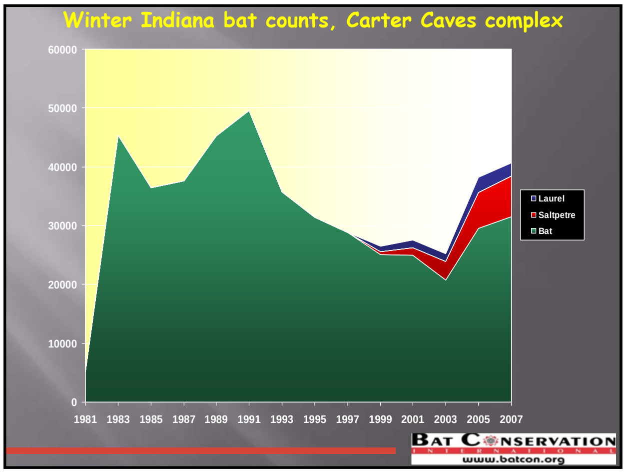
Q: Which roosts are more important and how do they relate to other roosts?

Some roosts are not independent.

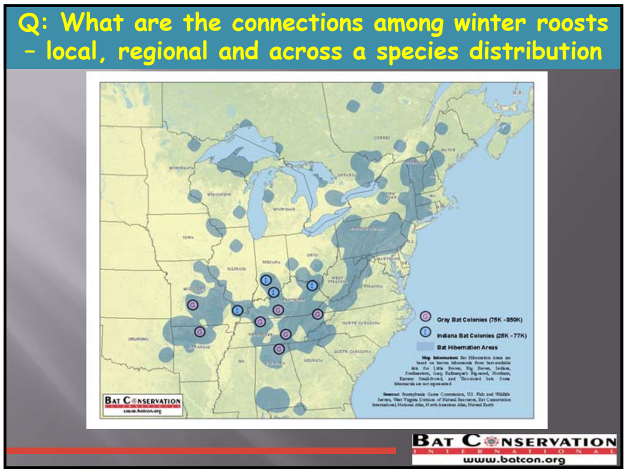
Some roosts may be “good” – “source” or “bad” – “sinks”



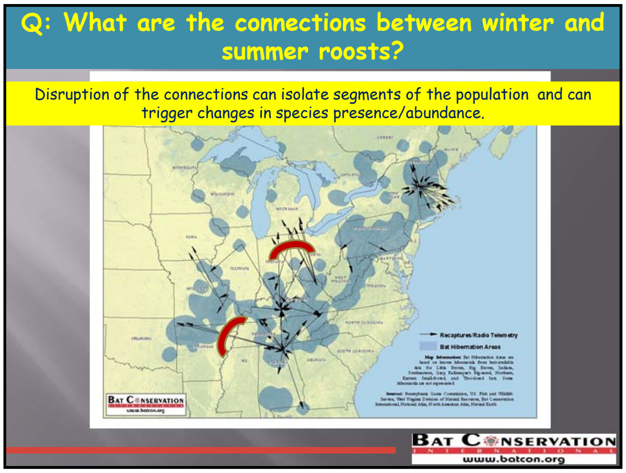
In the Real World, Regional Roost Complexes Exist



Winter Indiana bat counts, Carter Caves complex

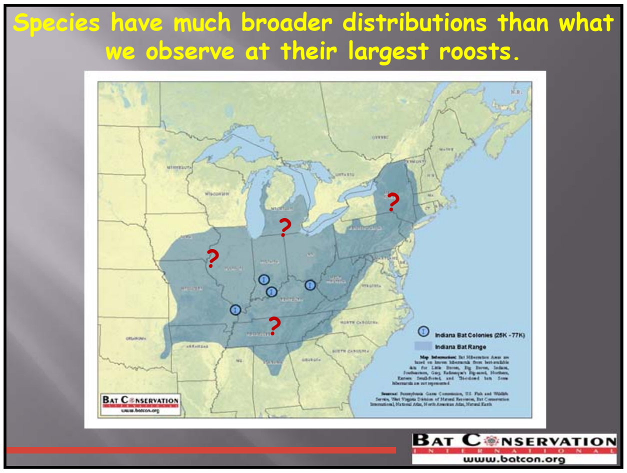


Q: What are the connections among winter roosts – local, regional and across a species distribution

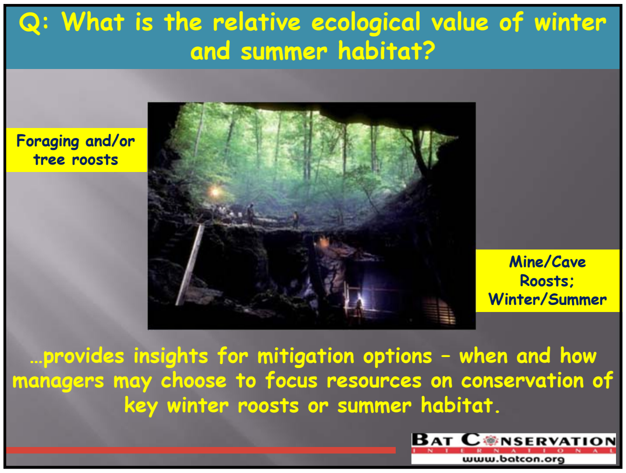


Q: What are the connections between winter and summer roosts?

Disruption of the connections can isolate segments of the population and can trigger changes in species presence/abundance.



Species have much broader distributions than what we observe at their largest roosts.

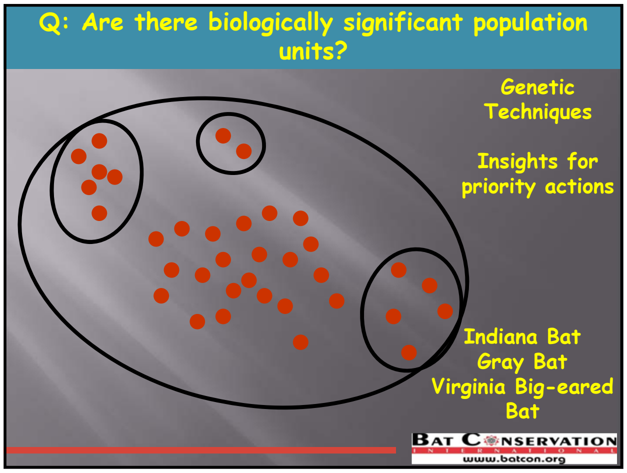


Q: What is the relative ecological value of winter and summer habitat?

Foraging and/or tree roosts

Mine/Cave Roosts; Winter/Summer

…provides insights for mitigation options – when and how managers may choose to focus resources on conservation of key winter roosts or summer habitat.

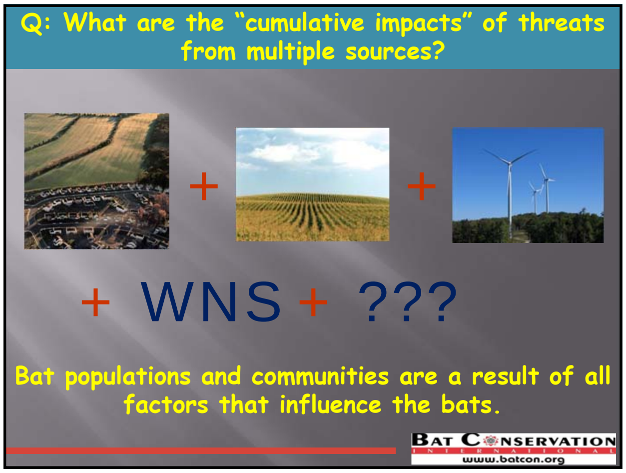


Q: Are there biologically significant population units?

Genetic Techniques

Insights for priority actions

Indiana Bat
Gray Bat
Virginia Big-eared Bat

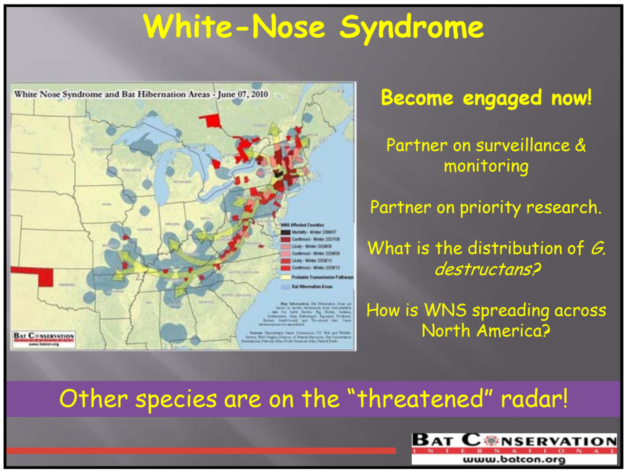


Q: What are the "cumulative impacts" of threats from multiple sources?

\+ \+

\+ WNS + ???

Bat populations and communities are a result of all factors that influence the bats.



White-Nose Syndrome

Become engaged now!

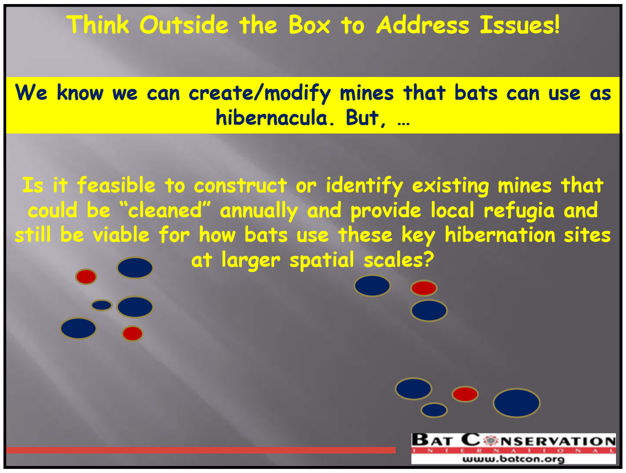
Partner on surveillance & monitoring

Partner on priority research.

What is the distribution of *G. destructans?*

How is WNS spreading across North America?

Other species are on the "threatened" radar!



Think Outside the Box to Address Issues!

We know we can create/modify mines that bats can use as hibernacula. But, …

Is it feasible to construct or identify existing mines that could be "cleaned" annually and provide local refugia and still be viable for how bats use these key hibernation sites at larger spatial scales?

Landscape Research

Best Done Through Collaboration!

BAT CONSERVATION AND ENERGY

Christy Johnson-Hughes
U.S. Fish and Wildlife Service
Arlington, VA

Abstract

As in most things in life, bat conservation is not a simple issue. Bats are not just affected by coal mining activities. And, as has been discussed during earlier presentations, bats are affected by non-development pressures, such as white nose syndrome. Bat conservation has become more complex with ever-evolving issues, particularly the latest concern about establishing secure, domestic energy that is centered on renewable energy sources.

This presentation focuses on the primary renewable energy sources that may affect bats and methods that are currently being used to mitigate for those impacts. There are several renewable energy concepts that will not be discussed here because the technology is not as developed. Therefore, this paper will focus on biomass and wind. It is unknown whether commercial, utility-grade solar facilities will affect bats. Transmission is also included because upgraded transmission lines are necessary for the connection of new energy facilities.

Non Coal Energy Generation Impacts on Bats

Biomass is not a new concept in the realm of renewable energy sources. What is new is the identification of new techniques and an increase in the scale of the effort. Various materials are being considered for biomass combustion, including logging debris and sugar cane stalks. Of greatest concern for bat conservation is the practice of managing forests for eventual clear cut to create biomass fuel. Such proposals include the planting of quick growing tree species, often as a monoculture, and then clearing the forest once the trees are suitable for combustion.

The most obvious threat to bats is the replacement of native, mixed species and mixed aged forests with an even-aged, single-species monoculture. Bats would lose roosting habitats. The area would lose many of its ecological functions. Insect availability and composition may change. From a bat's perspective, a monoculture tree planting could look the same as a clear cut area with limited resource availability. It is not known exactly how bats would react to large tracts of monoculture forest. They do use agricultural fields for foraging, so they do not necessarily avoid monocultures. However, the loss of high quality habitat with multiple roosts could not go unnoticed by the bat population.

Many studies have been conducted that evaluate impacts of wind energy development on bat conservation (for example, Arnett et al 2007). Turbine strings and associated infrastructure can fragment the existing habitat. Bats collide with moving turbine blades. On the other hand, wind energy can reduce greenhouse gas emissions and other pollutants. Entire forests are not clear cut and streams are not impacted. The difficulty lies in understanding whether the impact of wind energy is more or less a threat to bat populations when compared to surface coal mining activities. Surface mining can be very disruptive to forest lands and streams. Roosts are lost and insect availability and diversity is changed (Range-wide Indiana Bat Protection and Enhancement Plan Guidelines, rev December 2009). It takes years for the forest to re-grow and form new suitable roosts areas. A stream may never recover from fill placement.

Wind facilities are growing in size and number. Wind energy facilities fragment the landscape and pose a direct threat to bats, particularly migrating bats. There are currently no known methods for avoiding bat collisions with moving turbine blades (Baerwald et al 2009, Arnett et al 2010). In addition, there is less regulatory oversight of wind energy development than of surface coal mining. It can be difficult to modify a wind energy project once it is operational. At this point, it is difficult to tell which energy sector has the most impact on bat conservation. Wind energy, like coal mining, will continue into the foreseeable future. It is even more crucial to avoid and minimize impacts from both energy sectors in order to abate the threat from both.

One instrument in use today to avoid and minimize threats is the Avian and Bat Protection Plan. An ABPP spells out the known and anticipated impacts on bat populations and provides a detailed list of activities that may reduce the impacts to bats. Each ABPP is different because it is based on the project and the species impacted by the project. It can incorporate the tiered approach for assessing risks to wildlife and habitats described in the Wind Energy Federal Advisory Committee's

Recommendations to the Secretary of the Interior (March 2010). It promotes the use of best available science and management practices. It also promotes early coordination to get the greatest conservation benefit. It should also be kept in mind that developing an ABPP and applying for a listed species take permit is voluntary for wind energy development on private lands. This situation may result in regulated activities, such as coal mining, bearing more of the weight of species conservation.

An additional stressor in the Appalachian coal fields is the marked increase in natural gas wells due to the development of the Marcellus shale. Access roads fragment forested habitat and operation of the wells can cause contamination of water sources. The lack of coordination between the oil and gas program and coal mining programs can cause conflicts, resulting in diminished value of conservation areas or other conservation activities. This extraction is also not as well regulated as coal mining and can cause cumulative impacts that are not considered by state or federal agencies.

New energy development also means new transmission lines. Much of the wind development occurs in areas that are not currently served by an existing substation. Additional lines, and upgrades of existing lines, can increase forest fragmentation. Bats can use transmission corridors for foraging areas, but that may not be enough to offset the loss of contiguous forest cover.

Conclusion

The rapid increase in energy development in bat habitat has lead to a great interest and need to understand the cumulative impacts of these activities on bats and their habitats. Energy development needs to be evaluated at the landscape level. There is also a need to better understand bat migration and selection of maternity sites. White-nose syndrome is still poorly understood, and much more additional research is needed to keep bat species from becoming extinct.

In the meantime, conservation will have to rely on established practices to reduce population stress as much as possible. Wintering habitats need to be further identified and protected. Large-scale clear cutting of forests should be minimized. Migration corridors should be preserved as much as possible. Water sources should be protected and/or restored. Communication with and between various energy developers is crucial for establishing meaningful conservation. Mitigation and conservation banks should incorporate bat considerations, where appropriate. And finally, Landscape Conservation Cooperatives may be able to help evaluate cumulative, landscape-scale impacts to bat populations and to coordinate conservation measures so they have meaning at the landscape level.

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Arnett, E. B., M. M. P. Huso, M. R. Schirmacher, and J. P. Hayes. 2010. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment 2010; doi:10.1890/100103

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Christy Johnson-Hughes is currently a National Energy Coordinator for the U.S. Fish and Wildlife Service. She has been with the FWS over 10 years. She handles coal mining, oil and gas, nuclear, transmission, and wind issues. She has worked in several program areas, including Endangered Species and Federal Activities (now Conservation Planning Assistance). She spent 3 years in West Virginia working on coal mining issues. Christy has also participated in various bat-related activities, including surveys, trapping, tracking using transmitters, and habitat evaluation for Indiana bats. At this time, she is part of the team developing products discussed in the Surface Coal Mining MOU among the federal agencies, including stream mitigation measures, interagency coordination procedures, and GIS mapping.

Bat Conservation and Energy

August 2010

Christy Johnson-Hughes
U.S. Fish and Wildlife Service
Conservation Planning Assistance

Bat Conservation & Energy

- Energy development other than coal mining
- Impacts to bat species
- Methods used to mitigate for impacts

Cumulative Impacts of Renewable Development

- Biomass
- Transmission
- Wind

Cumulative Impacts

EIA 2009

Biomass

- Forest Service to allow use of downed trees or debris from logging operations as biomass fuel.
- Replacement of forest with energy crops.

NREL

Impacts to Bats

Changes to:

- Forest structure
  - diversity
  - availability

NREL

Transmission

- New transmission lines needed for new energy sources.

EIA 2009

Impacts to Bats

- Fragmentation of habitat
- Bats do forage in corridor

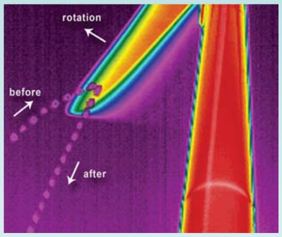
NREL

Wind Energy

- Wind energy can reduce greenhouse gas emissions, other pollutants
- **FWS concerns:**
  - endangered species
  - migratory birds
  - bat species
  - other trust resources and their habitats

Direct Impacts to Bats

- Direct impact with moving blades
- Barotrauma
- Population effects
- Reduce mortality?



Horn et al 2008

Impacts to Bats

NREL

- Construction of larger wind turbines and more facilities
- Fragmentation of habitat
- Changes in insect availability?

Wind Considerations

- Wind energy on private lands seldom has federal nexus
- USFWS encourages voluntary coordination to conserve trust resources

Wind FAC Recommendations: Highlights

- Tiered approach to assessing risks to wildlife and habitats
- Use of best available science and management practices
- Early coordination + timely review = greatest conservation benefit and cost effectiveness

---

Other Energy Development

- Oil and Gas Development
  - Standard oil and gas fields
  - Shales and hydraulic fracturing

BLM WY 2008

Impacts to Bats

Potential Impacts:

- Forest fragmentation
- Contamination of water sources
- Loss of water sources
- Development in conservation areas

BLM WY 2008

Overall Impacts to Bats

- Loss of habitat due to increased domestic energy production
- Potential for direct impacts, including mortality
- Additional stress to populations which may lead to listing historically common bats

Species Impacts

- Migratory foliage-roosting species
  - Hoary bat
  - Eastern red bat
- Migratory tree and cavity-roosting species
  - Silver-haired bat

Arnett et al 2007

How to Mitigate Impacts?

- Find and protect winter habitats
- Minimize large-scale clear cutting of forests
- Minimize impacts to known foraging areas
- Preserve/establish migration corridors
- Preserve water sources
- Establish communication with oil & gas

Avian & Bat Protection Plans

A tool to help identify potential impacts to bats and birds and to mitigate those impacts.

Conservation Plans can also be used. Can include HEA and conservation funds.

What Can We Do?

- Use Conservation funds and mitigation banks
- Work on the landscape scale to focus development and improve efficiency and success of mitigation – Landscape Conservation Cooperatives
- Work together to find ways to minimize impacts

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ACOUSTIC MONITORING AND SAMPLING TECHNOLOGY

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Abstract

Acoustic detectors have been used for monitoring flight activity of bats since G.W. Pierce developed sound capture technology in 1938. Recently, significant progress has been made in the areas of portability, weather resistance, and the collection and storage of large data sets over extended periods of time. This progress includes the continued development of new and potentially more accurate means of collecting the information contained within each call sequence, as well as more accurate and repeatable ways to identify the species making these calls. The two main categories of detectors used to collect these data are zero-crossing and full spectrum detectors. This study included three commonly used detectors; the zero-crossing Anabat (Titley Electronics, Inc.) and two full spectrum detectors, AR-125 (Binary Acoustic Technology) and SM2 (Wildlife Acoustics). Side by side comparisons were conducted for 34 nights during 2010 throughout Missouri. These data were used to compare average memory consumption, total files collected, total bat passes, species and species group identifications, quality of the call sequences, and reported call parameters. In addition, two automated call identification software packages were used for comparison; BCID (Bat Call Identification, Inc.) and Sonobat 3 NE (Sonobat). All recorded call files were passed through the automated software packages. Furthermore, full spectrum calls from the SM2 recorder were converted into zero-crossing call files allowing the software packages to analyze the same files. Species composition, calls parameters, and processing times were measured for each block of files. A total of 140,968 files were collected resulting in 22,228 identified bat passes and 117,680 noise files from the 3 detectors. Results suggested that these detectors are not interchangeable. There exist clear differences in the amount and type of data they record and therefore projects conducted with one are not necessarily comparable to projects done with another.

Introduction

The use of ultrasonic detectors to record echolocation calls has become an important part of studying bat ecology. With the presence of endangered species of bats and the increased awareness of bat activity in industries such as wind energy, mines, road construction, power lines, and timber, accurate identification of local bat fauna is imperative. Increasingly, the use of bat detectors to passively monitor these sites has become the preferred manner in which these surveys are conducted.

In 1938, Donald Griffin and Robert Galambos used sound capture technology developed by physicist G.W. Pierce that resulted in the discovery that bats produce and hear sounds in octaves above audible human hearing. After several years of experimenting with bats and the use of ultrasonic sound, Griffin, in 1944, coined the term echolocation to describe the phenomenon they were observing. Echolocation is a process by which an animal orients itself, or identifies the location, character, and perhaps movement of objects, by emitting high-frequency sounds and interpreting the reflected sound waves (Whitaker and Hamilton 1998).

Modern bat detectors use full spectrum or zero-crossing acoustic sampling techniques to record ultrasonic sound. Beginning in the 1980’s, zero-crossing detectors, specifically the Anabat, were increasingly used because of the low data consumption rates, field adaptability, and relative low cost. While full spectrum detectors did exist during this time, due to the lack of advanced computer technology and limited storage capacity, they were not often used as passive monitoring systems. With the rapid advancement of computer technology, it has recently become feasible to use full spectrum technology under field conditions. This naturally leads to the question, which system or detector leads to the most accurate and repeatable results in a user-friendly manner?

While the use of acoustic technology is currently possible in a long term monitoring situation, the large data sets require automated identification. Several attempts have been made to automate bat species identification using techniques such as discriminant function analysis, neural networks, and weighted classification trees. The most notable attempts using these methods have been made by Allen, 2010; Betts, 1998; Britzke et al., 2010; Corcoran, 2007; Fenton and Bell, 1981; Gruver et al., 2010; Krusic and Neefus 1996; Parsons and Jones, 2000; and Szewczak, 2010.

The purpose of this study was to compare both the hardware and the software of full spectrum and zero-crossing acoustic bat technology in a manner consistent with the manufacture's recommended use. While this introduced many variables to the comparison, it was the only way to satisfy the goal of comparing results when using standard techniques. For this study, we chose three commonly used bat detectors and the two known acoustic software packages that have graphical user interfaces.

Methods

This study included three commonly used detectors: Anabat (Titley Electronics, Inc.), AR-125 with an FR-125 recording unit (Binary Acoustic Technology), and SM2BAT (Wildlife Acoustics). Detectors were aligned next to each other on pelican cases on a table approximately one meter off the ground (Figure 1).

Figure 1. Setup of detector comparison. Anabat SD1 on left in this example, AR125 with FR125 in the middle, and SM2BAT on the right.

Detectors recorded between 4 and 8 hours each night. Data were collected from a variety of locations throughout Missouri (Figure 2). Detectors were placed in a variety of habitats including fields, near ponds, forested roads, and trails.

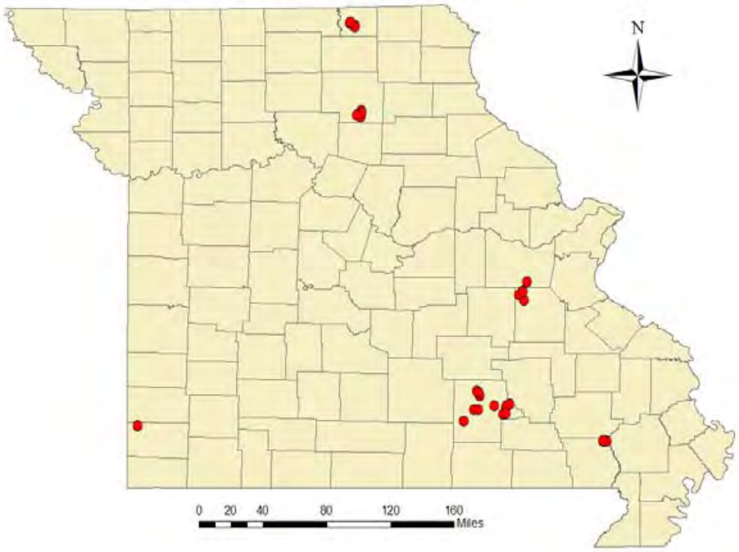

Figure 2. Locations of detector comparison test locations.

Two automated call identification software packages were used for comparison: BCID 10 (Bat Call Identification, Inc.) and Sonobat 3 Northeast (NE) version (Sonobat). Sonobat 3 is a full spectrum, discriminates function analysis identification software recently developed for several regions of the U.S. The northeast version was used in this study because a Midwest version was not available. BCID 10 is a zero-crossing, weighted classification tree analysis developed in 2007 and updated in 2010. It currently covers most of the northeast and Midwest species of the U.S.

The AR-125 and Anabat microphones were set at approximately 45° angles and 6" apart. Due to the unique configuration of the SM2BAT detector, it was set vertically next to the other two detectors. The SM2BAT was used with both microphones with the thought that most users would utilize the two microphones, taking advantage of this unique feature. Additionally, as stated in the introduction, this project was set-up with the purpose of duplicating standard techniques. Throughout the experiment, Anabat II with a ZCAIM, Anabat SD1, and Anabat SD2 units were randomly chosen each night. Due to cost constraints, only one SM2BAT and one AR-125 with an FR-125 recording unit were available for use.

Anabats were set with the sensitivities calibrated equally for all units and all units were synced in time. A division ratio of 16 was used for all test nights with a standard microphone. Anabat data were collected on a CF card and processed through CFCread version 4.2.1 with default settings. The AR-125 was set to a time-expansion (TE) of 10, duration of 15.0 second, idle of 3.0, delay of 0.0, low-frequency of 15.0 kHz and high-frequency of 90.0 kHz. Data were collected on an 8 GB flash drive and then run through the Sonobat Batch Scrubber 3 using default settings. The SM2BAT was set in accordance with the SM2BAT supplemental manual (Wildlife Acoustics, Inc, 2009-2010). An SMX-US microphone was used for both microphones and used in 192 kHz stereo. Data were run through WAC2WAV (Wildlife Acoustics Audio Compression Converter) version 2.9. WAC2WAV was set with default settings and split triggers, skip noise, and SMX-US compensation filter were selected.

Data were used to compare average memory consumption, total files collected, total bat passes, and reported call parameters (mean Fmax, mean Fmin, mean duration, Fc and Fk). Recording time varied each night; therefore, all nightly data reported were based on a 10 hour time period. This was done by calculating an average per hour and multiplying by 10. Full spectrum calls from the SM2BAT recorder were converted into zero-crossing call files using WAC2WAV software allowing Sonobat 3 NE and BCID 10 to analyze the same files. Direct comparisons could then be made between the Anabat and SM2BAT as well as the two software suites. To do these direct comparisons, 5 randomly chosen nights of data were used due to the large volume of call files. These same 5 nights of data were also used in the parameter comparisons. Parameter comparisons were done for eastern red bats, tri-colored bats, and silver-haired bats because they represent the full range of frequencies and call characteristics. Additionally, there were a large number of them available in the data for analyses. *Myotis* species could not be analyzed for parameter differences due to the low number of calls available. For these 5 nights of data, SM2BAT files converted to zero-crossing were compared to the Anabat files using BCID 10 (to compare detectors) and the un-converted SM2BAT and converted SM2BAT files were analyzed using the two different software packages in order to directly compare them.

Processing times of software packages were measured for each block of files when possible. Fewer data points exist for the full spectrum files due to extremely large SM2BAT files that would cause stack overflows and crash the software. Sonobat 3 NE was used to identify all full spectrum call files using default settings. Bat passes were calculated by the high/low tally from the output file given by Sonobat 3. The column MeanClassification was used for identification to species. BCID 10 was used to identify all zero-crossing call files using default settings. Bat passes were calculated with the minimum number of calls was set to 1 and species identification was calculated with the minimum number of calls set to 4.

Results

Comparisons were conducted for 34 nights from May 17 to July 17, 2010 throughout Missouri. A total of 140,968 files were collected resulting in 22,228 identified bat passes and 117,680 noise files from the 3 detectors. A total of 4,980 of these files were identified to species by the two acoustical software packages. An average of 0.02 MB/hr of data was collected from the Anabats, 2.06 MB/hr from the AR-125 and 3.55 MB/hr from the SM2BAT (Figure 3).

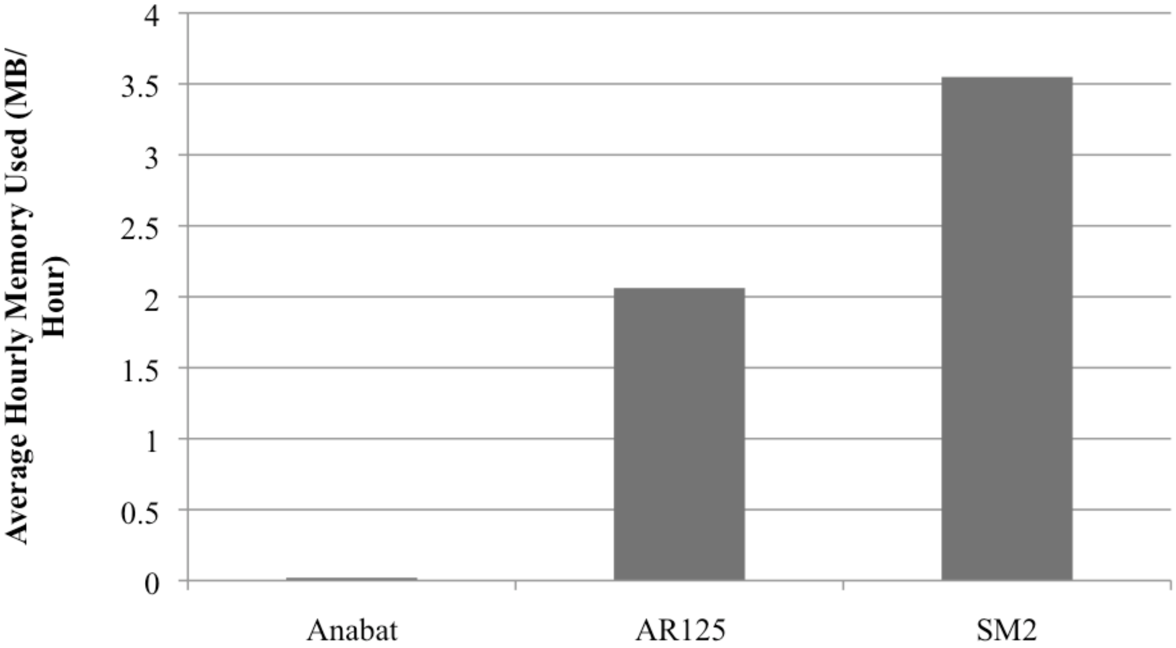

Figure 3. Average hourly data consumption for each detector over 2 weeks based on 10 hours of recording. This equates to: Anabat – 2.8 MB, AR125 – 288.6 MB, SM2 – 496.9 MB. Note: Will vary drastically by site.

Analyzing these data with 27 identical computers running BCID 10 and Sonobat 3 NE resulted in processing times of approximately 582 files/minute by BCID 10 and 3 files/minute by Sonobat 3 NE (Figure 4).

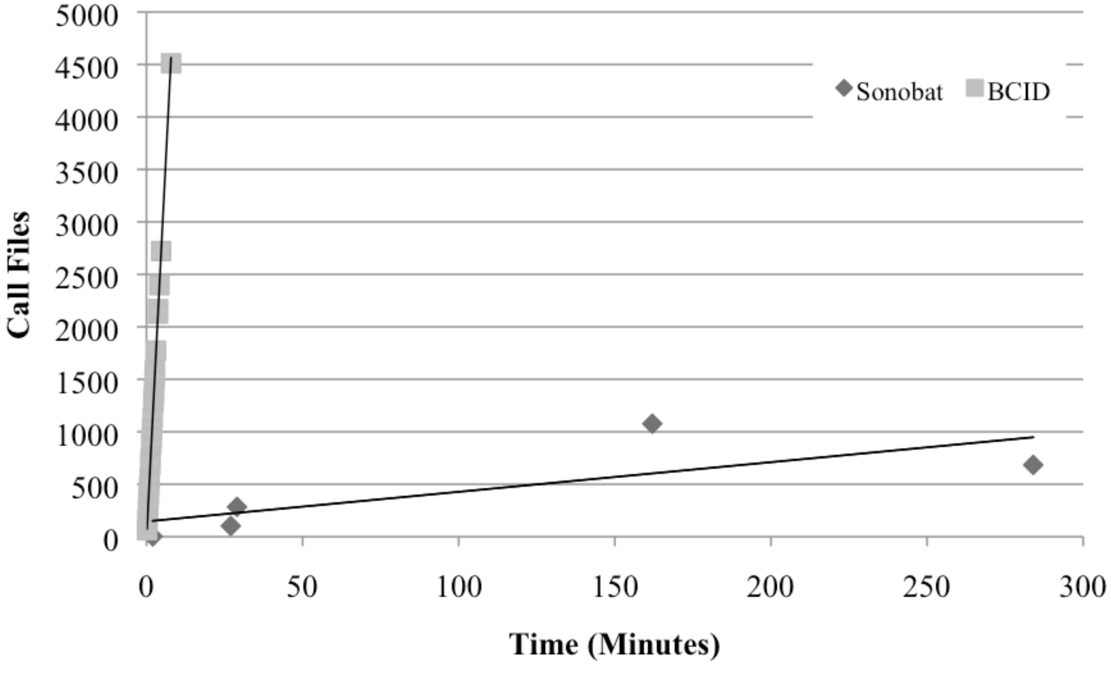

Figure 4. A comparison of processing time for BCID 10 and Sonobat 3 NE.

The parameter comparison using 5 randomly chosen nights of data for eastern red bats resulted in significant differences in the mean Fmax and Fk of all three detectors (Figure 5).

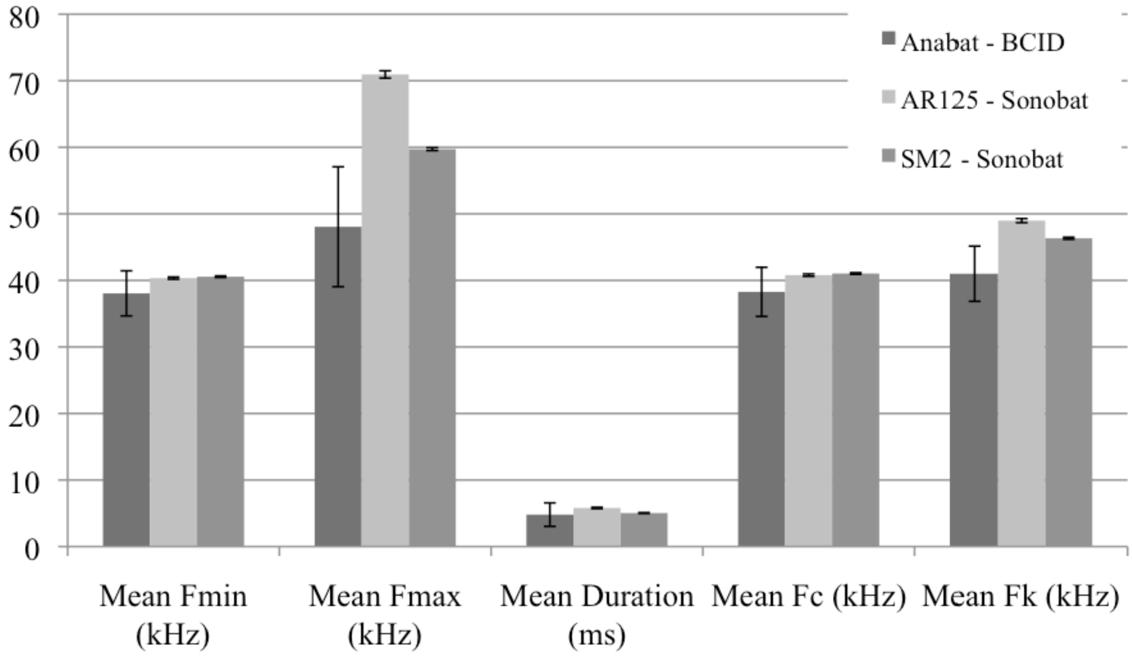

Figure 5. Parameter comparison for eastern red bat call files. Data analyzed was from 5 randomly chosen nights of data.

For tri-colored bats, significant differences were found among all three units for Fmax and Anabats differed significantly from the full-spectrum detectors for both duration and Fk (Figure 6).

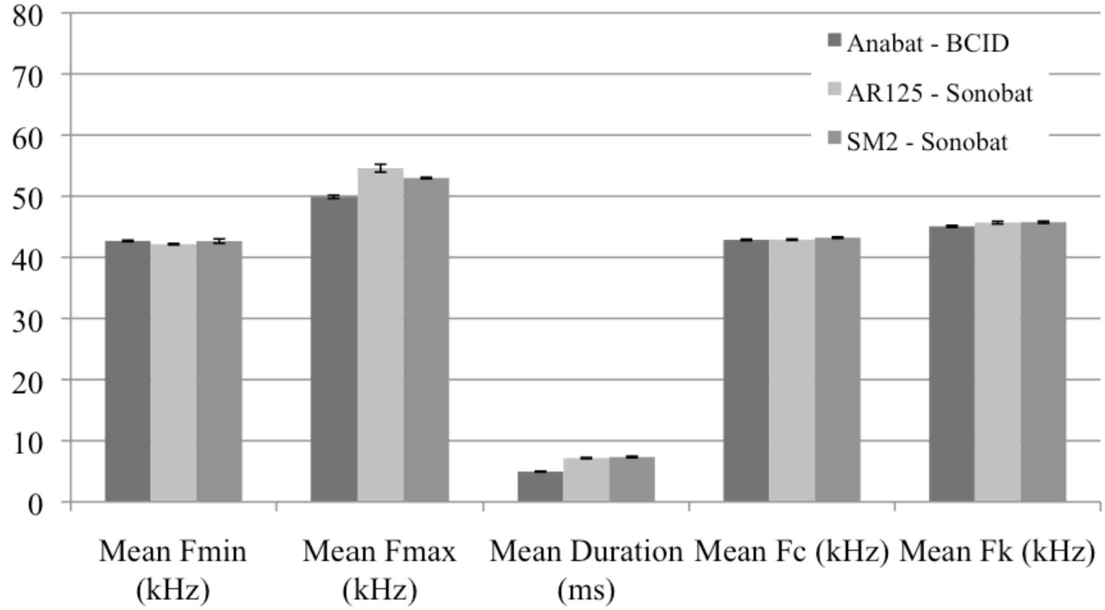

Figure 6. Parameter comparison for tri-colored bat call files. Data analyzed was from 5 randomly chosen nights of data.

Silver-haired bats produced significant differences in Fmin among all three detectors (Figure 7). The AR-125 significantly varied from the Anabat and SM2BAT in Fmax and Fc, and the SM2BAT varied significantly from the other two in duration for silver-haired bats as well.

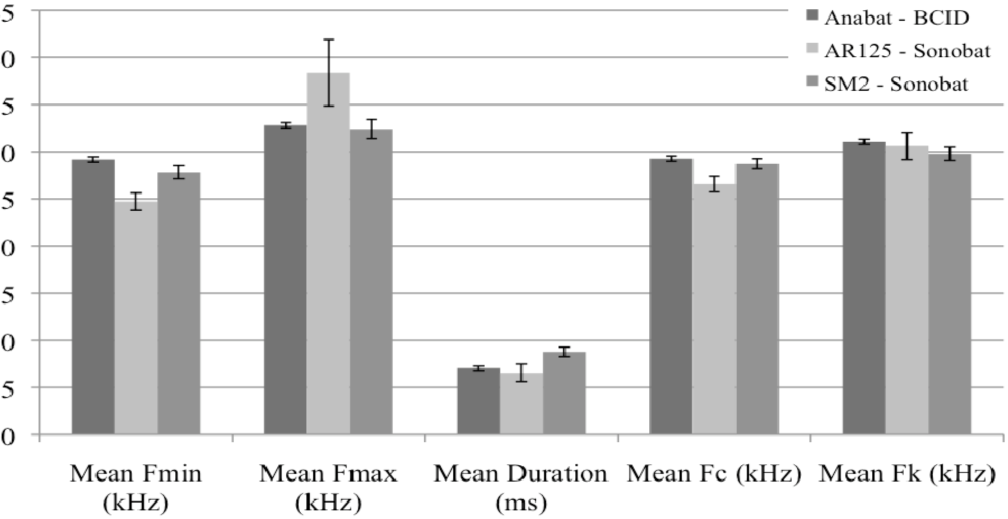

Figure 7. Parameter comparison for silver-haired bat call files. Data analyzed was from 5 randomly chosen nights of data.

The SM2BAT recorded the highest number of bat call files, noise files, and bat passes; however, it had the fewest sequences identified to species by Sonobat 3 (Figure 8).

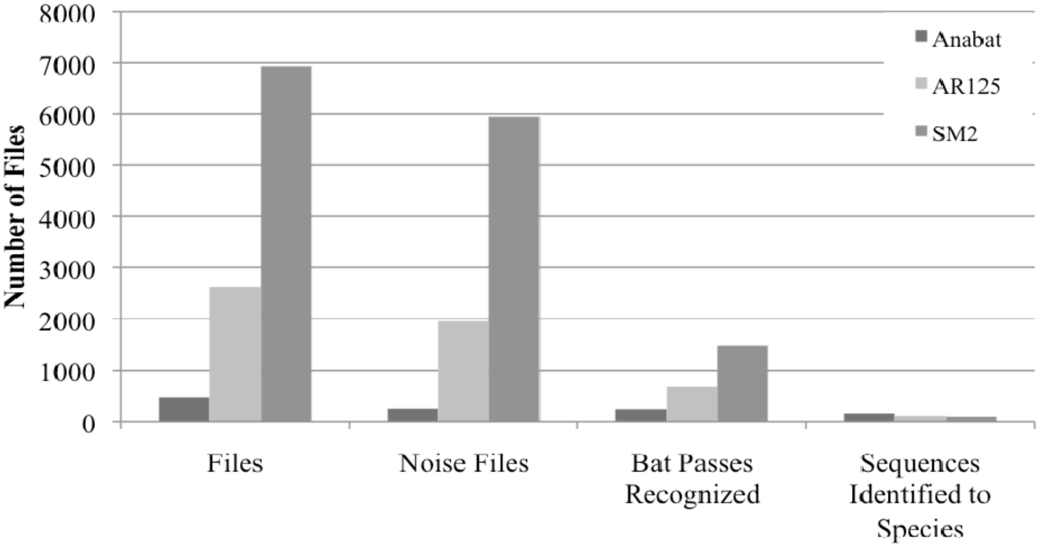

Figure 8. Average results based on a 10 hour period for both hardware and software comparisons.

Anabat files identified by BCID 10 were dominated by mid-frequency species (*Lasiurus borealis, Nycticeius humeralis, Perimyotis subflavus*) and the SM2BAT and AR-125 were dominated by high-frequency species, which includes all of the mid-frequency species plus the *Myotis spp*. There is no mid-species category when using Sonobat 3 (Figures 9-11).

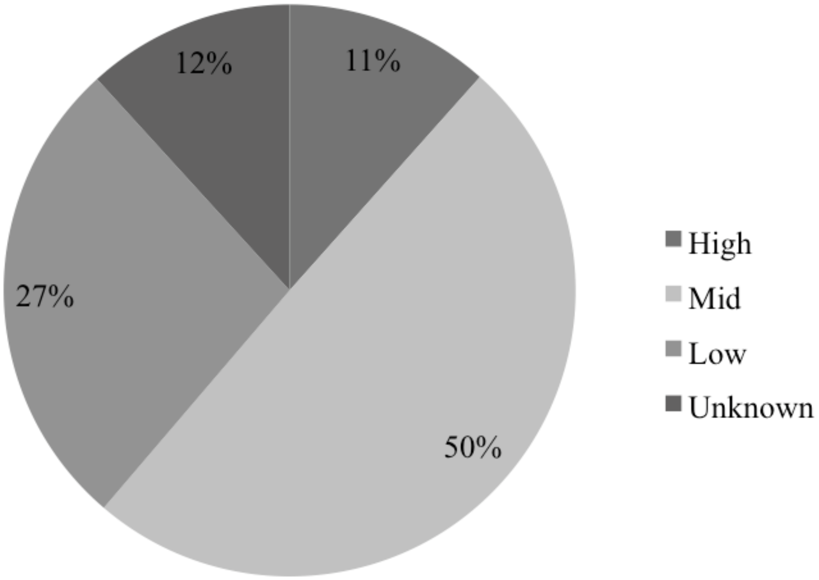

Figure 9. Species group composition for Anabat files identified by BCID.

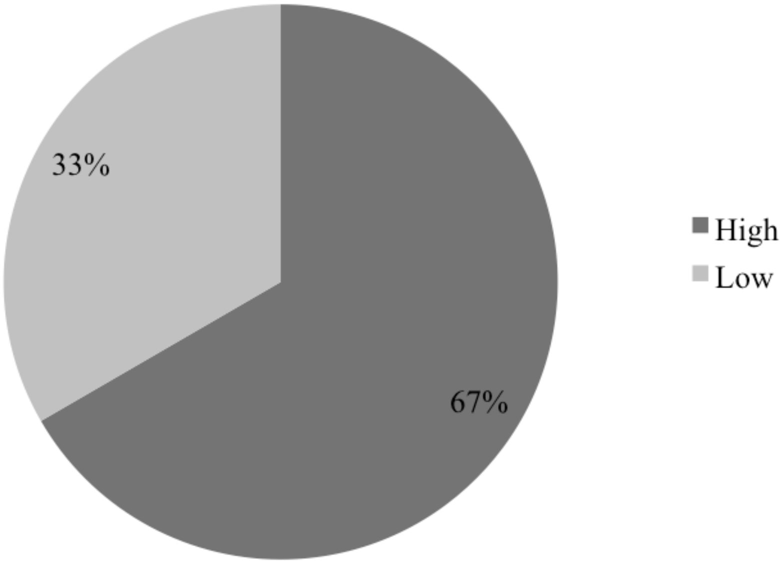

Figure 10. Species group composition for AR-125 identified by Sonobat.

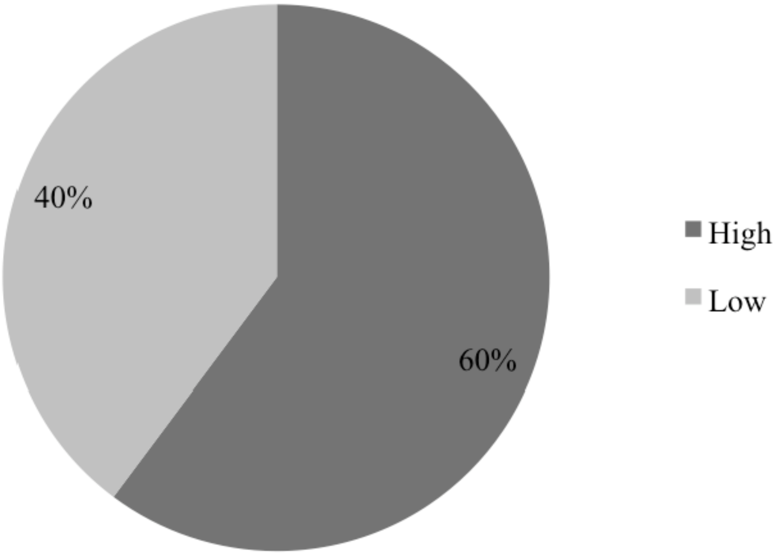

Figure 11. Species group composition for SM2BAT identified by Sonobat.

While the species distribution among all three methods was relatively consistent when looking at the entire data set, there were obvious differences when compared on a nightly basis (Figure 12). There was a large amount of variability in the species level identification of call files. Sonobat 3 in conjunction with the full spectrum detectors identified many more low-frequency calls to species (Figure 13), but relatively few *Myotis spp*. Only two *M. sodalis* and no *M. septentrionalis* were identified by Sonobat 3 NE, while BCID 10 identified 27 files belonging to these two species (Figure 15). Identification of *P. subflavus* was nearly equal among all three detectors, but BCID 10 identified many more *N. humeralis* and *L. borealis* (Figure 14).

On average, the Anabat in conjunction with BCID 10 and the SM2BAT in conjunction with Sonobat 3 NE, found eastern red bats and big brown bats to be the most common species (Figures 16 and 18). The AR-125 in conjunction with Sonobat 3 NE found hoary bats and big brown bats to be the most common species (Figure 17).

After analyzing the same randomly chosen 5 nights of SM2BAT files converted to zero-crossing files and Anabat files using BCID 10, there were clear differences in the species groups and species detected by the two detectors. The SM2BAT detected more high-frequency and low-frequency species than the Anabats; whereas, the Anabats detected more mid-frequency species (Figure 19). The most apparent difference in the species comparison was the much larger number of tri-colored bats detected by the Anabats (Figure 20). The use of these same 5 nights of data with the un-converted SM2BAT files and the converted SM2BAT files, allowed for a direct comparison between the software packages. For the species group composition comparison, BCID 10 identified more of both high and low-frequency species (Figure 21). The largest difference in the species comparison was the higher number of tri-colored and eastern red bats identified by BCID 10 (Figure 22).

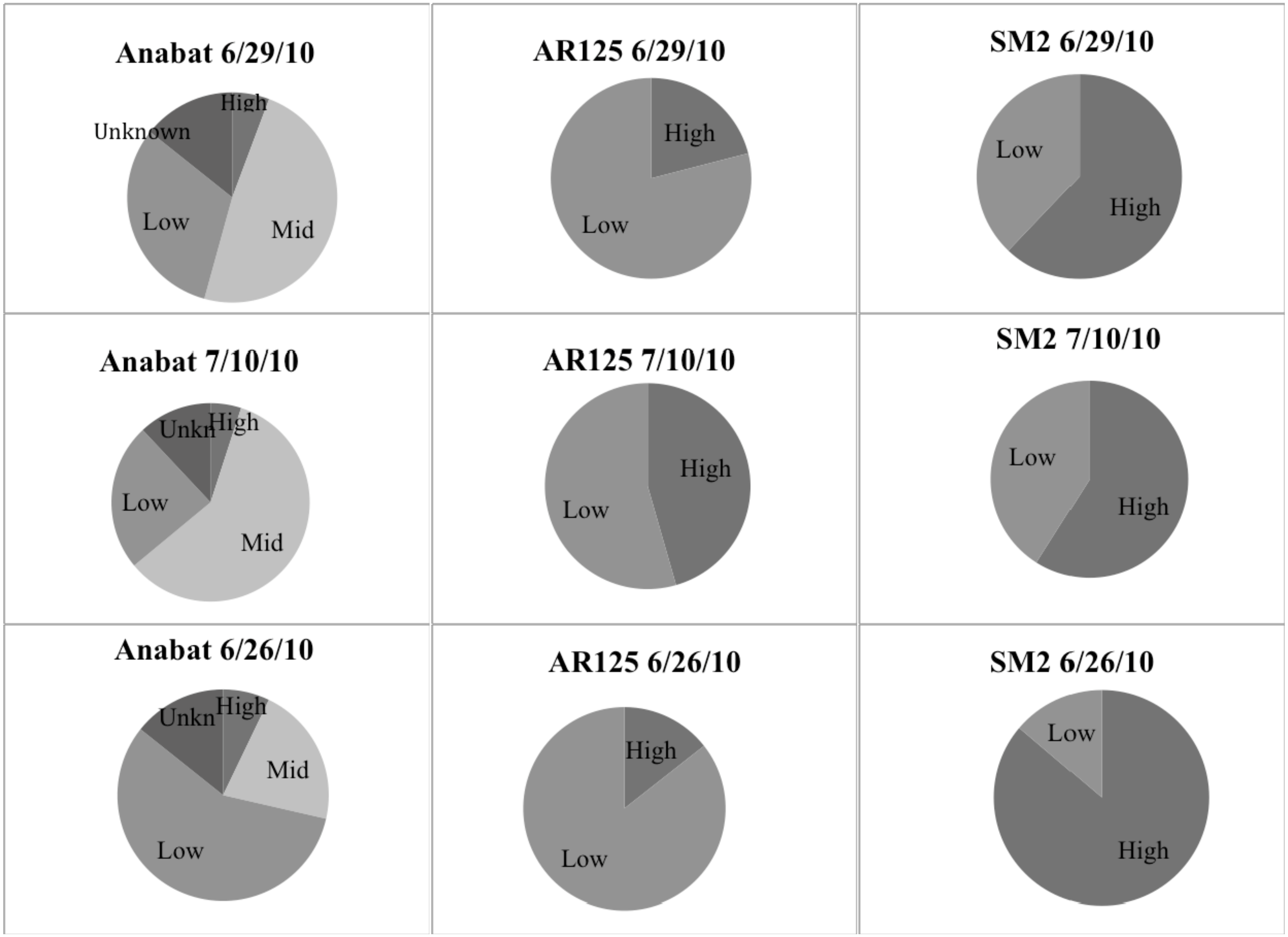

Figure 12. Example of daily results of species group composition and the variation that occurred in the species group composition recorded by each detector and identified by the two software packages.

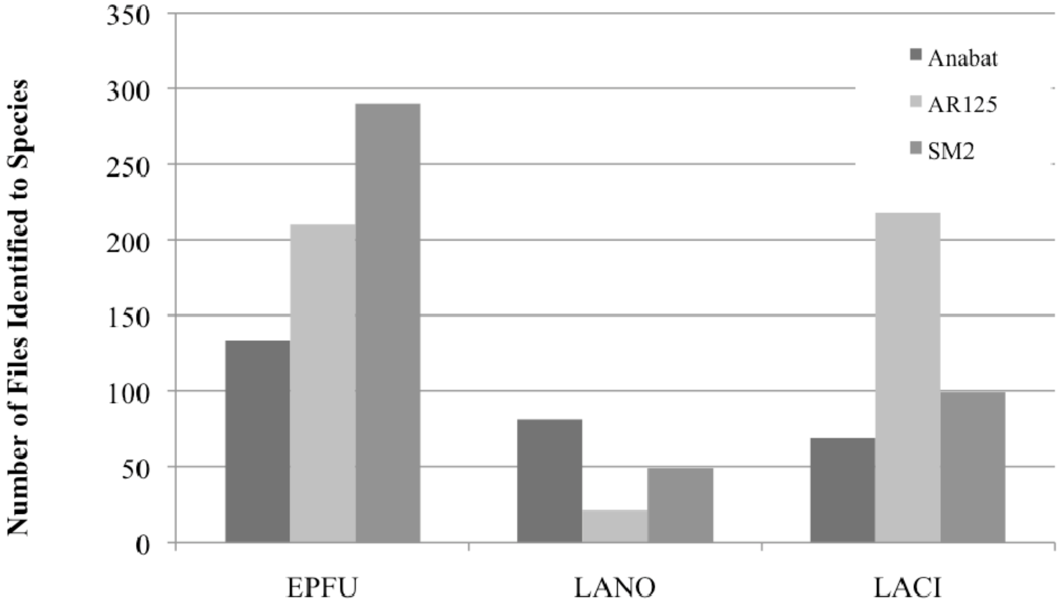

Figure 13. Total files identified to species for low-frequency species.

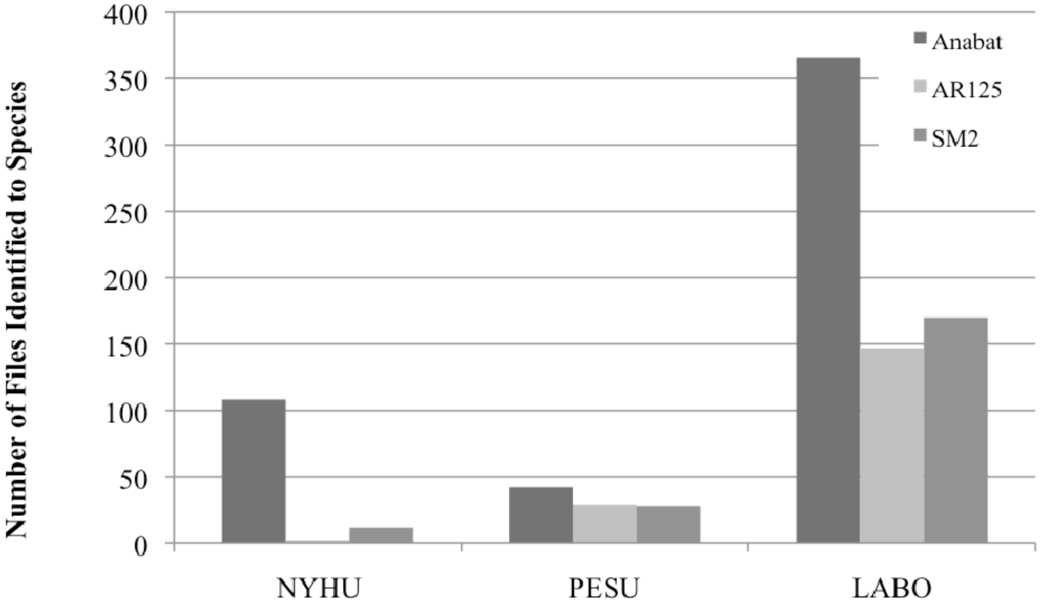

Figure 14. Total files identified to species for mid-frequency species.

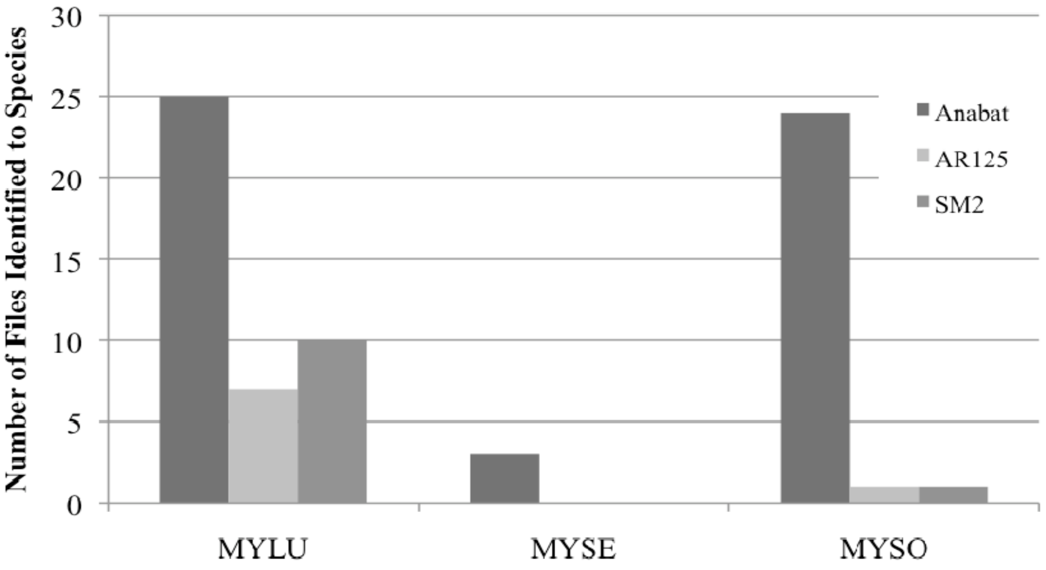

Figure 15. Total files identified to species for high-frequency species.

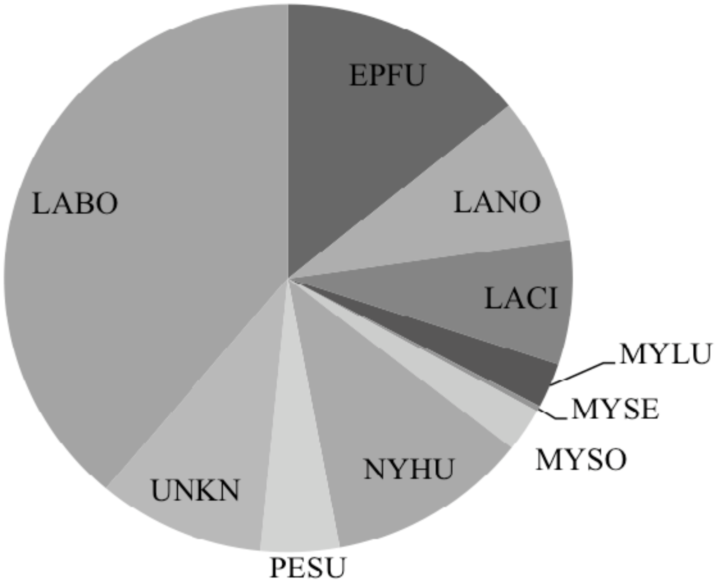

Figure 16. Species composition for Anabat files by BCID 10 based on a 10 hour period.

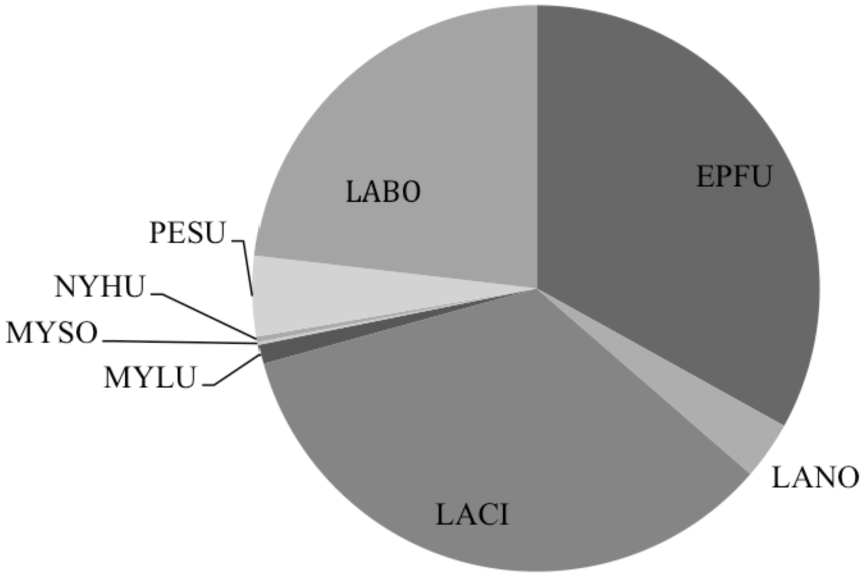

Figure 17. Species composition for AR-125 files by Sonobat 3 NE based on a 10 hour period.

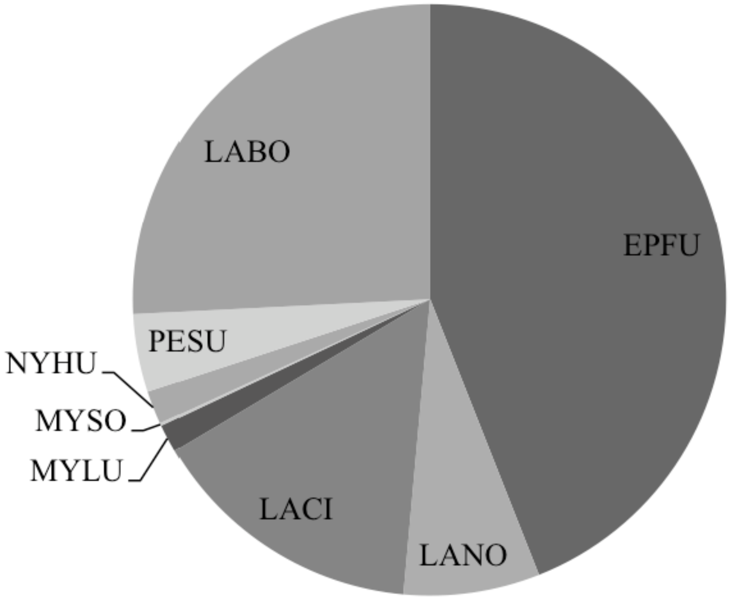

Figure 18. Species composition for SM2BAT by Sonobat 3 NE based on a 10 hour period.

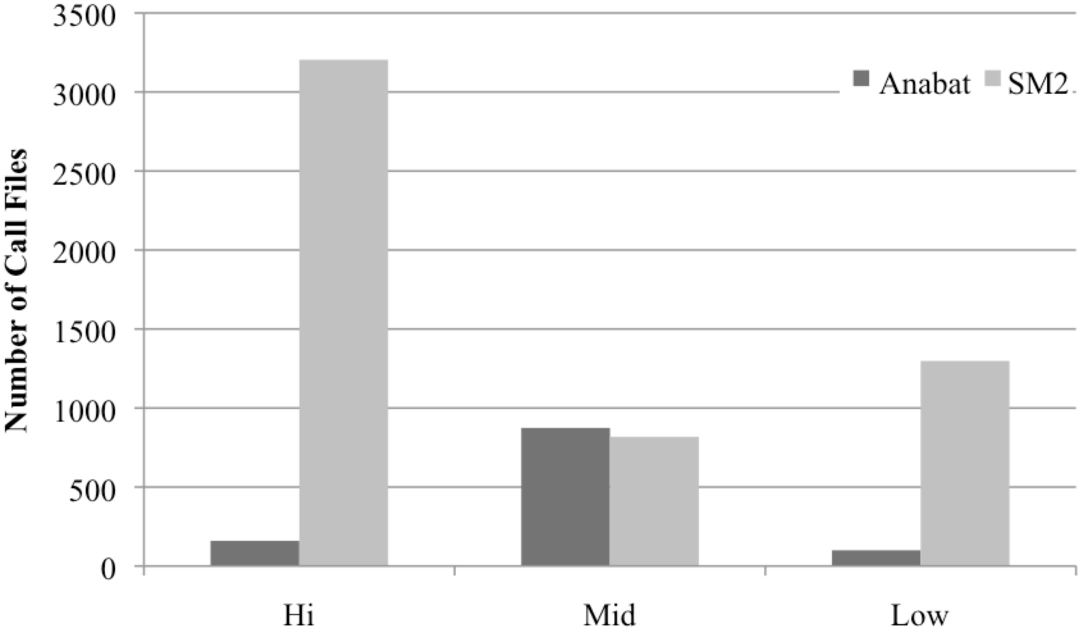

Figure 19. Species group composition of full spectrum files converted to zero-crossing files collected with the SM2BAT and Anabat files identified by BCID 10. BCID 10 was used to analyze the same 5 nights of data from the SM2BAT and the Anabats, allowing for a direct comparison of the species recorded by each detector.

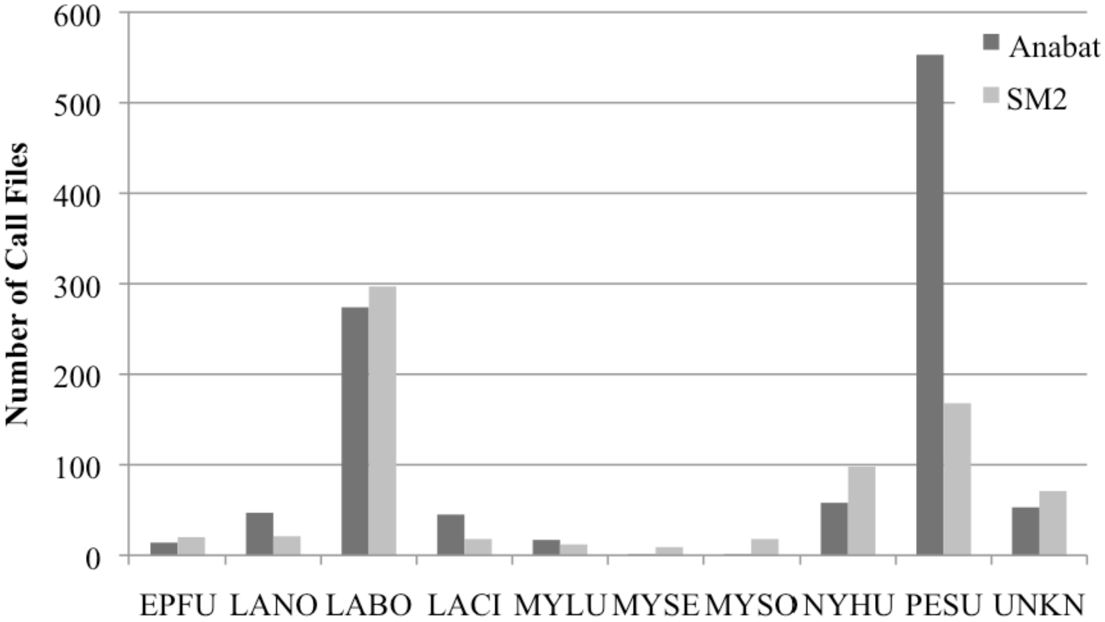

Figure 20. Species composition of converted full spectrum files collected with the SM2BAT and Anabat files using BCID 10. The same software was used to analyze the same 5 nights of data from the SM2BAT and the Anabats, allowing for a direct comparison of the species recorded by each detector.

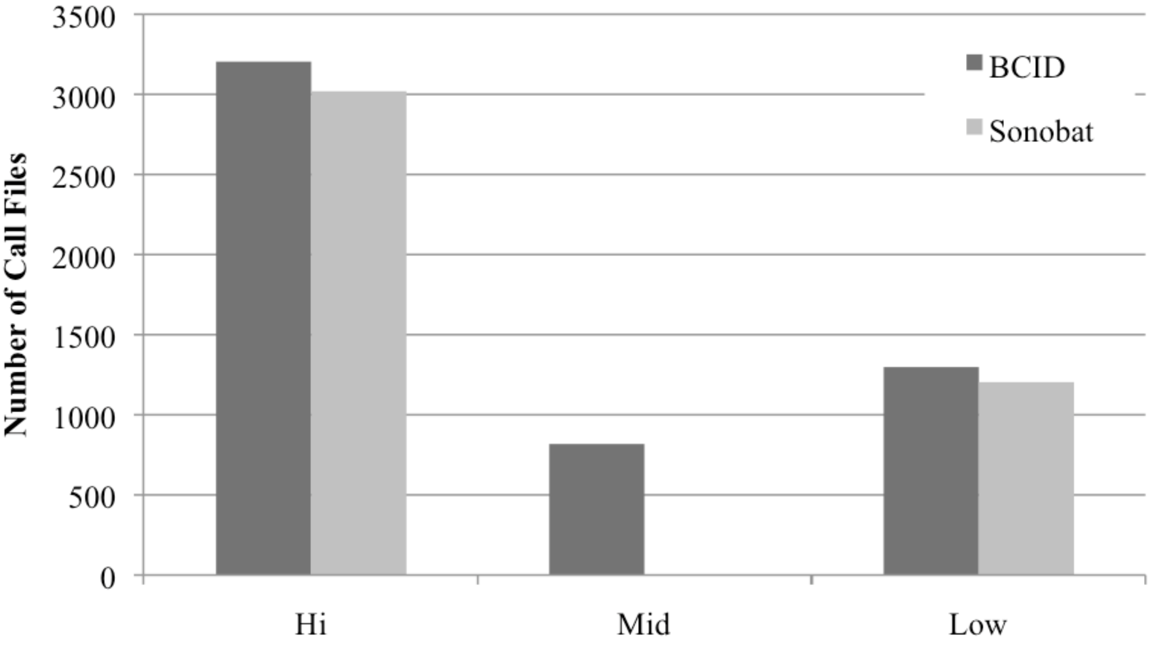

Figure 21. Species group composition of the same 5 nights of SM2BAT files (converted to zero-crossing and un-converted) using Sonobat 3 NE and BCID 10, allowing for a direct comparison of the software packages.

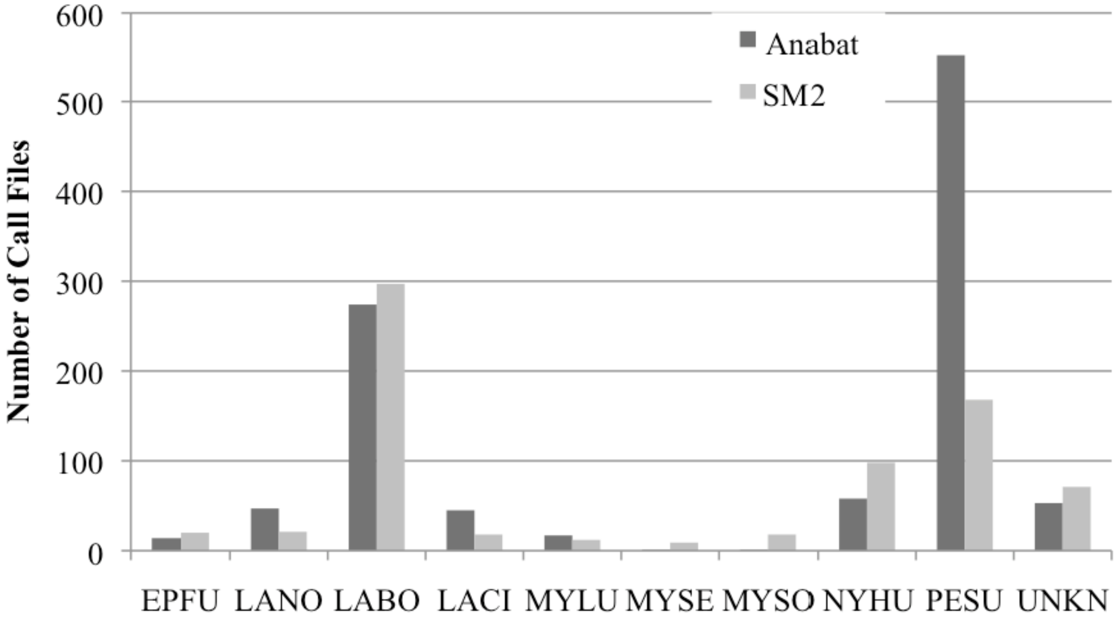

Figure 22. Species composition of the same 5 nights of SM2BAT files (converted to zero-crossing and un-converted) using Sonobat 3 NE and BCID 10, allowing for a direct comparison of the software packages.

Discussion and Conclusions

The overall results of this study suggest that these detectors are not interchangeable. There exist clear differences in the amount and type of data they record and therefore projects conducted with one are not necessarily comparable to projects done with another.

The full spectrum detectors clearly collect more data (Figure 3). This may make them more useful when attempting to collect calls from a rare, quiet, or difficult species. However, data processing times can be quite extensive (Figure 4). More bat passes appear to be identified using full spectrum equipment as well, but it is unknown at this time if this is an artifact of noise being attributed to bats or actual bat calls. There is some qualitative evidence that this is the case, but a full statistical analysis has yet to be done. It does appear that additional noise may play a role in the ability for software to identify a call to species. More bats appear to be identified to species using the BCID 10 software which is likely attributable to more extraneous noise present in full spectrum calls, as well as the conservative nature of Sonobat 3 NE (Figures 8). Additional filtering techniques are in the process of being developed which should eliminate some of this discrepancy (Joe Szewczak, pers. comm.).

While it is no longer a problem to store extremely large amounts of data, processing times are still an issue. The processing time for the zero-crossing call files for this project was approximately two hours, while the full spectrum call files took well over 200 hours. It is recommended that future software developers of full spectrum identification suites look into parallel processing as an alternative programming design. While this type of programming (e.g. CUDA) typically requires specific hardware for the user, the time saved could be well worth it.

Automated call identification is still being developed, but it is likely the future of acoustic sampling. The software developers recognize the current limitations and are continually expanding and improving upon their software. This study indicates that surveys analyzed with different software packages should not be considered comparable data for abundance and species composition type analysis, however, richness appears nearly equal across all variables over time with the exception of some difficult to distinguish *Myotis spp*. not being identified by Sonobat 3 NE. This issue is currently being addressed in new versions of the Sonobat software (Joe Szewczak, pers. comm.).

There were some differences in parameters recorded by the three detectors and reported by the software packages; however, the majority of them are not significantly different (Figures 5-7). It was expected that duration and Fmax would differ significantly from zero-crossing to full spectrum due to the sensitivity of full spectrum detectors and the differing sampling rates. The call files we chose for comparison were all identified using the software packages and visually to ensure that we were comparing the same species. However, both the BCID 10 and Sonobat 3 NE software rely heavily on the call parameters falling within a narrow band in order to make an identification. This effectively reduced the standard deviation of these data sets making the error rates appear extremely low. This subsequently showed some statistically significant differences between the hardware systems that may or may not actually exist. It has been shown that the natural variation of call parameters within a species greatly exceeds these error calculations and therefore the three detectors are likely comparable for reporting call parameters (Murray et al. 2001). It is suggested that more research be conducted in this area using unknown call files recorded simultaneously or artificial sound, eliminating the bias of the software systems. Another major problem that may lead to the differences in software identifications is the differences in the call libraries, which include species in the library, sample sizes of these species, and methods used to collect the data. We recommend that all data included in call libraries that are used for species identification be available for peer review, and all identifications using these libraries include identification probabilities and confidence limits of these species or species group identifications.

While this study has produced valuable insights into the behavior of these hardware and software systems, it has opened the door to many more questions. Future work still needs to be conducted to determine how these systems vary when most or all of the confounding variables have been removed. The overall impression is that all the hardware performs adequately in general but fails to standardize echolocation research as a group. This is somewhat expected given the complicated nature of recording high frequency sounds and the different designs (i.e. microphones, sampling rates, etc.) among the detectors. This in turn has a profound effect on the performance of any software package. At the same time, standard levels of acceptable confidence have yet to be developed for automated software, and there will always exist a trade-off between quantity over quality in the identification of bat echolocation. Currently, the software is being tailored to specific hardware, which is likely why Sonobat 3 NE is much more conservative than BCID 10. The hardware it is used with records a lot of extraneous noise, thus making the filtering process much more difficult. On the other hand a zero-crossing recorder can only record one sound at any given instance and likely misses some important information such as harmonics. The future direction of echolocation research will likely be more influenced by normal market conditions (cost, availability, time, ease of use, etc.) rather than specific technological advancements.

Acknowledgments

We would like to thank Ben Hale, Janelle Bowcock, Joseph R. Lemen, Joe Szewczak, and Ian Agranat for field and laboratory assistance. Funding for field projects that allowed us to run these comparisons was provided by: Missouri State University, Sho-Me-Power, Missouri National Guard, Ecology and the Environment, and the National Park Service.

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Dr. Lynn W. Robbins has been a professor at Missouri State University since 1985. Although his research has included many mammalian groups, he has been focusing on bat related issues in the eastern U.S. since 1998. He and his graduate students have published numerous papers on bat biology and conservation and many of these included acoustic analyses of activity and species identifications, with emphasis on endangered species. He is presently conducting research on the effects of forest management on endangered species, activity and relative abundance of bats prior to WNS in Missouri, and the use of acoustic, capture, and telemetry data and how they can be used in relation to wind turbine siting and operations in Missouri. He received his Bachelors' at California State University, Long Beach, a Master's from Fort Hays State University, Kansas, and a Ph.D. from Texas Tech University where he studied bat evolution and systematics.

ACOUSTIC MONITORING AND SAMPLING TECHNOLOGY

Lynn W. Robbins, C. Ryan Allen and Shannon E. Romeling

OR

When and Where, and What Do You Want It To Do?

Introduction to Ultrasonic Detection

- Griffin coined the term echolocation in 1940
- Insectivorous bats use echolocation to obtain information about the presence, position, course, speed, and even identity of potential prey
- Recorded echolocation calls now used to identify species, species groups, and to determine relative abundance and activity

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Purpose

- To describe and compare both the hardware and the software of full spectrum and zero-crossing acoustic bat technology as well as the advantages and possible disadvantages of each system

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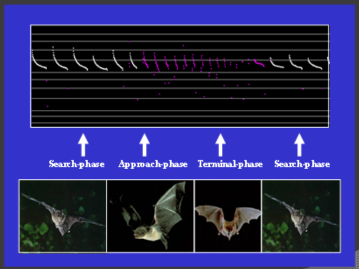
Species or Group Identification

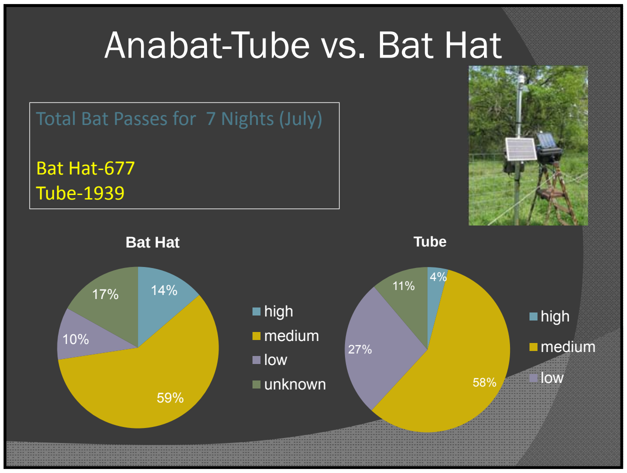
- More variation within the sequence from an individual than among individuals



Zero Crossing Hardware

- Anabat, Titley Electronics
  - Widely used by researchers and consultants
  - Study included Anabat II, SD1, and SD2 detectors

Typical Field Applications



Anabat-Tube vs. Bat Hat

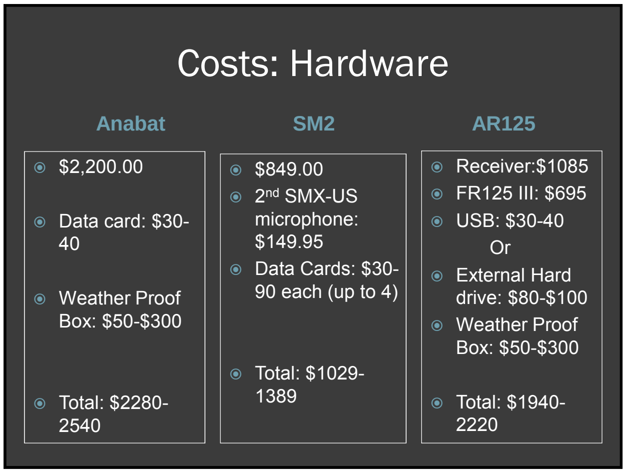
Total Bat Passes for 7 Nights (July)

Bat Hat-677
Tube-1939

Full Spectrum Hardware

AR125 with FR125

Song Meter 2 (SM2)



Costs: Hardware

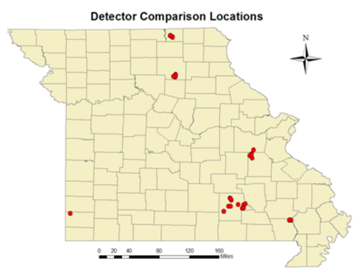
Anabat	SM2	AR125
◉ $2,200.00 ◉ Data card: $30-40 ◉ Weather Proof Box: $50-$300 ◉ Total: $2280-2540	◉ $849.00 ◉ 2nd SMX-US microphone: $149.95 ◉ Data Cards: $30-90 each (up to 4) ◉ Total: $1029-1389	◉ Receiver:$1085 ◉ FR125 III: $695 ◉ USB: $30-40 Or ◉ External Hard drive: $80-$100 ◉ Weather Proof Box: $50-$300 ◉ Total: $1940-2220

Methods

- Settings for detectors
  - Recommended /Default
  - Triggers, filters
- Download Anabat Calls using CFC read
  - Div 16
  - Default filter
- Download AR 125 calls
  - Batch Scrubber
- Download SM2 calls
  - WACtoWAV
    - Skip noise

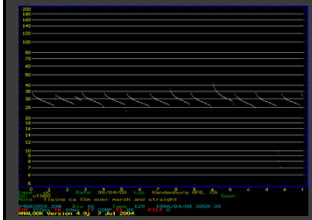
Methods-Hardware

- 3 detectors set next to each other
- 2.5 ft table
- 34 nights across Missouri
- May 17 – July 17, 2010
- Collected 140,968 call files
- Fields, near ponds, in forest, on roads

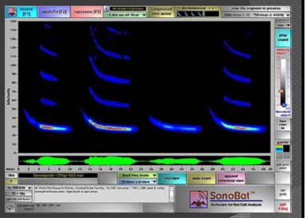


Examples of Calls

Analook DOS



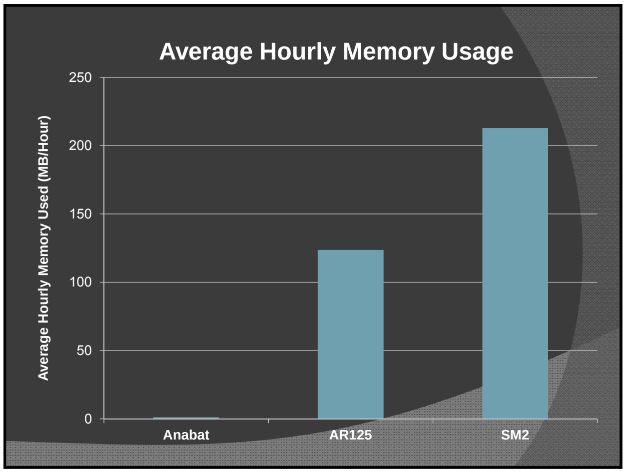
Sonobat 3

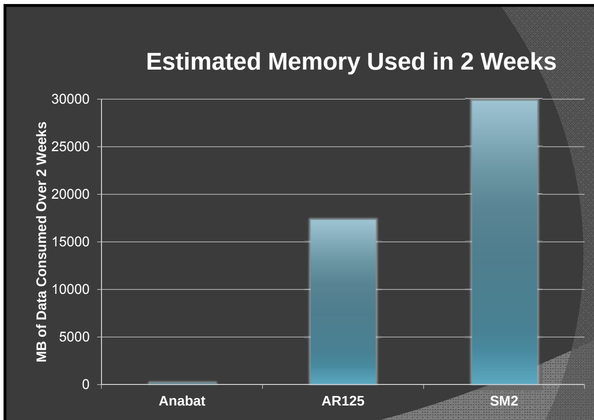


Brazilian Free-tailed calls

Hardware: Ease of Use

	Open box	Initialize card	Outside Power Source Necessary	Weather proofing Necessary
Anabat		X		X
SM2	X	X		
AR125			X	X





Hardware: Advantages and Disadvantages

	Advantages	Disadvantages
Anabat	-Low memory consumption -Settings are easily adjustable -Fewer noise files	-Costly -Not weather proof
SM2	-1 piece -Weather proof -Records more call files	-Large amounts of data
AR125	-Data easy to download -Records more call files	-Large amounts of data -2 pieces and 2 wires -Not weather proof

Species Identification

- Fenton, O'Farrell, Corben
  - Qualitative Characteristics
- Britzke, Parsons, Betts, Krusic, Corcoran
  - Filters, DFA and/or neural networks
- Allen (BCID)
  - Weighted classification tree
- Szewczak (Sonobat)
  - DFA

Software

- Requires large call libraries
- Methods of building libraries: Hand Release, Spot Light, Enclosure

Zip-Line

Light Tag

Methods: Software

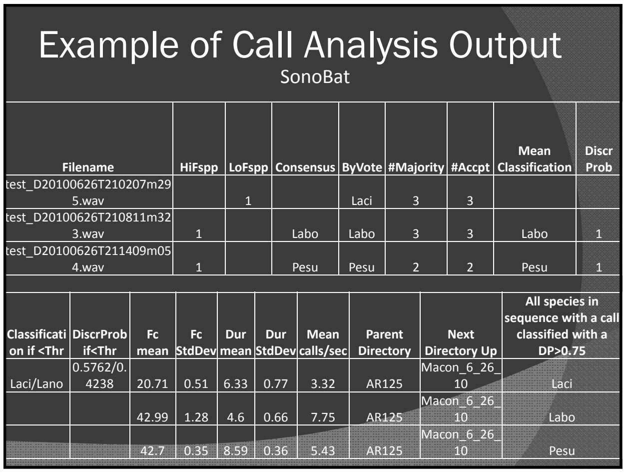
- SonoBat 3 NE
  - Full spectrum analysis
  - Northeast Version
  - Midwest version including grey bats will be available soon
  - Purchased from Sonobat.com: $1536.00
  - 7 geographic regions

Methods: Software

- Bat Call Identification (BCID)
  - Zero-crossing analysis
  - Can analyze converted full spectrum calls
  - Version used 1.2.5.3- Analook DOS
  - Current Version 2.0.0.1- AnalookW
  - Trial version available free from batcallid.com

Methods: Software

- Both software packages used with default/recommended settings
  - SonoBat – 80% quality, 90% DP, 8 max calls
  - BCID – 1 pulse for bat passes, 4 + to species
- Time recorded for each data set when possible

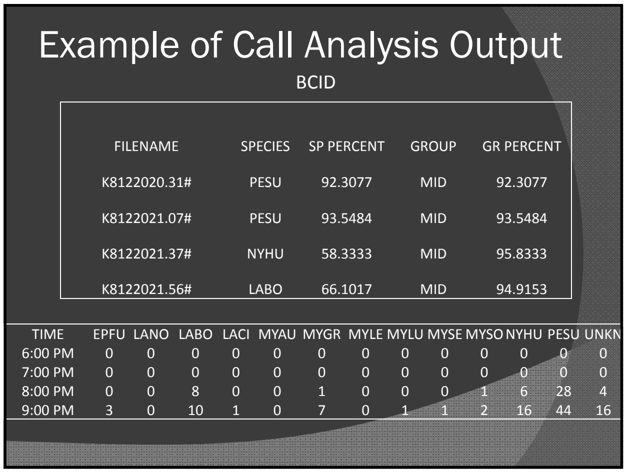


Example of Call Analysis Output

SonoBat

Filename	HiFspp	LoFspp	Consensus	ByVote	#Majority	#Accpt	Mean Classification	Discr Prob
test_D20100626T210207m295.wav		1		Laci	3	3		
test_D20100626T210811m323.wav	1		Labo	Labo	3	3	Labo	1
test_D20100626T211409m054.wav	1		Pesu	Pesu	2	2	Pesu	1

Classification if <Thr	DiscrProb if<Thr	Fc mean	Fc StdDev	Dur mean	Dur StdDev	Mean calls/sec	Parent Directory	Next Directory Up	All species in sequence with a call classified with a DP>0.75
Laci/Lano	0.5762/0.4238	20.71	0.51	6.33	0.77	3.32	AR125	Macon_6_26_10	Laci
		42.99	1.28	4.6	0.66	7.75	AR125	Macon_6_26_10	Labo
		42.7	0.35	8.59	0.36	5.43	AR125	Macon_6_26_10	Pesu

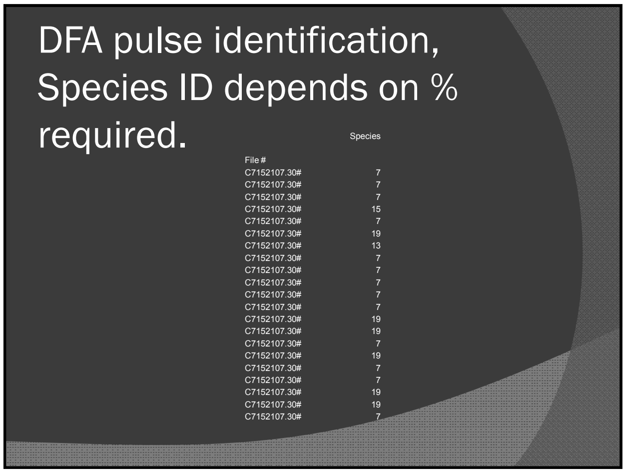


Example of Call Analysis Output

BCID

FILENAME	SPECIES	SP PERCENT	GROUP	GR PERCENT
K8122020.31#	PESU	92.3077	MID	92.3077
K8122021.07#	PESU	93.5484	MID	93.5484
K8122021.37#	NYHU	58.3333	MID	95.8333
K8122021.56#	LABO	66.1017	MID	94.9153

TIME	EPFU	LANO	LABO	LACI	MYAU	MYGR	MYLE	MYLU	MYSE	MYSO	NYHU	PESU	UNKN
6:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0
7:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0
8:00 PM	0	0	8	0	0	1	0	0	0	1	6	28	4
9:00 PM	3	0	10	1	0	7	0	1	1	2	16	44	16



DFA pulse identification, Species ID depends on % required.

File #	Species
C7152107.30#	7
C7152107.30#	7
C7152107.30#	7
C7152107.30#	15
C7152107.30#	7
C7152107.30#	19
C7152107.30#	13
C7152107.30#	7
C7152107.30#	7
C7152107.30#	7
C7152107.30#	7
C7152107.30#	7
C7152107.30#	19
C7152107.30#	19
C7152107.30#	7
C7152107.30#	19
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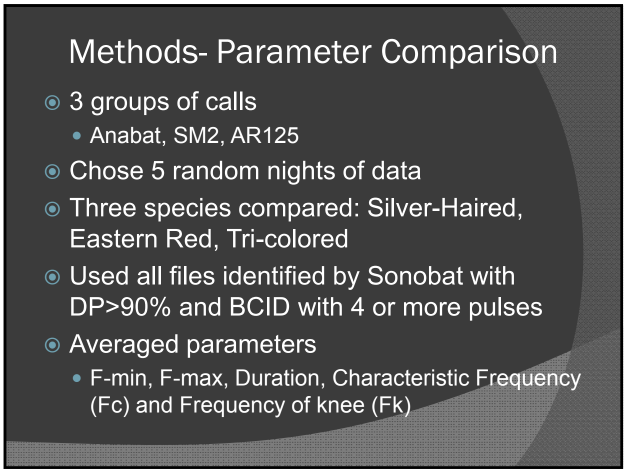
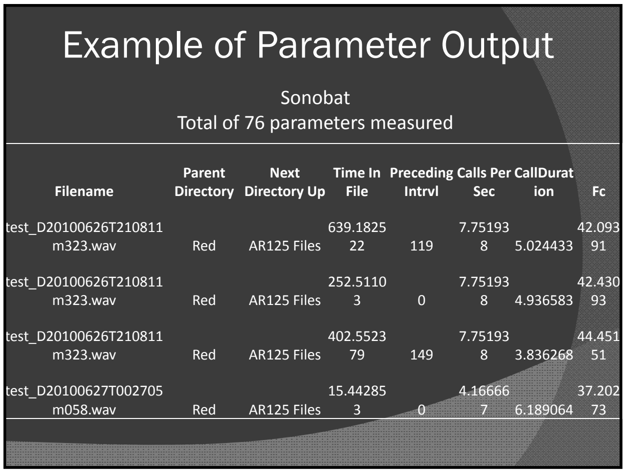
C7152107.30#	19
C7152107.30#	19
C7152107.30#	7



Methods- Parameter Comparison

- 3 groups of calls
  - Anabat, SM2, AR125
- Chose 5 random nights of data
- Three species compared: Silver-Haired, Eastern Red, Tri-colored
- Used all files identified by Sonobat with DP>90% and BCID with 4 or more pulses
- Averaged parameters
  - F-min, F-max, Duration, Characteristic Frequency (Fc) and Frequency of knee (Fk)

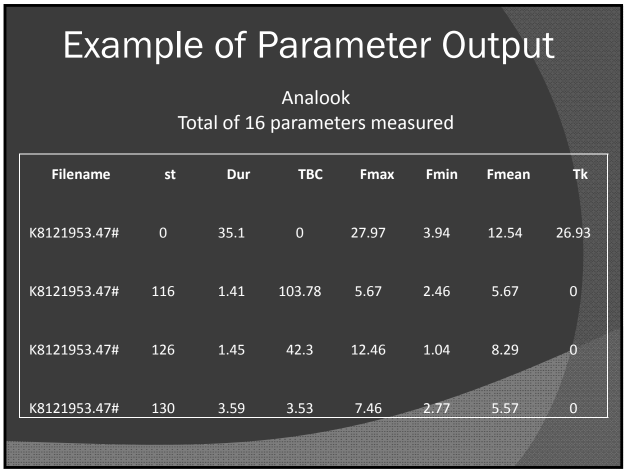


Example of Parameter Output

Sonobat

Total of 76 parameters measured

Filename	Parent Directory	Next Directory Up	Time In File	Preceding Intrvl	Calls Per Sec	CallDuration	Fc
test_D20100626T210811m323.wav	Red	AR125 Files	639.182522	119	7.751938	5.024433	42.09391
test_D20100626T210811m323.wav	Red	AR125 Files	252.51103	0	7.751938	4.936583	42.43093
test_D20100626T210811m323.wav	Red	AR125 Files	402.552379	149	7.751938	3.836268	44.45151
test_D20100627T002705m058.wav	Red	AR125 Files	15.442853	0	4.166667	6.189064	37.20273

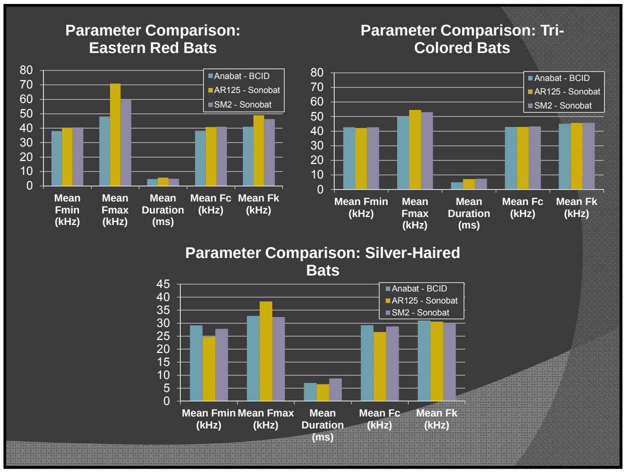


Example of Parameter Output

Analook

Total of 16 parameters measured

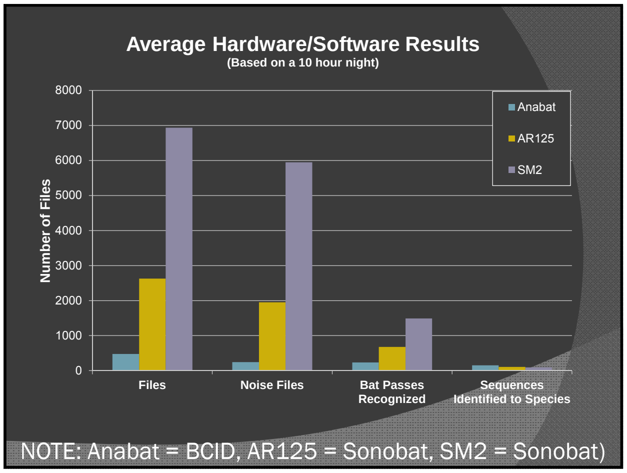
Filename	st	Dur	TBC	Fmax	Fmin	Fmean	Tk
K8121953.47#	0	35.1	0	27.97	3.94	12.54	26.93
K8121953.47#	116	1.41	103.78	5.67	2.46	5.67	0
K8121953.47#	126	1.45	42.3	12.46	1.04	8.29	0
K8121953.47#	130	3.59	3.53	7.46	2.77	5.57	0



Parameter Comparison: Eastern Red Bats

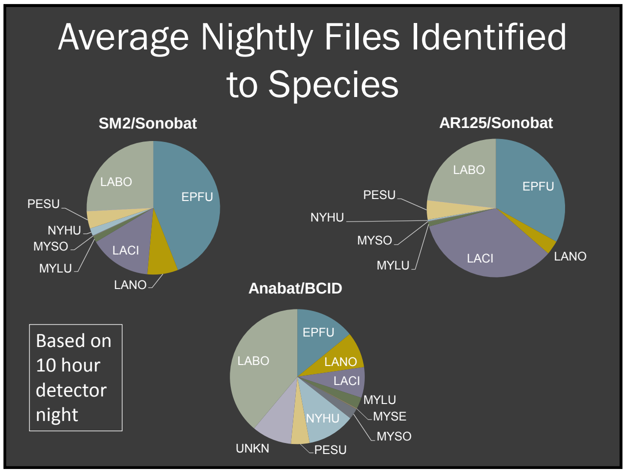
Parameter Comparison: Tri-Colored Bats

Parameter Comparison: Silver-Haired Bats



Average Hardware/Software Results
(Based on a 10 hour night)

NOTE: Anabat = BCID, AR125 = Sonobat, SM2 = Sonobat)



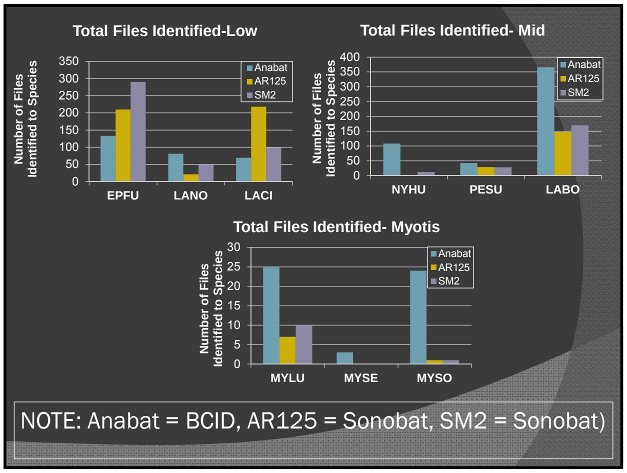
Average Nightly Files Identified to Species

SM2/Sonobat

AR125/Sonobat

Anabat/BCID

Based on 10 hour detector night

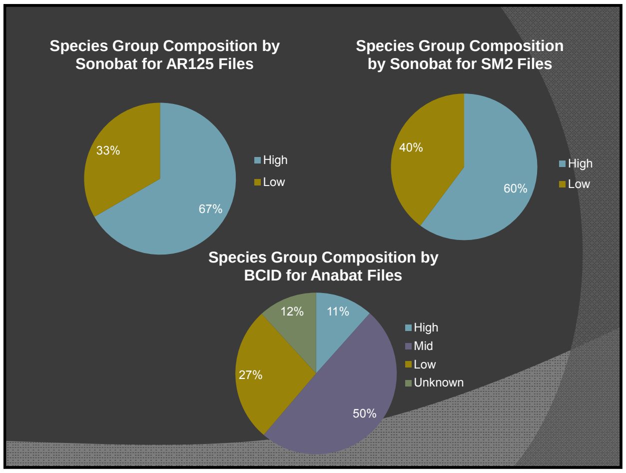


Total Files Identified-Low

Total Files Identified- Mid

Total Files Identified- Myotis

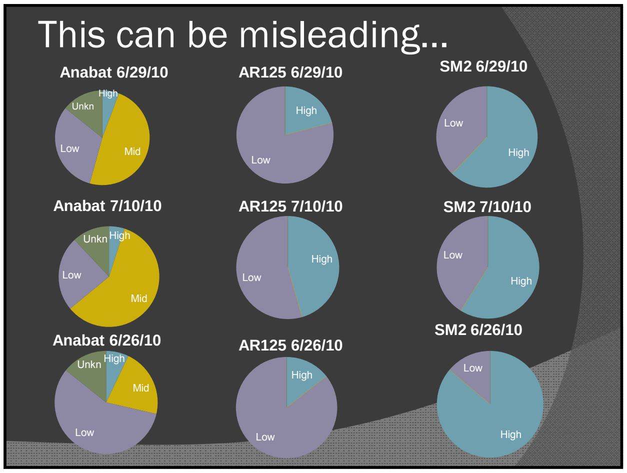
NOTE: Anabat = BCID, AR125 = Sonobat, SM2 = Sonobat)



Species Group Composition by Sonobat for AR125 Files

Species Group Composition by Sonobat for SM2 Files

Species Group Composition by BCID for Anabat Files



This can be misleading…

Anabat 6/29/10

AR125 6/29/10

SM2 6/29/10

Anabat 7/10/10

AR125 7/10/10

SM2 7/10/10

Anabat 6/26/10

AR125 6/26/10

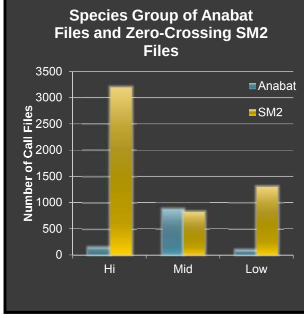
SM2 6/26/10

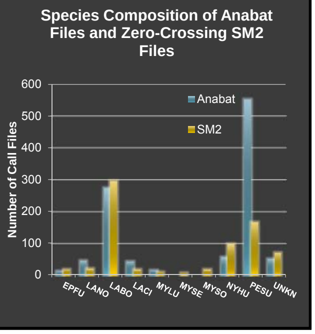
Software: Advantages and Disadvantages

	Advantages	Disadvantages
SonoBat	-Comparison view of pulses -Harmonic emphasis	-Long analysis time -Few calls identified to species or species group
BCID	-Quick analysis time --Ability to turn species off	-Zero-crossing analysis only -Limited geographic regions

Detector Comparison Using BCID

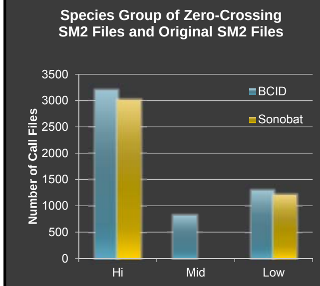
Based on 5 nights of data

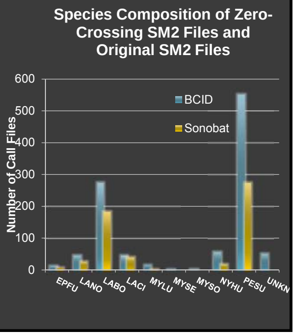

Species Group of Anabat Files and Zero-Crossing SM2 Files


Species Composition of Anabat Files and Zero-Crossing SM2 Files

Software Comparison Using SM2

(Based on 5 Nights of Data)


Species Group of Zero-Crossing SM2 Files and Original SM2 Files


Species Composition of Zero-Crossing SM2 Files and Original SM2 Files

Discussion

- Data analysis time longer for full spectrum calls
- Variation in species and species groups detected
- Extensive memory usage using full spectrum
- Full spectrum hardware detecting more bat passes

Determine your needs, Define your project, then choose your system

WHITE-NOSE SYNDROME: AN OVERVIEW OF ONGOING AND FUTURE RESEARCH NEEDS

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Gary F. McCracken[5], Marianne S. Moore[1], Jonathan D. Reichard[1], DeeAnn M. Reeder[7], Alison H. Robbins[7]

Abstract

White-nose syndrome (WNS) is an emerging infectious disease that is causing unprecedented mortality of hibernating bats in eastern North America and is threatening regional extinction of formerly common species. The rapid rate of spread and high mortality associated with WNS makes this epizootic one of the most threatening wildlife diseases ever reported for bats. Current estimates indicate that over one million hibernating bats among six North America bat species have died from this disease since its first discovery in New York in 2006. These six species are the little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*M. septentrionalis*), Indiana myotis (*M. sodalis*), eastern small-footed bat (*M. leibii*), tricolored bat (*Perimyotis subflavus*), and big brown bat (*Eptesicus fuscus*). A recent study predicted that if current assumptions about mortality rates and spread persist, *M. lucifugus*, the species that currently is the most severely affected by WNS, will experience regional extinction within 16-20 years. *Geomyces destructans* (*Gd*), the putative fungal pathogen associated with WNS, was recently isolated from three additional species, the southeastern myotis (*M. austroriparius*), gray myotis (*M. grisescens*), and cave myotis (*M. velifer*), but to our knowledge, evidence of *Gd* infection based on histopathology (the "gold-standard") has not been confirmed in *M. grisescens* from Missouri or *M. velifer* from Oklahoma. To date, no evidence of mass mortality has been reported for the latter three species. Researchers and wildlife managers are challenged by lack of sufficient knowledge on transmission dynamics and disease resistance in bats, which is limiting the ability of researchers to develop effective mitigation and management strategies. Research support is needed to investigate seasonal and geographic variation in fungal prevalence and loads, differences in species susceptibility and infectiousness to *Gd* infection, and mechanisms, routes and intensity of *Gd* transmission at different colony and geographic scales, with the purpose of identifying effective mitigation strategies to reduce mortality of affected bats and to implement protocols to protect populations at risk.

Key words: Chiroptera, *Geomyces destructans*, hibernating bats, North America, research needs, White-nose syndrome

Introduction

White-nose syndrome (WNS) is one of the most devastating diseases in recorded history to affect wildlife in North America (Figure 1). Since its discovery in upstate New York in February 2006, estimates indicate that over one million hibernating bats have died from this disease (Blehert et al., 2009; Frick et al., 2010a), with losses averaging 73%, but with decline of up to 100% in some hibernacula and maternity colonies in eastern North America. To date, six species are known to be affected by WNS, including the most severely affected little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*M. septentrionalis*), Indiana myotis (*M. sodalis*), tricolored bat (*Perimyotis subflavus*), and the apparently less affected eastern small-footed bat (*M. leibii*) and big brown bat (*Eptesicus fuscus*). Three other species, including the southeastern bat (*M. austroriparius*), the Federally Endangered gray bat (*M. grisescens*), and the cave myotis (*M. velifer*) have been diagnosed using PCR tests indicating presence of *Geomyces destructans,* but to date, infection from this fungal pathogen has not been confirmed based on histopathology for *M. griscescens* from Missouri or *M. velifer* from Oklahoma (USFWS, 2011)

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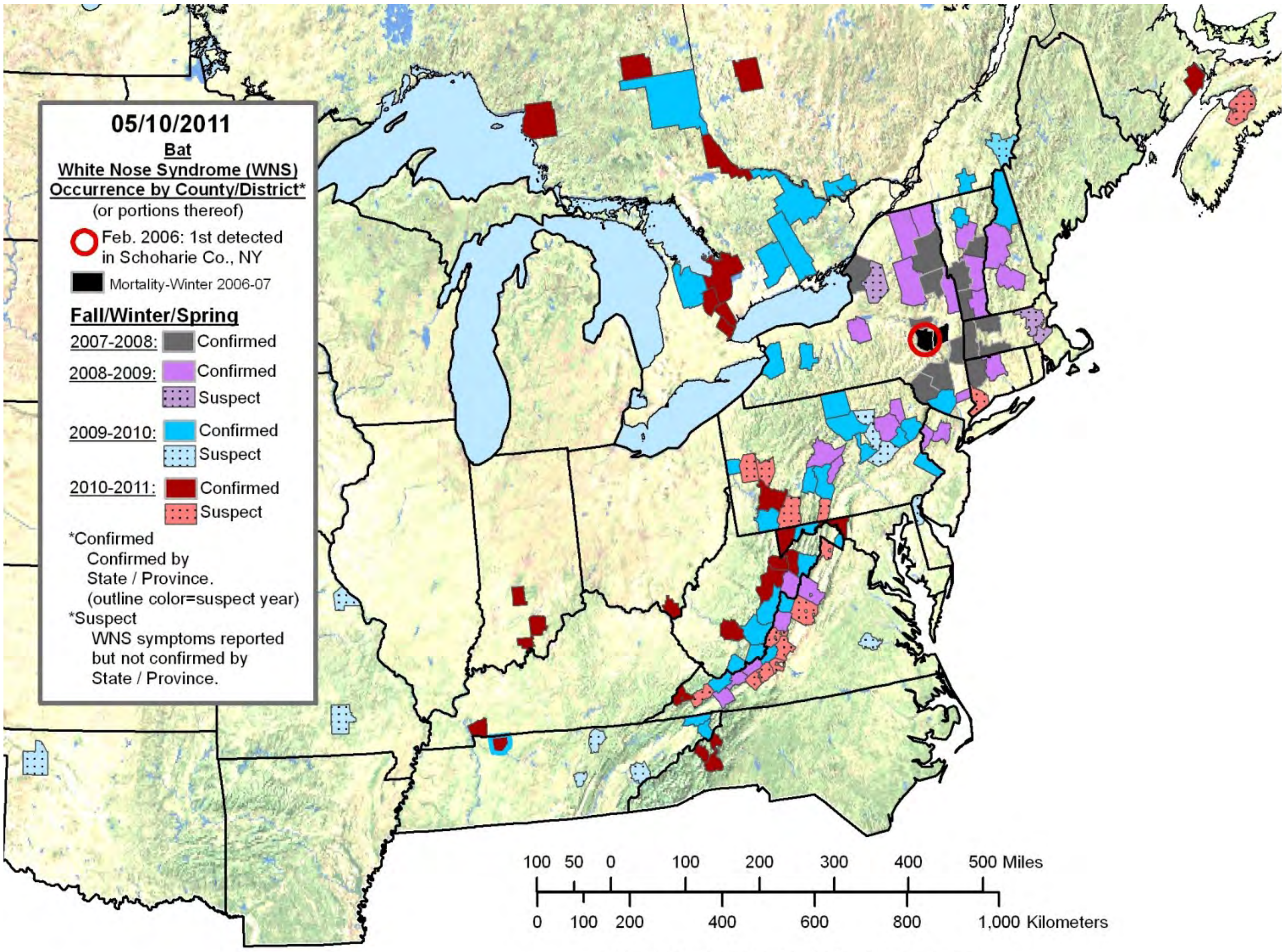
Figure 1. A hibernating little brown myotis (*Myotis lucifugus*) infected with *Geomyces destructans,* a fungus associated with white-nose syndrome (Photo credit: A.C. Hicks, New York Department of Environmental Conservation).

The earliest research on bats affected by WNS identified cutaneous fungal infections caused by *Geomyces destructans* (*Gd*), a previously unknown, cold-adapted fungus that grows optimally between 5^{o} and 10^{o}C, within the 2^{o} to 14^{o}C temperature range that is characteristic of hibernacula in North America affected by WNS (Blehert et al., 2009). Based on morphological and genetic (PCR) analyses, *Gd* has been reported from hibernating bats in 17 states (Connecticut, Delaware, Indiana, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Vermont, Virginia, West Virginia, Tennessee, Missouri, and Oklahoma), and four Canadian provinces (New Brunswick, Nova Scotia, Ontario, and Quebec) (Meteyer et al., 2009; Chaturvedi et al., 2010; USFWS, 2011; Figure 2). However, to date, mass mortality has only been reported from seven northeastern states (Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, and Vermont) and one Canadian province (New Brunswick).



Map by: Cal Butchkoski, PA Game Commission

Figure 2. Map showing the distribution of the fungal pathogen *Geomyces desctuctans* (*Gd*) and locations of bats manifesting symptoms of white-nose syndrome in North America http://www.fws.gov/whitenosesyndrome/maps/WNSMap_040411_300dpi_DS.jpg (accessed May 10, 2011).

Research and monitoring studies on hibernating bats in eastern North America have revealed that bats affected by WNS are characterized by the following symptoms: white fungal growth on exposed skin tissues, such as nose, ears, tail and wing membranes (Blehert et al., 2009; Gargas et al., 2009); prematurely depleted fat reserves (Blehert et al., 2009; Gargas et al., 2009; Courtin et al., 2010; J.D. Reichard, unpubl. data); immunological changes (M.S. Moore, unpubl. data; D.M. Reeder, unpubl. data); altered arousal patterns during hibernation (D.M. Reeder et al., unpubl. data); atypical flight behavior in mid-winter (A.C. Hicks, pers. comm.); and ulcerated, necrotic, and scarred wing tissue (Reichard and Kunz, 2009; Cryan et al., 2010).

Recent evidence suggests that *Gd* is a pathogen that was introduced to the U.S from Europe by human trade or traffic. Researchers have established that *Gd* is present in nine species of European bats, although no evidence of mass mortality has been reported (Puechmaile et al., 2010; Wibbelt et al., 2010; Martínková et al., 2010). Fungal isolates of *Gd* from selected hibernacula in the U.S. (Lorch et al., 2010; Lindner et al., 2010) appear to be derived from a single clone (Chaturvedi et al., 2010), suggesting a relatively recent introduction. Research on WNS in North America suggests that there is no difference in susceptibility caused by potential environmental toxins because they were similar in bats both affected and unaffected by WNS (Courtin et al., 2010; Kannan et al., 2010), although more work is needed in this particular context. Mass die-offs resulting from WNS (Figure 3; Frick et al., 2010b) are consistent with the hypothesis of an introduced pathogen in a naïve wildlife population (Cunningham et al., 2003). Notwithstanding, the origins of *Gd* in the U.S. will not be known until comparative genomic analyses of isolates from North America and Europe are complete.

Figure. 3. Dead and moribund bats lying on the floor of a hibernaculum in Vermont caused by white-nose syndrome (Photo credit: M.S. Moore, Boston University)

Several mitigation strategies have been proposed, including installation of heated roosts as "thermal refugia" in caves to reduce energy expenditure of aroused bats (Boyles and Willis, 2009), and culling to reduce the spread of *Gd* (Arnold Air Force Base, 2009). However, attempts to deploy heated roosts have not been successful (C. Willis, pers. comm.), and a recent modeling study demonstrates that culling would be ineffective in stopping the spread of *Gd* (Hallam and McCracken, 2011). Additionally, proposals for reducing the spread of *Gd* by closing caves and mines to human traffic are being practiced by some state and federal agencies, and protocols for decontaminating clothing and field equipment are being implemented (USFWS, 2010). However, comprehensive understanding of WNS epidemiology remains elusive (Foley et al., 2011).

Ongoing and Future Research Needs

Since 2008, wildlife biologists from state and federal agencies, non-government organizations, and academic researchers have participated in several regional WNS strategy meetings and conferences in an effort to identify research and monitoring needs (Bat Conservation International, 2009). Both non-government and academic scientists have developed and presented proposed budgets for research and conservation management activities at congressional hearings, but limited funding has been made available from federal sources or state governments to address this devastating and rapidly spreading disease. In October 2010, the U.S. Fish and Wildlife Service proposed a draft National Plan (http://www.fws.gov/whitenosesyndrome/nationalplan.html) to coordinate surveillance and monitoring efforts (Coleman, 2011), but as of this writing, this plan has not been implemented.

State and federal agencies, non-government organizations, and academic institutions have established partnerships (Waldien et al., 2011) to help develop and address key questions related to understanding and managing WNS (Bat Conservation

International, 2009). Examples of these questions include: (1) What are the mechanisms of disease-caused mortality in hibernating bats? (2) What are the physiological, behavioral and immunological responses of individuals to *Gd* infection? (3) How is *Gd* transmitted among individuals and across sites? (4) How does disease-related mortality from *Gd* affect population dynamics and viability of affected populations and species? (5) What is the origin of *Gd* and how is it spread? (6) Is there variability in the susceptibility of different bat species to *Gd*? (7) Does the rate of disease progression in bats vary in relation to microclimate of hibernacula? (8) Can quantitative diagnostic tools be developed for identifying *Gd*? (9) Can selected chemical compounds be used to reduce or eliminate *Gd* on skin surfaces? (10) Should anti-fungal compounds be used as a management strategy to reduce the effects of or spread of Gd? and (11) How can knowledge of ecosystem services be used to convey the value of bats to humankind and to help raise funding levels to support research and management of WNS?

Ongoing Research

1. Physiological and immunological responses to WNS infection

Changes in body composition of bats affected by and unaffected by WNS—Early field and laboratory observations in the northeastern U.S. have shown that bats affected by WNS have severely depleted fat reserves in mid-winter, a condition that is expected to compromise successful hibernation and ultimately reduce chances of survival. Studies have been designed to test hypotheses that reduced fat reserves (white adipose tissue, WAT) are caused by failure to deposit sufficient WAT during the prehibernation period or premature depletion of WAT reserves during hibernation, due in part to frequent or extended bouts of arousal. Other hypotheses state that over-winter survival and subsequent reproductive success of hibernating bats also requires sufficient quantities and qualities of WAT deposited during the pre-hibernation period (Kunz et al., 1998; Humphries et al., 2003), and that these reserves include sufficient quantities of essential saturated and polyunsaturated fatty acids (PUFAs) that can be obtained only from dietary sources because they cannot be synthesized by hibernating mammals, including bats (C.L. Frank, pers. comm). The latter hypothesis predicts that dietary deficiencies of certain PUFA's will affect the depth and duration of deep torpor during hibernation.

To date, analysis of body composition, including PUFA's, of little brown myotis (*M. lucifugus*) during the pre-hibernation period at sites affected and unaffected by WNS suggests that bats deposit adequate reserves of WAT in autumn (J.D. Reichard, unpubl. data). However, by mid-winter, WNS-affected bats have markedly less WAT compared to unaffected bats. As WAT reserves approach critical thresholds, bats affected by WNS appear to adopt behaviors causing them to emerge from hibernation prematurely in attempts to feed or gain access to water (J.D. Reichard, unpubl. data). At some WNS-affected sites, bats have also been observed roosting near mine or cave openings long before spring emergence (A.C. Hicks, pers. comm.). Such activities may reflect attempts by bats to sample outside conditions for early detection of spring warming or insect availability. If bats adopt these behaviors when WAT reserves are low, they may be responding to some minimum threshold of fat needed to initiate other physiological processes (e.g. immune responses or female ovulation).

Data collected to date have provided valuable insight for testing proposed hypotheses to help explain why hibernating bats are dying prematurely at hibernacula in the northeastern U.S. and also suggest directions for future study to better understand the etiology of WNS. Low reserves of WAT at the end of hibernation may reduce reproductive success of females, especially when leptin levels are low (Kunz et al., 1998). Current evidence suggests that little brown myotis affected by WNS have poorer body condition in spring and summer than unaffected individuals during the same period (Reichard and Kunz, 2009). Some stored fat reserves at the end of winter are needed to fuel spring migration and early foraging bouts and to sustain early gestation while energy sources transition from winter to the active season when insects and other arthropod prey become available.

Immune function of hibernating bats affected and unaffected by WNS—Understanding the immunological status of bats affected with WNS is essential to assess their ability to resist pathogenic or opportunistic infections. Effective immunological defenses against tissue-invading fungi generally include the activity of soluble complement proteins, direct killing through phagocytosis (e.g. by neutrophils, macrophages, dendritic cells), cellular inflammatory responses, T lymphocyte mediated responses, and antibody dependent cell-mediated cytotoxicity (Blanco, 2008; Shoman, 2005; Speth, 2004, 2008) with optimal resistance to fungi occurring at typical euthermic body temperatures (Bergman and Casadevall, 2010). However, because bats use long periods of deep torpor during hibernation, their ability to resist infection may be significantly decreased relative to the active season when bats are mostly euthermic. During the hibernation period, optimal temperature conditions are available for growth of *Gd* (Blehert et al., 2009). Numerous aspects of immune response are known to become depressed in other hibernating mammals (Jaroslow, 1972; Kurtz, 2007; Larsen, 1971; Manasek, 1965; Maniero, 2000; Maniero, 2002; Bouma et al., 2010). Additionally, several experimental studies have shown that immunological stimulation alters patterns of torpor and arousal (Burton and Reichman, 1999; Prendergast, 2002). Investigations are currently focused on multiple aspects of innate, adaptive, and cellular inflammatory immune responses in *M. lucifugus* affected by WNS, as well as research designed to investigate relationships between these responses, body temperature, stage of arousal, and body composition (M.S. Moore, unpubl. data; R. Jacob and D.M. Reeder, unpubl. data).

Relationship between body composition and immune competence of bats during hibernation—While several aspects of the immune response have been described, it is important to understand the relationship between levels of immune competence and the amount of energy available to hibernating animals in the form of fat reserves. In addition to fueling a variety of physiological processes and behaviors (Humphries et al., 2003), WAT is essential for proper immune function. Immune function exhausts energy reserves in two important ways. First, to restore and mount an immune response, animals must arouse from torpor to a euthermic state (Burton and Reichman, 1999; Humphries et al., 2003; Prendergast et al., 2002; M.S. Moore and J.D. Reichard, pers. obs.). At this time, bats may relocate to warmer parts of their hibernacula where the cost of maintaining elevated body temperature is reduced (Boyles and Willis, 2009), although periodic arousals also account for most of the depletion of WAT during hibernation (Thomas et al., 1990). Second, an immune response requires considerable amounts of energy following arousal. Limited reserves of WAT may adversely affect immune competence directly (Demas et al., 2003) and indirectly through leptin-mediated pathways, as has been shown in hibernating rodents (Demas and Sakaria, 2005). A similar pattern is expected in bats (M.S. Moore, unpubl. data). Metabolic rates may increase by up to 60% in animals that mount immune response to severe infections (Lochmiller and Deerenberg, 2000). Moreover, while some hibernators are able to upregulate immune mechanisms during their prolonged periods of euthermy (arousal bouts lasting ~24 h), arousal bouts of bats typically last only 70-90 minutes (Britzke et al., 2010; D.M. Reeder, C.L. Frank, et al., unpubl. data), which quite likely confers few immunological benefits. Lastly, given the fact that hibernating bats affected by WNS experience severely depleted WAT reserves by mid winter, they may also have reduced immune function owing to this deficit.

Quantifying arousal frequencies during hibernation—Periodic arousals from torpor during mammalian hibernation typically account for 80-90% of the energy expended throughout this period (Kayser, 1965). Thus, the premature depletion of WAT observed in WNS-affected little brown myotis may be due to more frequent arousals (thus, shorter torpor bouts). Increased arousals from torpor are postulated to occur in response to infection with *Gd*. Ongoing investigations are examining patterns of hibernation in hundreds of affected and unaffected little brown myotis in several hibernacula across the northeastern and midwestern U.S. (D.M. Reeder, C.L. Frank, E.R. Britzke, A. Kurta, G.G. Turner, A.C. Hicks, S.R. Darling. C.W. Stihler, in progress). How the behavior of WNS-affected little brown myotis differs from that of unaffected bats during these arousals is also the subject of an ongoing study (S.A. Brownlee, unpubl. data). Limited studies of hibernation patterns in the WNS-affected tricolored bat (*P. subflavus*), the moderately affected big brown bat (*E. fuscus*), and the as of yet unaffected Virginia big-eared bat (*Corhynorhinus townsendii virginianus*) are also underway.

2. Testing the Efficacy of Selected Chemical Compounds to Reduce or Eliminate Gd

The severe impact of white-nose syndrome on bat populations requires unusual intervention to explore possible treatment strategies for both captive and wild populations. Testing both pharmaceutical and non-pharmaceutical compounds for their capacity to safely combat *Gd* infection in bats is useful in that it may lead to the development of mitigation strategies for both free-ranging bats and captive bats. While a number of antifungal agents successfully kill *Gd*, many of them are undesirable for their other actions, including endocrine disruption. Thus, only a subset of pharmaceutical compounds is likely to be viable for treating bats. A number of non-pharmaceutical compounds also hold promise for treating free-ranging bats (H.A. Barton, pers. comm.) without having significant ecological consequences. Testing of agents on bats under captive conditions is ongoing in several laboratories (e.g.,. H.A. Barton, University of Northern Kentucky; D.M. Reeder, Bucknell University; and A.H. Robbins, Cummings School of Veterinary Medicine, Tufts University).

To date, several compounds have been identified using *in vitro* testing that effectively kill *Gd* grown in culture (H.A. Barton, pers. comm., M.A. Ghannoum, unpubl. data). The antifungal drug terbinafine has good fungicidal activity against *Gd* in culture, and has a long safety record in humans and domestic animals. A study of the safety and efficacy of terbinafine in WNS infected bats held in captivity is currently underway. Studies using other compounds to treat bats in natural hibernacula are also underway (D.M. Reeder, unpubl. data). However, it is important to emphasize that any compound or compounds used to treat bats must be effective, environmentally safe to use, and easily applied with minimal handling or disturbance.

3. Quantitative Diagnostic Tools for Identifying Gd and Assessing Transmission Dynamics

A quantitative PCR (qPCR) assay that reliably detects low-level amounts of *Gd* on bats is a fundamental tool needed to assess disease epidemiology of WNS. A recently developed qPCR assay will be used to identify infected bats, quantify *Gd* fungal load, and assess transmission. The challenge for any DNA-based assay for *Gd* is the abundance of closely related species of *Geomyces* in cave environments (Lindner et al., 2010). A similar challenge exists for histopathological studies in identifying *Gd* from closely related species. Thus, a diagnostic tool, based on qPCR, must be both highly sensitive and specific to provide reliable identification of *Gd*. Initial screening against >100 *Gd* isolates, *Geomyces* isolates, and PCR clones from cave soil extracts indicates that use of these two qPCR assays combined provides the most promising diagnostic tool for detecting *Gd* (J.T. Foster, unpubl. data).

Detection of *Gd* presence and quantification of fungal abundance will have broad applicability to the WNS research and management community for addressing questions such as testing the efficacy of disinfection techniques on field equipment, testing and quantifying infectious loads from skin swabs or fecal samples, and testing for efficacy of antifungal treatments on bats. In particular, these tools will make it possible to quantify the number of infectious particles on individual bats and to enable comparisons among infection levels of individuals of different species, at different times of the year, and to quantify transmission dynamics. This information could also be used to help identify infection stages in which interventions could reduce transmission or increase survival rates.

Future Research Needs

While the above studies are ongoing, additional research is needed to: (1) assess transmission dynamics of *Gd* and epidemiology of WNS; (2) determine optimal environmental conditions for growth and transmission of *Gd*; (3) determine variation in host susceptibility to *Gd*; (4) determine pathogen origin and factors driving spread of *Gd*; (5) assess population genetic structure and gene flow in bats at local and continental scales; (6) assess the population dynamics of maternity colonies affected and unaffected by WNS; (7) assess impact of wing damage from *Gd* on foraging ability and reproductive success; (8) evaluate and implement appropriate mitigation strategies; and (9) quantify the economic importance and ecosystem services of bats affected by WNS.

The results of the proposed research, highlighted below, are critical to understanding the causes and consequences of WNS.

1. Assess Transmission Dynamics of Gd and Epidemiology of WNS

Determining whether transmission is frequency or density-dependent and how contact rates vary among species that vary in social behavior are critical to understanding the impact of WNS on bat populations. Transmission of *Gd* may increase with bat density, if per capita contact rates increase with colony size. Transmission may also vary among species as a function of contact rates during arousal bouts, when bats are euthermic, active, and switching to other roost sites. Alternatively, transmission of *Gd* within hibernacula may be frequency-dependent, if social clustering of bats during hibernation eliminates the effect of overall density in a hibernaculum. If transmission is frequency-dependent, the main drivers of differences in transmission among sites may be due to variation in microclimate because of its effect on fungal growth (Blehert et al., 2009; Chaturvedi et al., 2010). The crucial reason it is important to determine whether transmission is frequency or density-dependent (or more generally, how it depends on density) is that a purely density-dependent disease will die out once bats reach low numbers, but if it operates as frequency-dependent because of clustering of remaining bats, it could cause extinction. It could also be density-dependent at high bat densities through several mechanisms, but frequency-dependent effects at lower densities would also make extinction possible. In addition, even if *Gd* is density-dependent and therefore less likely (but not impossible) to cause extinction and if the density transmission relationship could be quantified, one could predict at what density the populations would level out, which would be extremely valuable from a management perspective.

Seasonal variation in social behaviors and environmental conditions can both influence transmission rates (Bjornstad et al., 2002; Hosseini et al., 2004; Shaman and Kohn, 2009). Bat aggregations vary substantially from large mixed-species colonies in winter to smaller more species-specific and sexually-segregated groups in summer. In contrast, contact rates may be highest during fall when bats are mating and interacting in potentially infected environments (swarming sites and hibernacula). Microclimate conditions for *Gd* growth (but not necessarily transmission), such as moderately low cave and mine temperatures and high humidity occur most commonly in winter (Blehert et al., 2009; Chaturvedi et al., 2010).

2. Determine Optimal Environmental Conditions for Growth and Transmission of Gd

Seasonal variation in environmental conditions (e.g., temperature and humidity) can potentially influence growth, transmission rates, and prevalence of *Gd* in hibernacula (K.E. Langwig, pers. comm.). The highest rates of prevalence can be expected in late winter, after *Gd* has had the opportunity to grow and spread in hibernacula. Microclimate conditions for *Gd* growth are also expected to affect survival and transmission rates of *Gd.*

3. Determine Variation in Host Susceptibility to Gd

Multi-host pathogens demand increased theoretical and empirical understanding for planning conservation efforts for species at risk from emerging infectious diseases (Daszak et al., 2000). *Geomyces destructans* is a multi-host pathogen that infects bats with widely varying distributions and social systems. The rapid spread of *Gd* from its epicenter in upstate New York, southward to Tennesee and North Carolina, and westward to Oklahoma and beyond, provides an opportunity to empirically assess factors that influence the mode and rate of spread at both local and continental scales. Variation in pathogen-host interactions may be especially important for understanding transmission and levels of infectivity. Additionally, whether WNS will affect other hibernators, including hibernating ground squirrels (family Sciuridae) and bats that hibernate in trees rather than caves, remains to be determined (C.K.R. Willis, pers. comm.). Multi-host pathogens pose greater risks to endangered species because one species can serve as a reservoir to support persistent transmission while a more vulnerable species may go extinct. Measurements of contact rates, prevalence, and infection intensity among individuals of different species that vary in sociality (e.g., group size and composition) and environmental conditions are needed across different life stages at local and regional scales to better understand the transmission dynamics of *Gd*. Known species-specific preferences for particular microclimates in hibernacula (temperature, humidity, and airflow) will strongly influence which species are most likely to experience significant mortality. For example, the big brown bat (*E. fuscus*) prefers to hibernate at low relative humidity and at temperatures that are below the optimal growth rate of *Gd*, which may explain their apparent relative resistance to this fungus (L.E. Grieneisen, pers. comm.).

4. Determine Pathogen Origin and Factors Driving Spread of Gd

Recent advances in the speed and accuracy of whole genome sequencing of microbes using Next-Generation Sequencing provides a viable alternative to traditional cloning and sequencing methods (Mardis, 2008). This is particularly relevant to *Gd* where few genetic differences are expected between isolates due to the recent emergence of the fungus and most genetic methods may not be able to distinguish *Gd* isolates. With a reference genome for comparison, phylogenetic relationships between isolates from bats in the U.S., Canada, and Europe, as well as from closely related *Geomyces* species, can now be made using whole genomes. Studies are underway to sequence closely related congeners to identify unique characteristics of *Gd* and determine whether differences between North American and European isolates contribute to pathogenesis in bats of the U.S. With adequate variation in microsatellites, *Gd* can also be used to analyze spatial spread of *Gd*. Thus, understanding the genetics of *Gd* is essential for assessing disease epidemiology.

The rate of spread of *Gd* across North America may be affected by colony size and species richness of bats and regional prevalence of *Gd*. Alternatively, the spread of *Gd* across North America may be influenced primarily by abiotic factors (e.g., temperature and humidity) and traits of different bat species unrelated to social behavior. The rate of geographic spread may also depend on the distribution and density of hibernacula (T.G. Hallam, unpubl. data). The probability of invasion of a pathogen should be a function of propagule pressure, which, in a disease context, is the force of infection (i.e. the density of infected individuals moving into uninfected populations). The product of colony size and prevalence summed across species richness of bats could be used as a correlate of propagule pressure. However, the diffusion of a multi-host pathogen may also be influenced by traits of different host species (e.g. differential movements or rates of infectiousness), the permeability of the landscape, and climatic effects.

5. Assess Population Genetic Structure and Gene Flow in Bats at Local and Continental Scales

The identification of gene flow corridors and barriers to major bat hosts of *Gd* could be used to identify populations most at risk and to inform decisions on WNS surveillance, prevention, and mitigation. Geographic or other landscape features that pose barriers to, or facilitate dispersal of bats, could create complex patterns of gene flow. Previous studies of host-parasite relationships have shown that host population structure is reflected in gene flow, along with dispersal of a dependent parasite or pathogen (McCoy et al., 2005; Nadler et al., 1990; Mulvey et al., 1991; Blanchong et al., 2008).

Little brown myotis is relatively abundant and currently shows the highest prevalence of infection, and thus is likely to be the primary mode of dispersal for the fungus. Thus, the potential spread of *Gd* via dispersal might be predicted by using historical patterns of gene flow in *M. lucifugus* across North America, and knowledge of the population connectivity of this species is critical to predicting routes of spread and populations most at risk of WNS introduction (A.P. Wilder, pers. comm). Previous studies of little brown myotis sampled during summer months have found little genetic differentiation in populations, indicating that the species is wide-ranging and that dispersal is common. From this we can expect that an isolation-by-distance pattern, and spread of WNS from infected populations to uninfected populations will be highly correlated with spatial distance between colonies (A.P. Wilder, pers. comm.).

Samples of bats when they are breeding (fall swarming sites) or hibernating (fall and winter), may reveal more population structure than when populations have dispersed to maternity roosts (spring and summer). If populations of little brown myotis are structured, but the geographic pattern of WNS expansion is not predicted by patterns of gene flow, then other bat species may be playing the dominant role in the spread of *Gd* (A.P. Wilder, pers. comm).

6. Assess the Population Dynamics of Maternity Colonies Affected and Unaffected By WNS

While most prior research on WNS has focused on factors affecting mortality in hibernating bats, the impacts of this disease on bats during the active season have not been fully evaluated. Observed declines of bat populations in winter should be manifested by comparable declines during the active period in the same region. The little brown myotis has experienced severe winter mortality in the northeastern U.S. (Frick et al., 2010b) but could also be a valuable species for determining population-level impacts of WNS during the non-hibernating period. Relative to most other bat species affected by WNS, maternity colonies of little brown myotis can be readily monitored because this species roosts in relatively large numbers in a variety of anthropogenic structures (Kunz and Anthony, 1996; Kunz and Reynolds, 2003; O'Shea and Bogan, 2003). Long-term monitoring studies are crucial for obtaining demographic data needed for assessing both population dynamics (Frick et al., 2010a) and viability (Frick et al., 2010b). Similarly, acoustically monitoring the activity of bats during the warm season can also provide valuable information on a broader landscape scale (Brooks 2011). The studies by Dzal et al. (2010) and Brook (2011) confirms that the overall observed decline of 73% based on surveys of bats in hibernacula (Frick et al., 2010) is consistent with their data based on acoustic monitoring of bats in northwestern New York and west-central Massachusetts, respectively. Data derived from such studies should facilitate the development of strategies that will aid in informing future management decisions.

7. Assess Impact of Wing Damage from Gd on Foraging Ability and Reproductive Success

Little brown myotis at maternity colonies in spring and throughout early summer have shown moderate to severe wing damage associated with WNS (Reichard and Kunz, 2009). Such damage could adversely affect the abilities of these bats to forage efficiently and thus maintain normal body condition (Reichard and Kunz, 2009; S.A. Brownlee, unpubl. data; N.W. Fuller, unpubl. data). Moreover, reduced feeding efficiency could lead to lower survival and lower reproductive success (Reichard and Kunz, 2009). Thus, field-based studies are needed to assess the consequences of WNS-related wing damage, including the influence of wing damage on navigational ability, foraging success, and postnatal growth (a surrogate of reproductive success). If foraging success is compromised, one would predict that postnatal growth rates and survivorship of pups born to mothers with damaged wings will be greatly reduced (N.W. Fuller, pers. comm.).

8. Evaluate and Implement Ecologically-Sound Mitigation Strategies

Additional experimental research is needed to test the efficacy and safety of antifungal compounds to increase survival of bats infected with *Gd*. Protocols should be identified to rid individual bats of *Gd*, especially those targeted for captive studies and to create assurance colonies (see below). If an effective compound or compounds and treatment protocols are identified, research will be needed on delivery methods to treat large numbers of free-ranging bats in field settings, with minimal handling or disturbance to bats and their cave ecosystems. Drug safety and efficacy testing requires large numbers of animals. Research is also needed to develop an animal model of WNS to increase the pace of drug development studies and to reduce the lethal experimental use of dwindling bat populations (H.A. Barton, pers. comm.; D.M. Reeder, unpubl. data; A.H. Robbins, unpubl. data).

Research and management strategies that provide secure, protected maternity roosts are needed to promote long-term use by maternity colonies at risk of extirpation. This could be accomplished by installing thermally and structurally-enhanced bat houses and roost modules to promote reproductive success of surviving individuals in small, remnant colonies (T.H. Kunz, unpubl. data). For example, installation of roost modules in buildings that were previously occupied by little brown myotis could also be used for long-term population monitoring programs. Data derived from installing roost modules could be used to inform future management strategies needed to sustain populations and to promote recovery of bats currently being affected by WNS.

Protection of hibernating bat colonies will continue to be of paramount importance. Caves and mines not yet gated should be considered for gating to protect the small numbers of bats that may be resistant to WNS. Disturbance to hibernating bats must be kept to a minimum. If current studies of survival in relation to microclimate at hibernacula (L.E. Grieneisen, in progress) indicate significant survival of bats at sites outside the optimal growth range for *Gd* (i.e., caves and mines below 4°C), one possible mitigation strategy might be to alter the microclimate of mines and other human-made structures (e.g., abandoned military bunkers and artificial caves) to help promote the survival of hibernating bats. Such temperature modifications are currently being used by the Pennsylvania Game Commission (D.M. Reeder, unpubl. data).

Another mitigation strategy currently under discussion is the creation of captive colonies of affected species, or so-called ‘captive assurance populations’. This strategy has been employed in the amphibian conservation community in response to chytridiomycosis in frogs, another fungal infection with significant mortality in multiple species and extinction in an estimated 165 species (www.amphibianark.org). Dozens of species of amphibians have been brought into biosecure “amphibian arks” with the eventual goal of reintroduction into the wild. However, while protocols for amphibian husbandry are fairly well established, housing bats, and most especially establishing successful breeding colonies of bats in captivity, is not likely to be practical for most insectivorous species. Captive breeding has been proposed as a last ditch effort to protect against extinctions; however, maintaining breeding populations of insectivorous bats is difficult and labor intensive and sustaining sufficient numbers for gene pool integrity is a daunting prospect. The best prospect for pursuing such efforts is to engage the talented and dedicated services of the community of animal rehabilitators who specialize in maintaining bats in captivity (Barnard, 2010). Whether captive bats could ever successfully be reintroduced to the wild is highly questionable. Notwithstanding, in the final analysis, the scale and multi-species nature of WNS may ultimately call for such novel efforts.

9. Quantify the Economic Importance and Ecosystem Services of Bats Affected by WNS

The severe decline in numbers of bats in areas affected by WNS is likely to have significant impacts on agriculture, forest ecosystems, human health, and the economy in the forms of reduced crop yield, decreased forest production, increased pesticide use in agriculture, increased exposure of humans to these pesticides, and increased numbers of arthropod-borne pathogens. Little brown myotis can eat upwards of 100% of its body mass during peak lactation (Kurta et al., 1989) and at least one-half of its body mass, on average, during the warm season from mid-April to mid-October. Because over one million bats have already died from WNS in the northeastern U.S., this translates to approximately 660-1320 metric tons of insects have gone uneaten each year since mass die-offs from WNS have been reported (Boyles and Willis, 2009). Increased attention should be given to quantifying nightly food (Kurta et al., 1989; Kunz et al., 1995) and assessing dietary habits using molecular markers to identify potential insect crop pests, forest pests, and arthropods vectors of human diseases consumed by this and other species (Claire et al., 2010; G.F. McCracken, unpubl. data.). Partnerships between bat biologists, agricultural and forest land managers, disease ecologists, and economists should be established to explore relationships between population declines of bats and crop damage and yield in both traditional agriculture settings and where organic gardening is being practiced, and the possible transmission of insect borne diseases. This type of information, along with estimates of crop damage and pesticide costs, can then be used to more effectively assess the economic value of bat populations (Cleveland et al., 2006; Federico et al., 2008; Boyles et al. 2011; Kunz et al., 2011).

Conclusions

While one cannot foresee the future, it seems certain that researchers and wildlife managers are still in the early stages of assessing the WNS disease epidemic in bats. The spread of *Gd* is expanding geographically at an accelerating rate. As it does so, it continues to involve different bat assemblages and in landscapes that differ in climatic, topographic, and physiographic features. The current state of knowledge of the *Gd* pathogen, while still meager, has expanded enormously in a very short time, and the emergence and threat WNS, the disease associated with *Gd*, has motivated an enormous body of new and challenging research into poorly known and previously unknown aspects of bat biology. Our hope for mitigating the further spread of this devastating disease depends on increased levels of funding and additional research that stretches the limits of existing knowledge and technologies. Promoting the economic value of insectivorous bats to agriculture and to humankind for their cultural and aesthetic value are important steps toward educating the general public and government decision-makers that a relatively small investment now is preferred to much larger investments that will be needed later when ecosystems collapse and an increasing number of endangered bat species become listed.

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CONVERTING ABANDONED MINES TO SUITABLE HIBERNACULA FOR ENDANGERED INDIANA BATS

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Abstract

Abandoned mines can offer excellent opportunities to augment or even create habitat for bats. Mines often have the necessary microclimate characteristics that are required as hibernacula. However, not all mines have conditions that are appropriate for use by bats. Since bats may not possess the ability to assess modern hazards associated with many mines it is crucial that we initially determine if an abandoned mine is safe for use by bats. Similar to human occupation, safety concerns include stability of the site and air quality. If all or parts of a mine are considered safe for use by bats then an assessment of the microclimate characteristics is needed. Mines can then be manipulated as needed to create the necessary microclimate conditions required by the bats. In Southern Illinois, we successfully stabilized many mines, manipulated entrances to change internal temperatures and secured these mines from both disturbance to the bats and liability concerns. Other mines that were not deemed valuable resources to bats were simply closed for liability reasons.

Introduction

Greater than 50% of eastern bats hibernate in underground caverns. It has been estimated that as many at 70% of abandoned underground mines in the Eastern U.S. and Canada are used by significant numbers of bats (Tuttle and Taylor 1998). Bats use these mines because of the similar characteristics that they share with natural caves. Often these caverns are used as hibernacula. Suitable hibernacula are critical to the survival of bats because it allows them to survive long periods of time when food is unavailable. The internal conditions of these hibernacula are a critical component to the survival of these species. While the specific requirements may vary for each species there are over-arching themes that are common for all hibernating bats. Hibernating bats seek a location that has low temperatures near freezing but do not drop below freezing. It is also important that these temperatures remain stable with little fluctuation (Steffen 2007). For instance, Indiana bats (*Myotis sodalis*) have been found to prefer temperatures of 3-8^{o}C throughout the winter (USFWS 2007).

Not all caves or mines have these microclimate conditions that make them favorable as hibernacula. While it is wholly inappropriate to change the internal climatic conditions of caves because of the extensive biotic community that is adapted to current conditions, abandoned mines generally lack these biotic communities and are perfectly suited for climatic manipulation. However, since bats do not possess the ability to assess modern hazards of abandoned mines, we must first assess the safety of a mine prior to considering manipulation to attract bats. Major safety concerns revolve around air quality and mine stability. It is important to remember that current bat use does not indicate suitable, or even safe, internal mine conditions. Conversely, the lack of bats using a mine does not indicate unsuitable or unsafe internal conditions.

Once a mine is determined to be safe or is determined that it can be modified to become safe, a temperature profile can be used to determine the efforts that will be needed to create a suitable hibernaculum. The cost of conversion can be weighed against the benefits of producing potential hibernacula. Benefits of producing hibernacula are based on the availability and protection status of existing hibernacula in the local landscape and how this added resource is likely to affect local bats.

Air Quality

Coal mines are known to have poor air quality conditions within (see Sherwin et al. 2009). Active mines are frequently ventilated with fresh air from outside to remove air quality problems associated with equipment exhaust and natural poisonous and or flammable gasses emanating from the mine substrate. While abandonment of a mine eliminates the exhaust fumes from machinery it does not eliminate the gasses that may be produced by the mine. Elevated levels of many lethal gasses (e.g. carbon monoxide) cannot be detected without electronic equipment and as such pose a severe risk for bats and humans (Sherwin et al. 2009). While ventilating a mine with outside air can remove or reduce these gases to tolerable levels, the act of pumping air into the mine could potentially alter temperature regimes within the mine, resulting in decreased suitability. The cost associated with ventilation, combined with the added temperature issues that ventilation causes makes mines with poor air quality ineffective candidates for modification. While with enough money and resources any air quality issues can certainly be resolved, the cost of such modifications and continual maintenance usually makes such projects cost prohibitive.

Mine Stability

Mine stability is a complex issue with numerous variables to consider. However, in general, stability is usually considered in two areas: entrance stability (Figure 1) and interior stability. Often the entrance or portal has a tendency to erode because of exposure to outside elements. Eroding of the surface around the portal is caused from rain runoff as well the collapsing of materials from the frequent expansion and contraction associated with fluctuating temperatures above and below freezing. Both of these forces combine to dramatically increase the spalling (falling material from walls or ceiling) at the entrance area. This often leads the entrance to partially or completely fill, closing the mine to the outside. Since this spalling can happen relatively rapidly, the major concerns lie in the possible exclusion of bats from the mine or the entombment of bats in the mine during hibernation. There are additional issues with the accumulating material changing the air flow in or out of the mine that can have dramatic effects on the internal temperatures.

Figure 1. Unstable mine entrance being excavated in Southern Illinois.

Entrance stability is usually only an issue for the first 10 to 30 m of the portal entrance where outside temperatures fluctuate greatly. Inside the mine the temperatures are usually much more stable. These unstable entrances can be stabilized using a variety of methods. One of the most straight forward and effective is to build a short stabilization tunnel in the entrance area to maintain an open entrance. While a variety of tunnel systems exist, the steel arch with wooded cross beam system (Modern Welding Company of Kentucky 2010) has been constructed in numerous mines (Figures 2 and 3) with great success in Southern Illinois (Chadwick 2004). This method also provides a convenient location for adding bat-friendly gate (Fant et al. 2009) to prevent human access while allowing bats free access to the mine. Reducing human access greatly reduces liability concerns often associated with abandoned mines. Caution should be taken to avoid changing the dimensions of the entrance that is being stabilized, especially if the mine is currently used by bats. The size and shape of the entrance can have a significant impact on the air flow in or out of the mine and therefore affect the internal temperature of the mine and its suitability for bats.

Figure 2. Steel arch with wooded cross beam system in an abandoned mine in Southern Illinois.

Figure 3. Stabilized mine entrance in Southern Illinois with bat-friendly gate.

Internal stability is also a result of a few variables. Moisture and temperature are the primary variables associated with internal stability. An extensive study in southern Illinois found that the temperature, temperature variability, and rock moisture content were significant in predicting the amount of spalling (Corcoran 2009). Spalling happens most frequently when temperatures fluctuate above and below freezing. This causes the material to expand and contract which loosens material and promotes spalling. Elevated moisture levels exacerbate this with the increased expansion and contraction associated with the freezing and thawing of the water content. Spalling occurs less often in areas with relatively stable, above freezing temperatures. While these conditions of nonfreezing and stable temperatures are also important for bats (see below; Corcoran 2009, Steffen 2007), a safe mine does not mean a mine is suitable as a hibernaculum.

Internal Characteristics Important To Bats

The primary factors identified that affect use of a cavern by bats include internal temperature and temperature stability. Bat use has been positively correlated with cold temperatures that do not drop below 0^{o}C and that are relatively stable (Steffen 2007). Indiana bats for example prefer hibernation temperatures below 10^{o}C (USFWS 2007). Specifically, Tuttle and Kennedy (2002) and Brack (2007) found Indiana bats prefer temperatures between $3\text{-}7^{o}$C. Steffen (2007) found Indiana bats in southern Illinois mines that had average seasonal hibernation temperatures from 9.63 to 3.11^{o}C. Magazine mine which has the greatest population of Indiana bats in Illinois (<40,000 bats) had average seasonal temperatures (winter 2007) that range from 3.11 to 4.79^{o}C.

Temperature Monitoring

After a mine has been deemed safe for bats to use, the temperatures and temperature stability must be monitored to determine if it is suitable as a hibernaculum. This is most frequently done using temperature dataloggers. Hobo Data loggers (Onset Computer Corporation, Pocasset, MA) are perhaps the most commonly used data loggers. These or other data loggers are programmed to record temperatures over a series of months or years and store those data on internal memory. They are placed in various locations within the mine and downloaded the following spring after retrieval. Average weekly temperatures should be calculated during the hibernation season (November – March), and the level of temperature variation should also be calculated. There is no set target for temperatures or temperature stability. Generally, temperatures should be below 10^{o}C and as stable as possible. Ideally these temperatures would not fluctuate outside of the desired temperature range. In a larger mine, a gradient of temperatures should exist throughout the mine allowing bats to select the temperatures that suit them best. This would also allow bats to shift roosting locations should the temperatures change in mid hibernation and become less suitable. Bats are known to naturally arouse multiple times throughout the winter and will often move within the cavern to find the ideal hibernation location as conditions change (Brack and Twente 1985, Menzel et al. 2001).

Mine Modification

The easiest way to achieve temperatures suitable for bat hibernation is to manipulate mine entrances to control air flow. Air flow in and out of a mine determines the internal temperatures and also the stability. It is best to think of air in terms of hydrodynamics. That is, air flows or acts similar to water with cold dense air sinking and warm light air rising. Cold air, if allowed to enter a mine, will collect in the lowest areas (cold air trap – Sherwin et al. 2009). Warm air will tend to rise and will vent out of the mine if warmer than outside air. Alternatively, warm air may rise and become trapped in a high spot or dome and remain (warm air trap) until the air cools and drops (Sherwin et al. 2009). Keeping these two facts in mind, an evaluation of the current conditions of the mine can direct future modifications.

If mines are too warm then modifications need to allow warm air to exit and/or for cold air to enter. Often in single entrance mines, there is not enough air flow to allow for exchange of cold air for warm. This results in many single entrance mines and caves being too warm to be suitable hibernacula for most bats. In many cases opening up a second entrance to the mine will allow warm air to escape creating a vacuum which will cause cold air to be drawn in. The difference in elevation between the two entrances will determine how quickly air is exchanged. The greater the elevation difference the faster the warm air will ventilate and cold air will enter. Similarly, the size of the entrances will also affect the volume of air that enters or exits the mine. The cross sectional area of the smaller entrance and the elevation difference between entrances combined will determine the overall volume of air per time that passes through the mine. As such, changing the size of the smaller entrance is one method for controlling air flow.

Additionally, the shape and position of entrances on the landscape can influence the movement of air into or out of a mine (Figure 4). Each day as outside temperatures begin to drop, much like water, cold air falls and runs down slopes toward the lowest part of the landscape. If a mine portal is situated at the base of a slope or low on a slope and is shaped to catch the cold air as it runs down the slope it will funnel that air into the mine. Similar mines on a ridge top or at the top of a slope will not have this source of cold air and may not get as cold as a mine further down the slope. Changing the shape of an entrance can increase or decrease its ability to funnel cold air into a mine. Conversely, cold air intake can be reduced by diverting or blocking cold air from the entrance. Soil berms can be created above and around an entrance to divert cold air as it moves down the hillside. Mine entrances at the base of a valley can have the entrance built up with soil allowing the entrance to draw in air from above the cold air blanket at ground level.

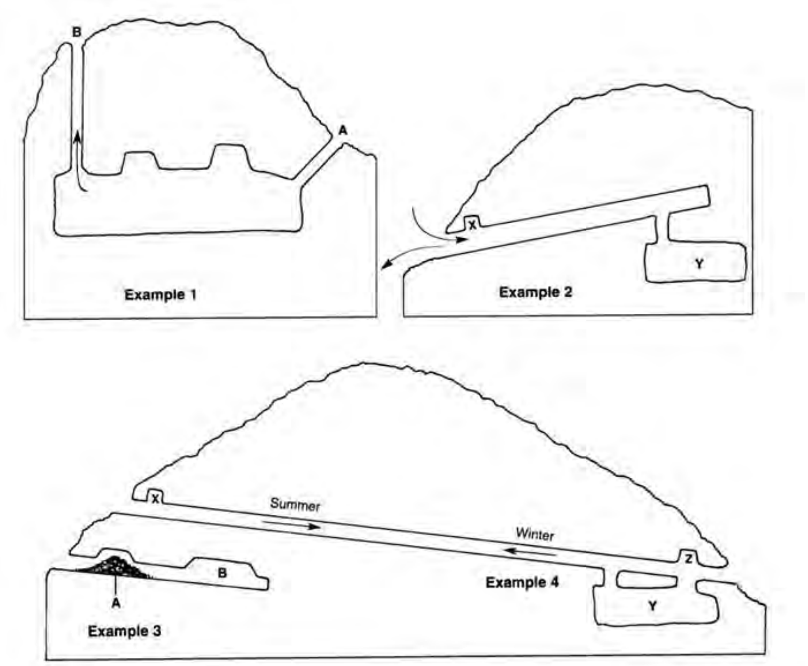

Figure 4. Common mine types with typical air flow pattern. Reproduced with permission from Tuttle and Taylor 1998.

Mines that have unstable temperatures often have too much air flow. Many times there is an entrance that is at or near the lowest part of the mine. This acts as a drain and allows cold air to exit the mine. As this cold air exits the mine, it draws in warm air from the upper entrance(s). This draining will cycle on and off as the outside temperatures change in relation to internal temperatures. When the air inside the mine is colder than the air outside, the mine will drain cold air. When the internal temperatures are above that of the outside air the mine will ventilate warm air out the upper entrance and draw in cold air from the lower entrance. This cycling often results in unstable temperatures. In these cases, the lowest entrance needs to be completely or partially closed to slow the draining of the cold air and allowing a cold air trap to develop. This will stabilize temperatures and increase mine suitability for bats. If closing the entrance stabilizes temperatures, but makes the mine either too warm or too cold, then the remaining entrances can be modified to increase or decrease the amount of cold air that enters the mine. Mines with entrances located at the lowest elevation of the mine rarely produce suitable internal conditions. Most suitable mines have some portion of the mine that is lower in elevation than the lowest entrance which allows cold air to collect (cold air trap). These same concepts of manipulating air flow in and out of a mine can and should also be considered for the internal structure of the mine. Internal berms or elevation changes can redirect or block the flow of cold air. Some internal modifications may also be needed to direct cold air flow as needed.

This process was successfully completed in Southern Illinois. A large mine (Birk 2) had four entrances, two that were man-made and two from cave-ins. One man-made entrance was a shaft that entered from above and sloped into the mine while the second entered horizontally at the main level of the mine. During the first winter survey of this mine, we counted less than 500 bats. Mines of similar size in the area often have thousands if not tens-of-thousands of bats. During the survey, the temperatures appeared to be at or near suitability. We installed a series of temperature data loggers (Figure 5) and the following year downloaded the data (Figure 6). We discovered that while the average temperatures in the main shaft were near the suitable levels (est. 6^{o}C), the temperature fluctuated wildly throughout the hibernation period (max of 18^{o}C and min -2^{o}C). While standing in front of the second man-made entrance (horizontal shaft), we observed a very strong breeze of cold air rushing out of the mine. We came to the conclusion that any cool air that entered the mine through the upper entrances quickly drained out of the mine through this lower entrance. In midsummer, we closed this lower entrance using heavy equipment and fill dirt (Figure 7). We incorporated a 20ft long-4ft diameter culvert in the closure to facilitate ease of mine access for surveys and also allowing some fine-tuning of airflow by adjusting the make-shift door applied to the end of the culvert. The following winter the temperatures stabilized to an average of 11^{o}C with a maximum of 13^{o}C and minimum of 8^{o}C. While these temperatures are somewhat high, there are other parts of the mine that were slightly lower in elevation and the cold air settled in these locations making them more suitable. That next winter numbers increased to 1500 bats, and 2 years following closure the mine was used by 2500 bats including some endangered Indiana bats.

Figure 5. Installation of data logger.

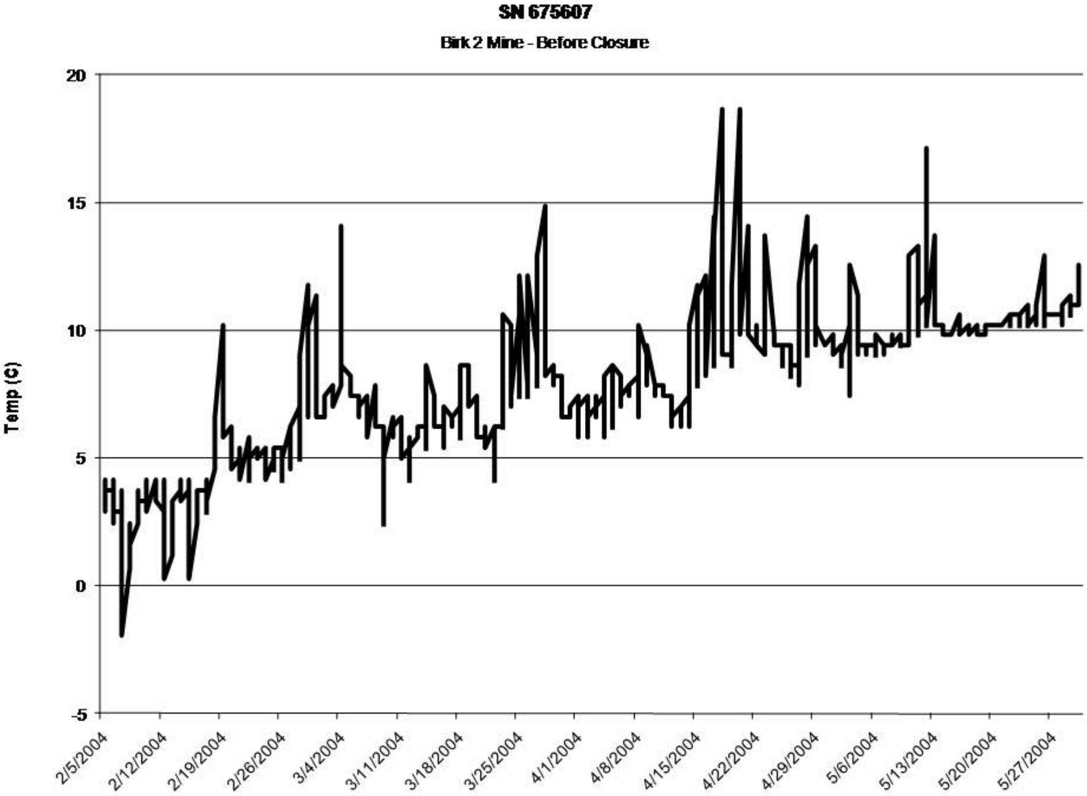

Figure 6. Temperature fluctuation in Birk 2 mine prior to closure of one entrance.

Figure 7. Closure of lower entrance in Birk 2 mine to reducing air flow for better control of internal mine temperature.

Conclusion

Converting abandoned mines to hibernacula for bats, including the Indiana bat, requires a basic understanding of physics and biology. It also requires a little artistry to compare known bat hibernation requirements with the current conditions within the mine and develop a plan to achieve the desired results. There is no one way to convert a mine to a hibernaculum. Every mine is different, both in terms of internal (volume, elevation, topography, etc.) and external (entrance location, vegetation, entrance size, etc.) characteristics that ultimately affect internal temperature regimes. While the exact modification required may differ, many modifications can be made relatively easily and quickly with available equipment.

While most mines can be modified, it is important to be aware that some situations are not well suited for conversion. Obviously, mines where hazardous/unsafe conditions are present should not be modified to attract bats. In these cases complete closure should be considered for both the safety of bats and humans (see Sherwin et al. 2009). Future land use should also be taken into account when considering modification. Should endangered species begin to use the mine, area land use and mine entry restrictions may be enforced by the USFWS.

Suggested Readings

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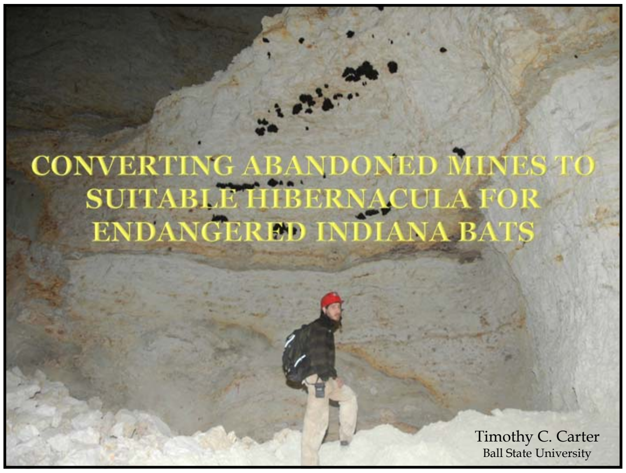
Dr. Timothy Carter is a Certified Wildlife Biologist by The Wildlife Society and is currently an Assistant Professor in the Department of Biology at Ball State University, Muncie, IN. He teaches General Biology, Mammalogy, and Wildlife Biology. Dr. Carter has worked with bats extensively for the past 16 years, and his research has focused on the Endangered Indiana bat (*Myotis sodalis*) for the past 12 years. His interests center on non-game and endangered species and the impacts of current land management decisions. He received his BS and MS from the University of Georgia and his Ph.D. from Southern Illinois University Carbondale.

Bradley Steffen is a biologist with BHE Environmental, Inc., an environmental consulting company where he specializes in regulatory compliance relating to threatened and endangered species issues. He also designs and implements field surveys for threatened and endangered species. Mr. Steffen has worked with bats for the last seven years and much of his research and survey focus has been the endangered Indiana bat, including his Master's thesis "Effects of mine characteristics on hibernacula selection by bats in southern Illinois". He received his BS and MS degrees at Southern Illinois University Carbondale.



CONVERTING ABANDONED MINES TO SUITABLE HIBERNACULA FOR ENDANGERED INDIANA BATS

Timothy C. Carter
Ball State University

Fundamental Question

Q: Can mines be converted in to bat hibernacula?

A: Some certainly can; many should not!

Mine Evaluation

- Before moving forward with converting a mine into a bat hibernacula we must evaluate all aspects of the mine to determine if it is an economical pursuit
    - This includes safety and internal conditions

Modern Hazards

- Greater than 50% of eastern bats hibernate in underground caverns (caves and mines)
- Bat do not posses the ability to assess modern hazards of abandoned mines

Mine Safety

- Before we modify or improve a mine for bats we must first determine if a mine is safe for bats to use
- The two main considerations include:
    - Air Quality
    - Structural Stability

Air Quality

- Air quality standards for bats should be similar to those expected for humans
- If the air quality is not safe for humans then the mine should be sealed so bats are kept out
- Ventilation systems could rid mines of noxious gasses – but it difficult to ventilate a mine and still maintain the favorable internal environment that bats need

Structural Stability

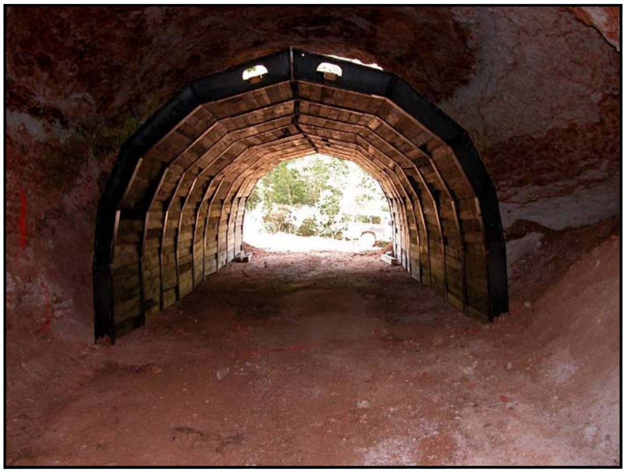
- Structural stability has two major areas to consider
  - Entrance & Interior
- The main concern with the entrance is having it collapse enough to change internal conditions or seal closed
- The main concern with the interior is spalling events (collapses) that can kill bats

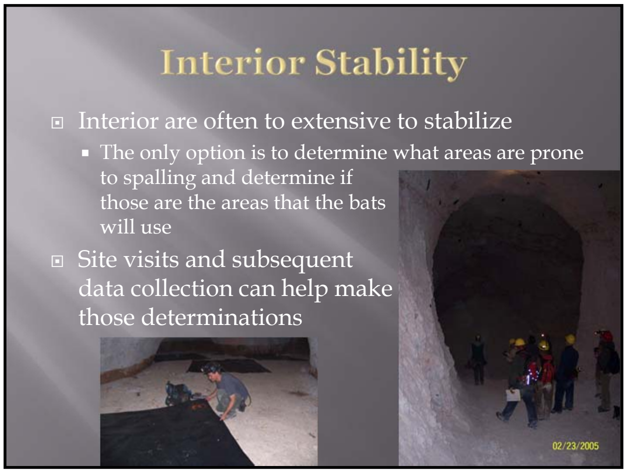
3 Jan-07

3 April-07

Entrance Issues

- Entrance spalling is primarily caused by freezing and thawing action and also rain water run-off
  - Water run-off is easily taken care of with proper landscaping
  - Freezing and thawing is not easily controllable
    - The best solution is to construct short tunnels or other structures to catch and control the spalling material



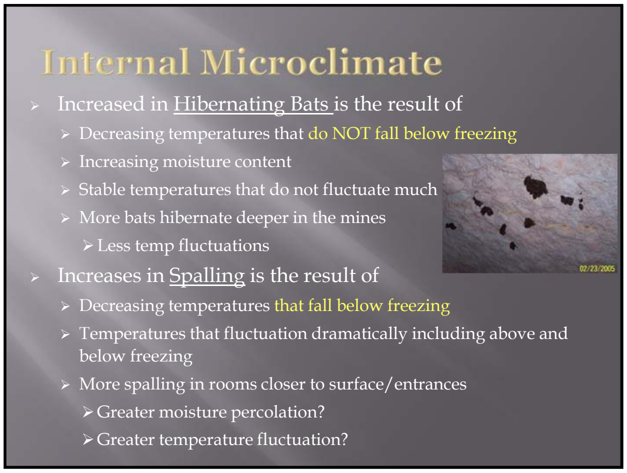


Interior Stability

- Interior are often to extensive to stabilize
  - The only option is to determine what areas are prone to spalling and determine if those are the areas that the bats will use
- Site visits and subsequent data collection can help make those determinations

Safety vs. Suitability

- Just because a mine is safe does not mean bats will use it
- The internal microclimate is a fundamental determinate if bats will use a cavern
  - Data suggest that the two main issues include average temperature and temperature stability

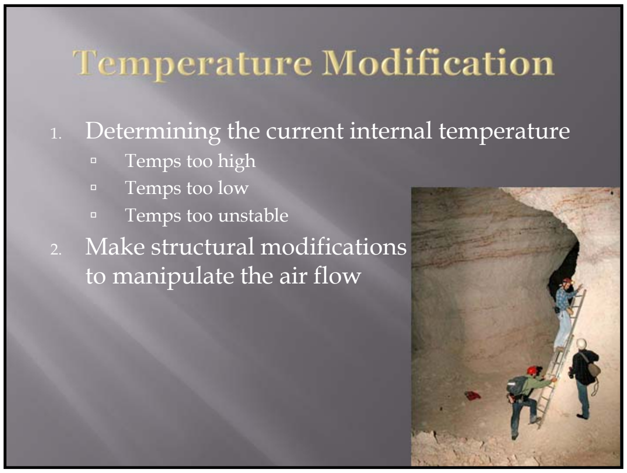


Internal Microclimate

- Increased in Hibernating Bats is the result of
  - Decreasing temperatures that do NOT fall below freezing
  - Increasing moisture content
  - Stable temperatures that do not fluctuate much
  - More bats hibernate deeper in the mines
    - Less temp fluctuations
- Increases in Spalling is the result of
  - Decreasing temperatures that fall below freezing
  - Temperatures that fluctuation dramatically including above and below freezing
  - More spalling in rooms closer to surface/entrances
    - Greater moisture percolation?
    - Greater temperature fluctuation?

Internal Microclimate

	Temp	↑ Temp Variation	↑ Moisture
Bats	↑ Down to 0^c	↓	↑
Spalling	↑ When includes 0^c	↑	↑

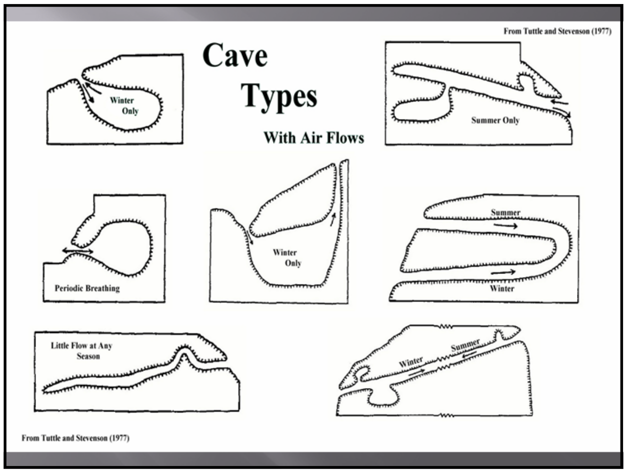


Temperature Modification

1. Determining the current internal temperature
   - Temps too high
   - Temps too low
   - Temps too unstable
2. Make structural modifications to manipulate the air flow

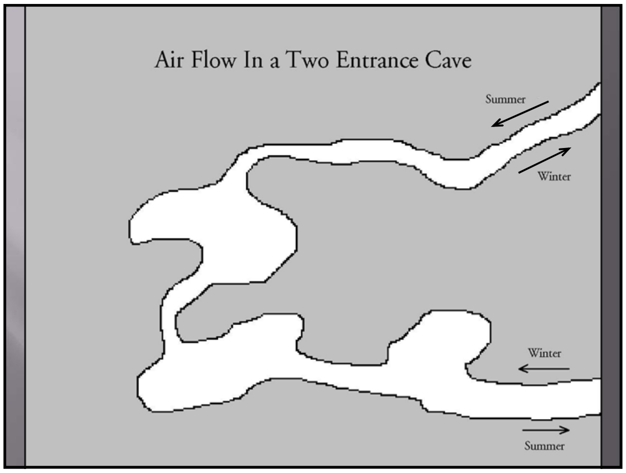
How Do We Manipulate Internal Climate?

- Temperature and stability are regulated by controlling air flow
- Always remember: **Cold air sinks & hot air rises**



From Tuttle and Stevenson (1977)

From Tuttle and Stevenson (1977)



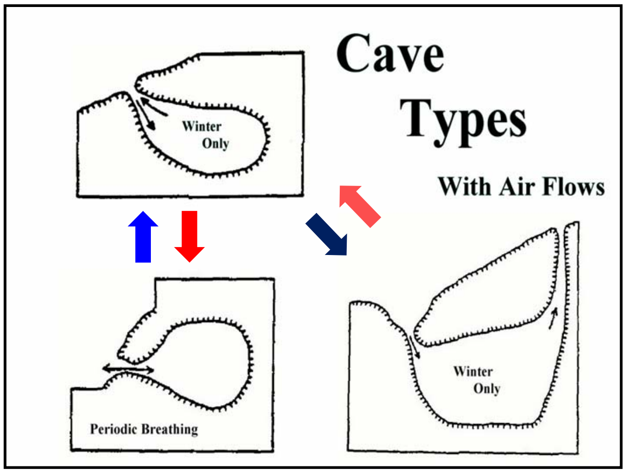
Air Flow In a Two Entrance Cave

BCI Bats 2000

By David Chapman

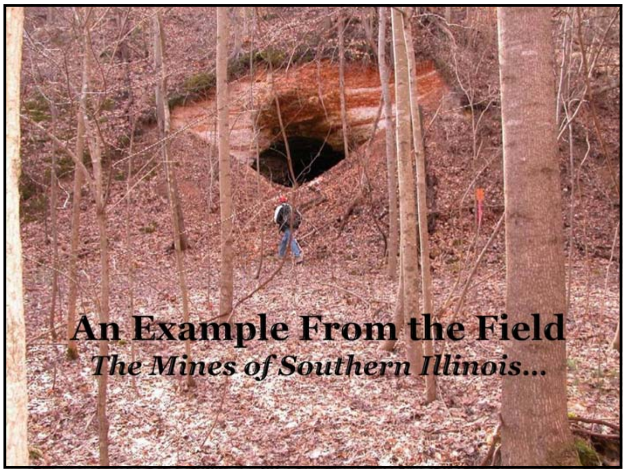
Manipulating Temps

- Temp to high
  - Increase intake of cold air
- Temp to low
  - Decrease intake of cold air
- Temperature unstable
  - Reduce volume of air flow
  - Large mine are generally more stable than small ones



Cave Types

With Air Flows



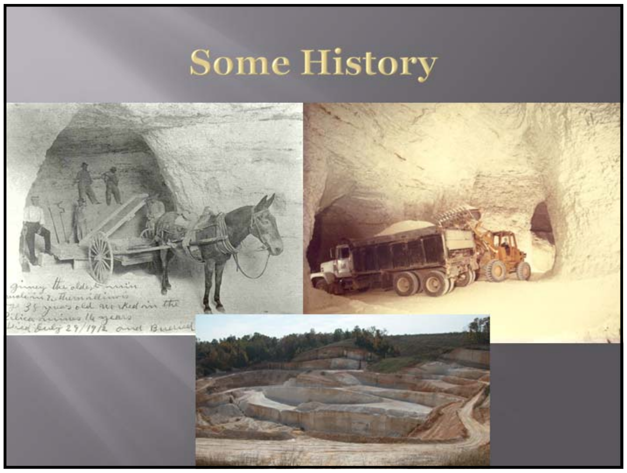
An Example From the Field

The Mines of Southern Illinois…

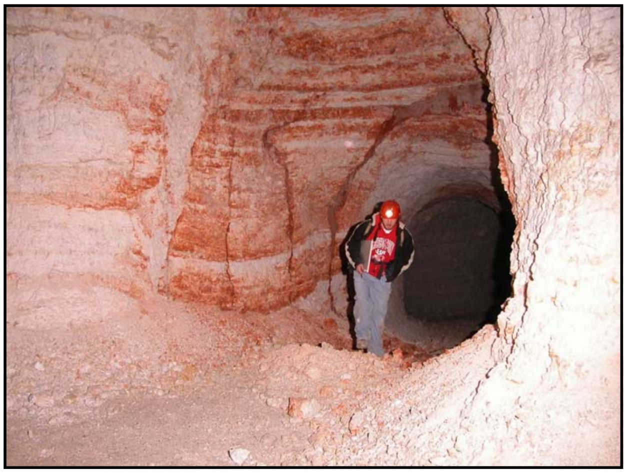
Microcrystalline Silica

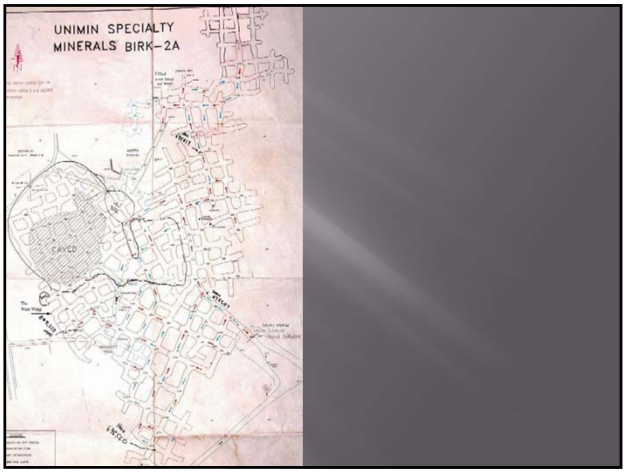
- Mined only in southern Illinois
- In a relatively small area (4.6 km by 9.6 km)
- Used in many products
- About 50 mines have been found to date
  - Only 20 originally known

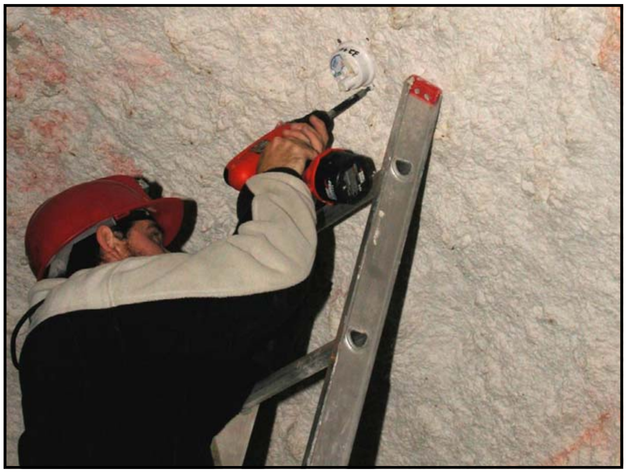
Microcrystalline Silica

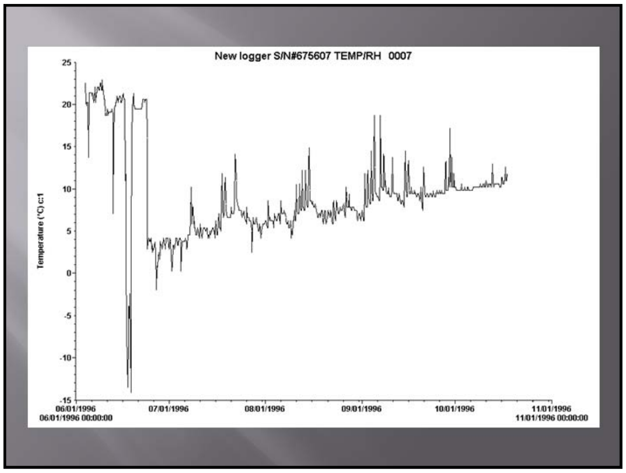


Some History








New logger S/N#675607 TEMP/RH 0007
Temperature (°C) c1
25
20
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-5
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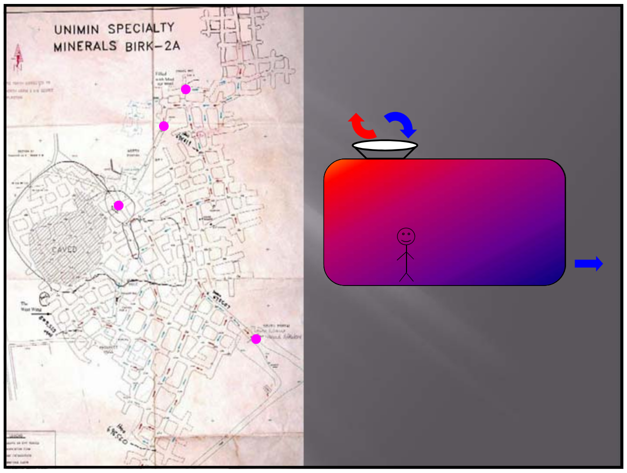
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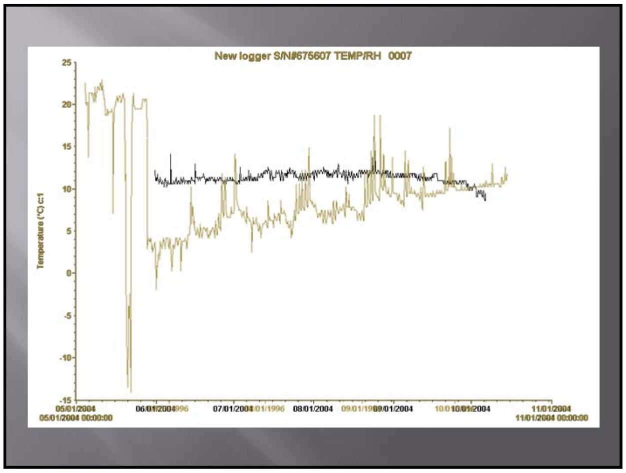

RECAP…

1. Determine safety of mine
   - Air & structural stability
2. Determine internal climate
   - Temperature & temperature stability
3. Worthy project? What will it take?
4. Make safety modifications
5. Make climatic modifications


Questions?

WHERE DO WE GO FROM HERE?

FORUM PARTICIPANT RECOMMENDATIONS

At the conclusion of the forum on September 3, 2010, the participants provided the following recommendations concerning issues or concerns deserving attention and efforts by the Bat Conservation and Mining Steering Committee.

1. Prioritize which species to protect and how to protect them.
2. Continue to observe changes in bat protection until some resolution is achieved related to protection of T& E species and WNS.
3. Hold an acoustic monitoring workshop related to its acceptability for bat monitoring.
4. Guidance for a coal operator on how to follow the bat guidance document. Develop a short document that the public would understand explaining the bat guidance document.
5. Develop a specific workshop for AML programs on bat issues and guidance for installing bat gates.
6. Develop workshops or forums on EPA related issues on water quality, such as total dissolved solids (TDS) and impacts to benthos.

PARTICIPANT SURVEY RESULTS
PROTECTING THREATENED BATS AT COAL MINES

FORUM

TOTAL PARTICIPANTS	86	100%
TOTAL COMPLETING THE SURVEY	32	37%
LEVEL OF SATISFACTION WITH THE FORUM		
EXTREMELY SATISFIED	17	
VERY SATISFIED	15	
SATISFIED	0	
DISSATISFIED	0	
VERY DISSATISFIED	0	
Average level of Satisfaction 4.5 or Very Satisfied		
100 % rated the event Satisfied or better		

FIELD TIP

TOTAL PARTICIPANTS	67	100%
TOTAL COMPLETING THE SURVEY	26	38%
LEVEL OF SATISFACTION WITH THE FIELD TRIP		
EXTREMELY SATISFIED	16	
VERY SATISFIED	8	
SATISFIED	2	
DISSATISFIED	0	
VERY DISSATISFIED	0	
Average level of Satisfaction 4.5 or Very Satisfied		
100 % rated the event Satisfied or better		

WHO DID THEY REPRESENT?

PARTICIPANT AFFILIATION	PARTICIPANT #	PARTICIPANT %
State Mining Regulatory Agency	26	31
Consultant	21	25
OSM	11	13
U.S. Fish & Wildlife Service	11	13
University	4	5
Industry	4	5
Other Federal Agency	4	5
Bat Conservation International	3	3

WHERE DID THE PARTICIPANTS COME FROM?

REGIONAL REPRESENTATION	PARTICIPANT #	PARTICIPANT %
EAST	70	81
MID-CONTINENT	16	19

PARTICIPANT RATING ON USEFULNESS OF TALKS

4.0=EXCELLENT
3.0=GOOD
2.0=FAIR
1.0=POOR

SESSION 1 WHITE-NOSE SYNDROME IMPACTS ON BATS AND MINING

PRESENTER	AVERAGE RATING	RATING RANGE
Jeremy T. Coleman	**3.6**	**4-3**
Mike Armstrong	**3.3**	**4-2**
Panel Discussion	**3.2**	**4-2**
OVERALL SESSION 1 AVERAGE	**3.4**	

SESSION 2 FEDERAL EFFORTS FOR THE RECOVERY OF THE INDIANA BAT

PRESENTER	AVERAGE RATING	RATING RANGE
Scott Pruitt	**3.0**	**4-2**
Andy King	**3.5**	**4-2**
Carrie Lona	**3.0**	**4-1**
Peg Romanik	**3.5**	**4-2**
OVERALL SESSION 2 AVERAGE	**3.3**	

SESSION 3 STATUS OF STATE PERMITTING/RECOVERY/MITIGATION/ IMPLEMENTATION STRATEGIES

PRESENTER	AVERAGE RATING	RATING RANGE
Kimery C.Vories	**2.8**	**4-1**
Gregory E. Conrad	**3.0**	**4-2**
Bernard Rottman	**3.3**	**4-1**
Panel Discussion	**3.2**	**4-2**
OVERALL SESSION 3 AVERAGE	**3.1**	

SESSION 4 STATUS OF ON THE GROUND RECOVERY EFFORTS

PRESENTER	AVERAGE RATING	RATING RANGE
Scott Eggerud	**3.4**	**4-1**
Jim Ratcliff	**3.5**	**4-2**
J.D. Wilhide	**3.4**	**4-2**
Robert Rice	**3.7**	**4-2**
Calvin M. Butchkowski	**3.7**	**4-3**
Mike Masterman	**3.2**	**4-2**
OVERALL SESSION 4 AVERAGE	**3.5**	

SESSION 5 RESEARCH EFFORTS AND RESEARCH NEEDS

PRESENTER	AVERAGE RATING	RATING RANGE
Dr. David Waldien	**3.3**	**4-2**
Christy Johnson-Hughes	**3.2**	**4-1**
Dr. Lynn W. Robbins	**3.3**	**4-2**
Dr. Thomas H. Kunz	**3.7**	**4-3**
Dr. Timothy C. Carter	**3.9**	**4-3**
OVERALL SESSION 4 AVERAGE	**3.5**	

MOST USEFUL TOPIC

- White-nose syndrome
- Blasting design to prevent disturbance
- Legal definition of “take”
- Talk on Acoustic Monitoring and Sampling
- Clarification of current regulations and the review of new ones
- Talks that integrated science with successful, “real world” management situations
- Protection and Enhancement Plan Issues
- Forestry/summer habitat replacement
- Bat Gates constructed at mine openings and development of better habitat at mines
- Permitting Process
- Session 3 on State Activities and Session 5 on Research Needs.
- Discussions on mitigation and management strategies.

SUGGESTIONS

Future Forums or Workshops

- Indiana Bat Recovery Plan once finalized.
- Changes to the Protection and Enhancement Plans
- Success of restoration of summer habitat related to use by the Indiana bat and other species.
- A workshop for the coal industry as few owners/operators have any understanding of bats, bat habitat, and need for bat protection.
- Improved mitigation techniques and the roles of consultants.
- Impact of additional habitat needs of new species listed as Endangered due to WNS.
- Bat gate construction.
- Mine closure training for AML
- Steam Benthic Issues
- Bat management issues after WNS.

Forum Content and Presentations

- More information on the Protection and Enhancement Plans
- Need a greater number of coal mining operators at these events.
- Seemed to be a lot more information on bats than mining.
- More bat talks

- The format was very successful.

Additional Topics

- More case studies on AML successes and failures
- Overview on bat biology
- Mitigation options for coal mining protection and enhancement plans
- Application of the Indiana Bat Guidelines to Oil, Timber, and Natural Gas companies as well as Wind energy.
- Additional permitting topics
- More case studies from coal operators
- Are conservation measures imposed by the regulatory process having a positive impact on the species.
- Determine funding priorities of large-scale research projects that OSM/FWS/Coal operators should pursue

APPENDIX 1: RECORDED DISCUSSIONS

Edited by
Kimery C. Vories
Office of Surface Mining, Reclamation & Enforcement
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. The topic of each question is arranged in alphabetical order for ease of access. 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: WHITE-NOSE SYNDROME IMPACTS ON BATS AND MINING

1. Current Status of the Research and Management of White-Nose Syndrome
    - **Archeological Evidence of WNS**
    - **Susceptibility of other Cave Species to WNS**

2. How White-Nose Syndrome may Affect T & E Species, Permitting and Recovery
    - **Non Hibernating use of Caves by Male Bats**

SESSION 1: INTERACTIVE PANEL DISCUSSION: Management Opportunities for Addressing White-Nose Syndrome

- **Alteration of Caves or Mines for Temperature and Humidity Control**
- **Captive Breeding Programs**
- **Chemical Experiments in Mines**
- **Decontamination of Mist Nets**
- **Funding Priorities for WNS**
- **Funds from States**
- **Funds from PA Conservation Fund**
- **Fund Availability from Foundations**
- **Increasing Indiana Bat Populations**
- **Listing of Additional Bat Species as T & E due to WNS**

SESSION 2: FEDERAL EFFORTS FOR THE RECOVERY OF THE INDIANA BAT

1. Indiana Bat Recovery Plan Status

2. Indiana Bat Population Status and Trends
    - **Environmental Variable Comparison**
    - **Priority Designation Changes**

3. The Range-wide Indiana Bat Protection and Enhancement Plan: Where We Were, Where We Are, and Where We Hope to Be

4. Everything you wanted to know about “take” in the Endangered Species Act

SESSION 2: INTERACTIVE DISCUSSION

- **Mining Versus Forestry**
- **Tree Clearing Versus Mist Net Surveys**

SESSION 3: STATUS OF STATE PERMITTING/RECOVERY/MITIGATION/ IMPLEMENTATION STRATEGIES

1. A Comparison of Indiana Bat Population and Coal Mining Trends
   - **Mining Data Analysis**

2. Industry Perspective on Bat Protection Efforts
   - **Assuming Presence Versus Mist Netting**
   - **Costs for Assuming Presence**
   - **Guidance Changes**
   - **Increasing Disturbance**

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DISCUSSIONS BY SESSION

SESSION 1: WHITE-NOSE SYNDROME IMPACTS ON BATS AND MINING

1. Current Status of the Research and Management of White-Nose Syndrome
Dr. Jeremy T. Coleman, U.S. Fish & Wildlife Service, Hadley, Massachusetts

Question: (**Archeological Evidence of WNS**) Has there been any archeological investigations that would search for evidence of the presence of the WNS fungus in North American caves?

Answer: There have not been any excavation investigations to date. One of the problems with the current detection technology is that we have to conduct field investigations to identify the fungus. These PCR techniques require that the sequence of the entire genome be determined, which is a very involved process. They are working to improve these techniques. We are hoping that this is developed and at least tried in Europe where we think the fungus originated.

Question: (**Susceptibility of other Cave Species to WNS**) Is there any evidence that the WNS fungus is spreading to any other cave dwelling species?

Answer: Although there has been anecdotal reports of what appear to be fungal infections on arthropods, spiders, and snakes there is no real evidence that WNS has spread to any other species. Currently, the fungus appears to only attack hibernating bats. It attacks anything that would go into hibernation and drop its temperature down to the range where the WNS is active and whose immune system would not be active. There has been some research proposed but not yet tried to infect other species in a controlled environment to see if they would be affected. It remains to be seen what other species might be susceptible.

2. How White-Nose Syndrome may Affect T & E Species, Permitting, and Recovery
Mike Armstrong, U.S. Fish & Wildlife Service, Frankfort, Kentucky

Comment: (**Non-Hibernating use of Caves by Male Bats**) We need to be looking at WNS as it relates to the difference between the behavior of male and female bats. Males spend much more time in the underground hibernacula than the females. We need to be looking for the presence of the WNS on the males who use the hibernacula in late spring, summer on for early return in the fall.

SESSION 1: INTERACTIVE PANEL DISCUSSION: Management Opportunities for Addressing White-Nose Syndrome

Question: (**Alteration of Caves or Mines for Temperature and Humidity Control**) How could the microclimate of caves or mines be modified to improve the microclimate for control of WNS?

Answer: There have been several success stories related to that in Kentucky and Indiana. Jim Kennedy has had some success with Bat Conservation International (BCI) working with Kentucky state parks, the state fish and wildlife agency at Salt Peter Cave, reopening sink holes to restore air flow and replacing poorly designed bat gates. In response, the number of Indiana bats has increased from a few hundred to almost 10,000 in 5 years time. Missouri also has a good example of that at their Pilot Knob mine which is the largest hibernacula for the Indiana bat in the state.

Question: (**Captive Breeding Programs**) Has there been any effort to: (1) separate the species that are threatened by WNS and (2) set up a captive breeding program to prevent extinctions for possible release latter?

Answer: A model has been developed with Kitric fungus associated with amphibian decline. They have been able to successfully breed and release amphibians, and this provides the closest model we have seen for this type of effort. Our experience with being able to house and bred insectivorous bats has not been so successful. The rehabilitation community is still very optimistic but this is based on experience with a very small number of species, primarily Big Brown bats. To date there has been no demonstrated success with current Threatened and Endangered (T & E) species. However, it is quite possible we could be looking in the near future at being down to a small number of individuals with some of these species. Then we will need to keep as large a number alive as possible to insure a sufficiently large gene pool for the species to survive. Much of the dilemma goes back to competition for limited funding between, research, treatment, and captive breeding programs. The zoos have stated an interest in coming up with their own funding to begin such a program that would not compete with funds for research and treatment. There are a lot of unknowns and it will be a difficult process to map out the best course of action.

Question: (**Chemical Experiments in Mines**) Since mines do not have the same ecological systems that are found in caves, would it be possible for some mines to be made available for chemical treatment experiments?

Answer: Mines should be available for experiments that would modify their temperature or humidity to minimize the ability of WNS to infect the bats. Most coal mines however, even if they are being used by bats, are not safe for people to enter which may limit what can be done experimentally.

Answer: WV has found T & E species in coal mines. Most bat surveys have taken place at the mine entrance because of the health and safety issues related to entering the mine.

Answer: There are significant populations of Indiana bats in limestone mines. The limestone mines become very similar to limestone caves and in some cases actually contain cave organisms similar to those found in natural caves. Some of these limestone mines contain sensitive cave fauna where it would be inappropriate to conduct chemical experimentation.

Question: (**Decontamination of Mist Nets**) Does West Virginia have its own guidance for decontamination of Mist Nets?

Answer: West Virginia uses the decontamination guidance provided by U.S. Fish and Wildlife Service.

Question: **(Funding Priorities for WNS)** How much of the available funding goes to research and how much to regulation and control? How much of available funding is spent on WNS causes and how it is transmitted and how much is spent on efforts to save the species? Is there any value in bringing all of the various research monies into one place where it could be more effectively focused on the issue?

Answer: The U.S. Fish & Wildlife Service (USFWS) is currently trying to identify the highest priority research and control areas where funding needs to be applied. The funding is spread between three directions: basic research on WNS, conservation issues related to treatment, and then the control of the spread of the disease. The rapidity of the spread of the disease and the limited amount of funds available reduces the options for pursuing the priorities for each of these directions.

Question: **(Funds from States)** How is funding being provided for WNS research and are the states providing any research funding?

Answer: The USFWS is not set up to fund very much of this research. In addition to its own funds, USFWS has competed for some preventing extinction grants that have funded both research and additional positions that can focus on the problem. USFWS received $1.9 million in congressional funds for FY 2010 for research of specific WNS efforts or manpower. Some congressional funds have also been directed to support work by the states on WNS. Some funding has been provided by USGS, Forest Service, and Department of Defense to do WNS work within their jurisdiction. There has been a congressional request for an additional $5 million for WNS work to the Department of Interior. Some states are getting funding through their state wildlife grant process. Private sources such as BCI, the National Speleological Society, and Indiana State University have been significant sources of non-governmental funding.

Question: **(Funds from PA Conservation Fund)** How does the State of Pennsylvania spend its conservation fund monies?

Answer: The money can be spent by the Pennsylvania Game Commission to buy targeted land, purchased as bat habitat in perpetuity. Since we know where the bat hibernacula are in the state, we want to make sure that the land around important hibernacula is available for long term recovery of the species.

Question: (**Increasing Indiana Bat Populations**) Why did the Indiana bat population increase significantly just prior to the outbreak of WNS?

Answer: During the almost 10 years that the Indiana bat population increased prior to WNS, the increase to the Indiana bat population seems to be a product of improved protection of the underground hibernacula. This species is very sensitive to disturbance during midwinter and protection of the hibernacula reduces the midwinter arousal giving them a better chance to survive and increase.

Question: **(Listing of Additional bat species as T & E due to WNS)** Where are we in the process of listing more bat species as endangered due to WNS?

Answer: The USFWS received a petition in January of 2009 for the northern long eared bat and the eastern small footed bat to be listed. We are now developing a 90 day finding to determine if the petition is substantial and the petition action is warranted. This should be completed this fall. Then we will conduct a status finding that will conclude one year after we announce the 90 day finding with a decision on whether or not to list the species. There is currently a petition being prepared to list little brown bats as endangered within the next two months.

SESSION 2: FEDERAL EFFORTS FOR THE RECOVERY OF THE INDIANA BAT

1. Indiana Bat Recovery Plan Status
   Scott Pruitt, U.S. Fish & Wildlife Service, Bloomington, Indiana

2. Indiana Bat Population Status and Trends
   Andy King, U.S. Fish & Wildlife Service, Bloomington, Indiana

Question: (**Environmental Variable Comparison**) Have you been able to compare other variables such as temperature with your annual population data?

Answer: There is another group of researchers (the Yellowstone Ecological Research Center from Bozeman, MT) who are currently involved with looking at our population data in relation to a large number of environmental co-variables using NASA images and funding. There is also an effort by USGS using a hibernacula complex approach to trend. We have always looked at the data on a state by state basis and by USFWS region. We have never done any analysis that looks at what is happening within the hibernacula. We do know that bats will shift from one cave to another in response to a disturbance.

Question: (**Priority Designation Changes**) Underground hibernacula are given a designation related to their importance for the Indiana bat. Will these designations change based on the impact of declining numbers due to WNS and, if so, would that affect management of the hibernacula?

Answer: USFWS does use these designations in its recovery plan in determining the management plans for a given hibernacula, especially in terms of which hibernacula needs to be protected. Currently, we are trying to ensure that 80% of the priority one hibernacula are protected. Since protection looks different at different hibernacula, each hibernacula would have a specific protection plan. However, the way USFWS defines the priority designation of a hibernacula determines that, once a site is designated a priority one hibernacula, it is always a priority one hibernacula. We now have some priority one hibernacula where there are no Indiana bats.

3. The Range-wide Indiana Bat Protection and Enhancement Plan: Where We Were, Where We Are, and Where We Hope to Be
   Carrie Lona, U.S. Fish & Wildlife Service, Frankfort, Kentucky

4. Everything you wanted to know about “take” in the Endangered Species Act
   *Peg Romanik***,** *U.S. DOI Solicitor’s Office, Washington, D.C.*

SESSION 2: INTERACTIVE DISCUSSION

Question: (**Mining Versus Forestry**) In the Kentucky surface mining program, in a good year, we clear 40,000 acres of trees that is considered habitat. During the same year, the Division of Forestry in Kentucky clears 250,000 acres of trees. Where is the fairness in this? Why doesn’t USFWS regulate this much larger tree removal process?

Answer: The answer is that everyone and every institution is liable for “take” of an endangered species. In general, the criminal aspect of the endangered species act is not applied to other government agencies and is more likely to be applied to individuals where liability can be more directly proven. Governments in the western U.S., including states and counties, are more likely to develop agreements with USFWS to ensure that their actions do not involve the “take” of endangered species. Governments in the eastern and midwestern U.S. have been slower to work out such agreements, although this is currently happening in Indiana where the state is pursuing a Habitat Conservation Plan (HCP) on its forest lands. The USFWS would encourage state and local government agencies to develop HCPs for their forest clearing activities but they do not have the staff to pursue enforcement.

Question: (**Tree Clearing Versus Mist Net Surveys**) In the Indiana bat guidance document, concerning the selective tree removal, the guidance document no longer allows selective tree removal. This is because of the potential to miss a tree or habitat that could have been created between the time the trees were felled and the time the bats arrived, even though the rest of the trees would be cleared the very next season. If this is the case, how can you justify having the mist net survey protocol that has the potential to miss bats and that the surveys be valid for 5 years?

Answer: Selective tree removal is still allowed where it is reasonable such as when the area of removal is 5 acres in size. It is assumed that resident female bats may select another nearby tree if their normal maternity tree is removed. If this new tree were removed during the spring or summer this could result in problems. The guidelines are guidelines. If the permittee feels that another alternative would be acceptable they just need to get the agreement of the local FWS office and the State Mining Regulatory authority to agree to another alternative. When you do a mist survey, it is to determine absence or presence of the species. When you are doing a Protection and Enhancement Plan (PEP) it is because you are assuming the species is present. That is the difference. The 5 year period of validity for the mist net survey is based on the permit term and also upon research on the validity of the survey. However, for non SMCRA permits you only get 2 years on a mist net survey in Kentucky.

SESSION 3: STATUS OF STATE PERMITTING/RECOVERY/MITIGATION/ IMPLEMENTATION STRATEGIES

1. A Comparison of Indiana Bat Population and Coal Mining Trends

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

Comment: (**Coal Mining Data Analysis**) I think that just using the geo-political boundaries in your study will confound this type of analysis because bats that hibernate in Indiana may summer in Michigan or some other state, so that doing a state by state comparison of coal mining data makes it difficult to make any kind of comparison. I think it would be better to find a local mining district and look at nearby hibernacula or summer habitat in order to understand the effects of mining on bats.

Response: What this study was trying to do was look at the big picture in terms of what role, if any, the coal mining industry has played in terms of the declining Indiana bat population since 1965. Since the coal mining data exactly overlaps the Indiana bat population data, I think this data shows that coal mining has played a relatively insignificant role in the decline of the Indiana bat population. What this study cannot evaluate is that of a specific permit. In this case, any given coal mine that clears trees in the summer habitat of an Indiana bat will have the potential to impact a local population of Indiana bats. This illustrates the importance of the Surface Mining Reclamation and Control Act (SMCRA) programs in ensuring that these mining activities minimize their impact to the Indiana bat. This is why OSM works with the states to make sure that the mines do their part to protect the species.

2. Industry Perspective on Bat Protection Efforts

Bernard Rottman, Peabody Energy, Evansville, Indiana

Question: (**Assuming Presence versus Mist Netting**) Your company assumes presence rather than mist netting to determine presence or absence. If you mist net and do not find any Indiana bats then you would not have to worry about clearing maternity trees during the winter. Why doesn't your company do more mist netting?

Answer: We have definitely considered just this option. The problem is that these mining operations are dynamic and the permits may be for thousands of acres so that you cannot survey the entire permit area in a year. Predicting exactly where the operation will be a year or so in advance is not always possible. The mine operation does not want to risk not being able to mine during the summer because it may or may not have conducted a mist net survey in the area to be mined. Assuming presence and planning accordingly involves less uncertainty, and uncertainty and unpredictability can be a very high cost item.

Question: (**Costs for Assuming Presence**) What is the worst case scenario for increasing costs due to having to assume presence and clear the trees in winter ahead of the operation?

Answer: I am not sure about total costs but whenever you have to clear trees you could be talking over $1000 per acre. If you were in a bottomland setting, it would be much higher than that.

Question: (**Guidance Changes**) Are there any of the provisions of the Indiana bat guidance document that if changed would maintain the appropriate levels of protection for the species but also be more protective of other aspects of the environment?

Answer: Allow the coal operators to take out the potential maternity trees that have significant potential as maternity habitat, without clear cutting of all of the trees. We do not need to be clearing forests wholesale during the winter. We need to minimize our disturbance on the landscape.

Question: (**Increasing Disturbance**) How many more acres do you need to disturb now prior to mining that you didn't have to disturb before implementation of the new Indiana bat guidance document?

Answer: In the past, clearing in front of the mine pit was minimal for a typical Midwestern truck shovel operation. The actual disturbance is shovel by shovel just in front of the pit. After the guidance document, we are clearing hundreds of acres in front of each pit in order to get us through to the next winter.

3. State Survey of Indiana Bat Protection and Enhancement Measures and Interactive Panel Discussion on State Specific Bat Protection Strategies at Coal Mines
Gregory Conrad, Interstate Mining Compact Commission, Herndon, Virginia

SESSION 3: INTERACTIVE PANEL DISCUSSION: State Specific Bat Protection Strategies at Coal Mines

Question: (**ANABAT Survey Requirements**) What is the future of mist netting? When are the guidance documents going to require an ANABAT survey?

Answer: Mist netting will not be going away. It is anticipated that there will be more use of the ANABAT survey in the future. We have been looking at the protocol for determining presence or absence because our directors have been asked this same question. Kentucky has been incorporating the use of ANABAT surveys into its presence/absence surveys for the last three summers. There seems to be concurrence that when you use the combination of mist netting and acoustics, you increase your detect ability. There is no survey method technology that gives you 100% detection, so there will always be some level of error. With WNS decreasing our numbers of Indiana bats, we are going to want the best survey methods available so that we can detect those populations that are surviving on the landscape. It is our interpretation of results that is difficult. If you do not capture Indiana bats in the mist nets, do we have enough confidence in the ANABAT identification of the species? We will probably not come up with a protocol that specifies what acoustic equipment you need to use.

Comment: (**Benefits of Increased Bat Requirements**) The talk on the industry perspective brings out the additional costs associated with the additional protection measures necessary to protect the species. This includes not mining part of the coal reserve in addition to operation costs. What I have not seen demonstrated is that the additional costs incurred by the mining industry actually results in an offsetting benefit to the species.

Response: From a state regulatory perspective, we have to make findings that a coal operation will not negatively impact T & E species. The Fish and Wildlife Service needs to make similar findings. We can all argue the science but it still comes down to the regulatory responsibility to make these findings.

Question: (**Coal Mining Trend Analysis1**) In the talk on the analysis of coal mining and bat population trends, you are using bat population numbers in hibernacula in states and coal numbers in states. Are you making the assumption that the potential impacts of coal mining are on hibernating bat populations?

Answer: The analysis used the data that exists and was available for the analysis. This is the very same data that USFWS uses to determine population trends for the species and the coal data exactly and completely overlaps the population data. It makes no assumptions as to what proportion of the threat to the species is due to underground versus surface habitat.

Comment: (**Coal Mining Trend Analysis2**) In some of the other talks we see the evidence of extensive migratory movements of bats. These studies show that bats many times summer in different states than the state where they hibernate in the winter. Since this is the case, it would seem that state bat hibernacula counts would not necessarily be correlated with state coal production data.

Response: The bat population numbers are determined in hibernacula and reported by state and are the numbers that USFWS uses to represent the total bat population and trends-population for both their summer and winter habitat. The coal production numbers reported by state represent the total coal production for exactly the same geographic area (both summer and winter habitat) as that represented by the bat population data. To be sure, a more accurate comparison could be made if specific data could be provided that measured total bat populations in their summer habitat by state for comparison with state coal production data. The point of the analysis, however, was to use the best data that existed to see if there was any evidence that coal mining played any significant role in the recent historic decline in the Indiana bat population. The conclusion of this analysis was that there is no evidence that coal mining has played any significant role in the population decline. This conclusion is supported by the data from the U.S. Forest Service which specifically looks at summer habitat and compares that with coal mining acreage to see that, in a worst case scenario, the coal industry only has the maximum potential to impact less that 1% of the forest cover (i.e. summer habitat) utilized by the Indiana bat for summer habitat. This is also supported by the requirements of the SMCRA program which is one of this country's most comprehensive programs for protection of the public and the environment. The evidence that exists indicates that whatever the causes are for the decline in the Indiana bat population, it is not SMCRA regulated coal mining.

Comment: (**Conservation Measures versus Conservation Benefits**) I am concerned that people believe that there are USFWS conservation measures that do not have a conservation benefit to the species. It is the burden of the USFWS to adequately explain how each conservation measure does provide a conservation benefit to the species. Does USFWS need to provide a better explanation or do we need more research that would demonstrate the benefits more clearly?

Question: (**PA More Stringent Requirements**) Why did Pennsylvania decide to develop state Indiana bat protection requirements that are more stringent than the guidance provided by the combined USFWS/IMCC/OSM guidance?

Answer: The Pennsylvania guidance is for more than the coal industry. It includes all industries including all mining, wind energy, and pipelines. Pennsylvania expands its protection around hibernacula to a ten mile radius around hibernacula. This is based on telemetry studies conducted by the Pennsylvania Game Commission. The Commission decided to expand this protection based on these studies. Pennsylvania has a small percentage of the Indiana bat population and felt it was very important to protect their Indiana bat hibernacula. The Commission also felt that they wanted a high percentage of reforestation of their reclaimed mine land.

Question: (**PA Forest Cover Requirement**) In Pennsylvania, was there any science to back up the requirement for 90% forest cover on reclaimed mine land?

Answer: I have not seen any science behind this requirement. This seems to be a decision on the part of the Commission to err on the side of protecting bat summer habitat.

Comment: (**Reasonable Measures Versus Extreme Measures**) In Pennsylvania, the State College office of the USFWS was suggesting that they should be considering trees with a three inch or greater diameter as potential maternity trees. They were told to take that off the table because it was ridiculous. The industry already thinks five inch diameter trees are ridiculous. I think that the goal should be to come up with a game plan that is reasonable where you can get company buy in. The more extreme the conservation measures the more ridiculous they are going to appear and the more people are going to try to find a way around the requirements. We have already seen this where a land owner begins discussions with a mine operator and it is suggested that the land would be more attractive for mining if the trees were clear cut. No trees, no bats, no problems. Conservation measures that are viewed by the public as extreme will prevent the type of cooperative effort that would result in more on the ground protection for the species.

Comment: (**Serious Consequences of Timber Clear Cutting**) If you clear cut a roost tree, that is still a "taking" of the species even if it does not "kill" a bat. It is removing an active maternity habitat and based on the definition of "harm and harass" cutting that maternity tree is a "take" not of just one bat but of the whole maternity colony that used that tree. Even if the maternity tree is cut in the winter it is still a "take" under the endangered species act because the bats still intend to come back and roost in that tree. Even if it were a secondary roost tree that could potentially be a “take.” In this case, we could not presume presence because when a maternity tree is removed the bats may move out of the area during the next spring.

Question: (**Uniformity Results**) The new Indiana bat guidance document is for greater uniformity of requirements both within a state and between states. Is this greater uniformity actually happening on the ground?

Answer: Yes. Prior to the new guidance document, in a state that was serviced by two different USFWS offices, there were different requirements within the same state based on different directions from different USFWS offices.

Answer: The industry would agree that the new guidance document has brought greater uniformity of requirements across the range of the Indiana bat which the industry views as a positive change. What shocked the industry were the totally new requirements that were added when the new guidance document was published. The definition of a potential maternity tree as being a tree with a 5 inch or greater diameter, rather than the previous 12 inch diameter requirement, significantly changed the amount of work necessary to prepare an area for mining. This would be a negative aspect of the new guidance from the industry perspective.

Comment: (**Unique Tennessee Guidance**) The USFWS in Tennessee is in a dynamic situation. We are evaluating the guidance document and on the one hand trying to be more consistent with other states but on the other hand we have our own specific requirements. We currently have a requirement to assess potential impact for a mining operation that is within 10 miles of a hibernacula. Recently, we have data from one cave where there seems to be maternity habitat within 25 miles of this cave. So we may start using a 25 mile radius for assessing impact in the near future. Tennessee may also want to adopt something similar to the 40 acre forest cover requirement currently used by Pennsylvania. We have been allowing winter timber harvest in the past but since there is the potential for the removal of maternity trees that bats may not find when they come out of hibernation, we may require mist netting rather than allowing the operator to assume presence.

SESSION 4: STATUS OF ON THE GROUND RECOVERY EFFORTS

1. Creating Summer bat habitat on surface mines in Appalachia using the Forestry Reclamation Approach (FRA)
   Scott Eggerud, Office of Surface Mining, Pittsburgh, Pennsylvania

2. Blasting and Endangered Bat Portals: Not Disturbing Bats While Mining
   Jim Ratcliff, West Virginia DEP, Office of Explosives and Blasting West Virginia

3. Active Mining Recovery Opportunities: Boone North No. 3 Surface Mine
   J.D. Wilhide, Compliance Monitoring Laboratories, Chapmanville, West Virginia

4. Preservation Efforts of Potential Bat Habitat
   Robert Rice, West Virginia DEP, Office of Abandoned Mine Lands, West Virginia

Question: (**Bat Gate Potential for WV**) If you gated all of the abandoned mine openings with potential for bat habitat in the State of West Virginia, how many would that be?

Answer: I cannot say for certain, but it would probably be in the hundreds. We will be installing bat gates until the program is done.

Question: (**Life Span of Culverts**) Since you are using culverts with your bat gates and these are usually exposed to mine water, do you have any information of the type of culvert that is most resistant to AMD and what is the expected lifespan of that culvert?

Answer: Every situation is unique. In the situation where there is mine drainage, then we install a drain beneath the culvert used for the bat gate. We tend to use a HDPE culvert because they last longer. There are instances where we will have to use a metal culvert because you can get the metal culvert in an elliptical shape which better suits the mine opening because the rubber culverts only come in round.

Comment: (**On Line Web Based Bat Gate Decision Tool)** There is a big need to monitor these gating efforts in terms of their long term effectiveness and value as a reclamation tool. BCI is working with the BLM to start an online interactive web based decision making tool for mine bat gating efforts. The idea is to build upon the knowledge and experience of all of those who are involved in gating mine openings both in the west and in the east. The importance of an online tool is that it can be updated as new knowledge is gained rather than producing a state of the art publication but then having it quickly outdated.

Question: (**Toxic Mine Gas**) Some of these mines may produce toxic gases. Are you doing anything to ensure that you are not creating a future problem by identifying abandoned mine openings with the potential to produce toxic gases that could harm the bats? Is there any monitoring at the site to determine if the mine opening is producing toxic gas?

Answer: In most cases we have to leave some type of opening to allow for drainage from the mine. The AML program is trying to eliminate problems rather than create them and to date we are not aware of any situation where we have created such a problem. There is no monitoring for toxic gas at the opening once construction is complete.

Question: (**Up-Dip Versus Down-Dip Mine Openings**) Does the program close or gate up-dip mine openings as well as down-dip openings?

Answer: Yes. We either close or gate any abandoned mine opening. If an opening has collapsed prior to investigation we do not attempt to reopen it. If the mine opening is still open when we investigate then we are now putting culverts and bat gates in all of the openings whether they are up-dip or down-dip.

Question: (**Water Quality Issues**) Is there a potential for improving water quality?

Answer: The AML program addresses all environmental issues related to previous mining, and water quality is a big part of that. We have done passive treatment systems and we are moving into installing active treatment systems. We fund drinking water lines into areas where people's water supply has been degraded by AMD.

Question: (**Winter Construction**) Is there any preference for doing this in the winter as the construction activity could potentially disturb the bats?

Answer: The thought is that two weeks of construction to secure the mine opening and keep people out is better than people having access to the opening and going into the mine to party or ride their ATVs, and end up with disturbance all winter long.

5. Pennsylvania Bat Gating Efforts
   Calvin Butchkoski, Pennsylvania Game Commission, Harrisburg, Pennsylvania

6. Microclimate Research to Support Endangered Species of Bats in Hellhole and Schoolhouse Cave and Technological Advancements in Monitoring Systems
   Mike Masterman, Anvesh Singireddy, Shana Frey, Extreme Endeavors, Philippi, West Virginia

SESSION 4 INTERACTIVE DISCUSSION

Comment: (**AMD in West Virginia**) West Virginia has a significant problem with acid mine drainage from abandoned underground mine openings. There are approximately 521 streams in West Virginia affected by AMD which equates to about 3,000 stream miles. Historically, West Virginia has used passive treatment to mitigate AMD that has proved inadequate to the task. More recently we have been using OSM set aside funds to use in stream dosing systems to actively treat the large scale AMD treatment problems. We will then allow the watershed groups to go upstream of the in stream dosers and install additional passive treatment systems.

Question: (**Bat Surveys prior to Gating**) Does West Virginia AML do bat surveys on abandoned mine openings prior to making a decision to install a bat gate?

Answer: Five years ago West Virginia made the decision to provide culverted bat gates during the reclamation of all abandoned mine openings. Prior to that time we did bat surveys on three mine openings and, based on the bat use encountered, we made the decision to do culverted bat gates at all mine openings.

Comment: (**Mine Investigations to Improve Design**) In Pennsylvania, our underground mines may have multiple openings and extensive connectivity underground at different elevations. When evaluating how best to develop the mine for bat habitat, we try to obtain copies of the mine maps to determine where all of the openings are and how the closure or gating of those openings will help or hurt the bat habitat. By closing the lower openings, we can reduce the loss of cool air and better keep the cold air inside the mine.

Comment: (**Post Gating Monitoring**) Our experience at Pilot Knob mine in Missouri revealed that after the bat gate was installed the angle of the iron work on the gate was such that it was resulting in bat mortality when the bats flew into the gate rather than through it. This may have had something to do with air currents at the mine opening. At mine openings, where there may be large numbers of bats using the mine, it is very important to do some post construction observations to make sure that the gate is not injuring the bats trying to fly through it.

SESSION 5: RESEARCH EFFORTSAND RESEARCH NEEDS

1. Connections between Landscape-level Bat Research and Mining
   Dr. David Waldien, Bat Conservation International, Austin, Texas

2. Big Picture Mining and Bat Permitting Issues
   Christy Johnson-Hughes, U.S. Fish & Wildlife Service, Arlington, Virginia

Question: (**Indiana bats Killed at Wind Farms**) Have there been any known takes of Indiana bats at Wind farms and what were the consequences?

Answer: Yes, at the Faller Ridge Wind Farm in Northern Indiana in September of last year. Many of the investors of wind energy will now not invest unless the HCP appropriate permit is obtained. Law enforcement discussions are common in discussions with wind energy but we cannot cover all of the wind farms being built or operated.

3. Acoustic Monitoring and Sampling Technology
   Dr. Lynn W. Robbins, Department of Biology, Missouri State University, Springfield, Missouri

4. Current and Future Research Directions on White-Nose Syndrome
   Dr. Thomas H. Kunz, Boston University, Center for Ecology and Conservation Biology Boston, Massachusetts

5. Converting Abandoned Mines to Suitable Hibernacula for Endangered Indiana Bats
   Dr. Timothy C. Carter, Ball State University, Muncie, Indiana

SESSION 5: INTERACTIVE DISCUSSION

Question: (**Bat Boxes as Mitigation**) USFWS has been discouraging at coal mines the replacement of summer habitat with bat boxes as mitigation. Now that maternity colonies may be disrupted by WNS, could building more summer habitat with bat boxes be beneficial?

Answer: Providing bat boxes or other summer bat habitat should provide the opportunity for small maternity colonies to survive and thrive. One person in Canada has built bat habitat in a cave that has taken one cave from 7 thousand bats to over 100,000 bats. I think that bat boxes will last much longer than the bat habitat on a tree.

Question: (**Prioritization of AML Bat Gating**) Out west, the BLM has a program that evaluates mine openings in a large area and determines which are the best mines for bat habitat. They then build bat gates for those and seals the other mines. Do some of the states do anything similar?

Answer: In southern Illinois, we just inventoried about 50-60 mine openings and did the same type of evaluation. Although I do not know of any mine opening that do not have any bats, we have sealed about 15-20 of the least used openings and are only going to gate the openings with the most bats that are best for bat habitat.

APPENDIX 2: MANAGING FOREST HABITAT FOR BATS

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Introduction

This paper will focus on eastern species of bats, though many of the ideas should be applicable elsewhere. What is a forest bat? Different species of bats use forest or forest remnants in different ways. We think of forest bats as those that can live most of their life in forests and make relatively little use of other habitats other than for foraging.

Twenty species of bats (Table 1, listed in order of decreasing tendency to use forests) occur in the eastern United States (Whitaker and Hamilton, 1998); all are in the family Vespertilionidae except one fruit bat (Phyllostomidae) and three species of free-tailed bats (Molossidae). Bats need a place to form summer and winter roosts, areas to forage, and a means to migrate between summer roosting areas and winter hibernacula. The extent to which bats use forests for these purposes varies greatly between species of bats. For most bat species, more is known about the summer and winter roosts than about foraging habits.

As is often the case with wildlife, greater habitat diversity often provides the best situation for bats. A mixture of habitats providing woods with large trees for roosting (Crampton and Barclay 1998), adequate open areas for foraging, and streams and other openings in woods for foraging and commuting probably provide the best general habitat for forest bats.

Forest Management Techniques

The first and best strategy, when possible, is to leave the habitat alone, assuming that the bats have adequate roosting and foraging areas, a ready water supply so that they can drink without flying too far, and also adequate means by which to move from area to area. In particular, forest managers should strive to maintain old stands with tall decaying trees suitable for roosting (Crampton and Barclay 1998, Kalcounis-Rueppell et al. 2005). For example, maternity colonies of Indiana bats selectively roost in large trees (usually > 20 in dbh) with sloughing bark receiving sunshine most of the day (Whitaker and Mumford, 2009). Such trees can occur in hedgerows, swamps (Kurta et al. 2002), along edges, or in canopy gaps in forests (Britzke et al. 2003) where sufficient solar exposure is present. Indiana bats often use broken habitat, as much of their foraging is along the edges of open areas in fields. Adequate water is also necessary, as they generally fly off and get a drink before they begin foraging. Other habitat situations apply to other species as indicated (Table 1) on the needs of individual species.

Table 1. General Habitat (forests, caves or buildings) of Bats in the Eastern United States.

<u>Forest Bats</u>

Myotis septentrionalis. Northern myotis. This species often has its roosts in cracks and crevices of trees within forests. Apparently the roost site does not need to be in the sun. It seldom uses buildings for its summer roost. It hibernates in cracks and crevices in caves and mines which is why usually very few are seen in routine cave winter counts. It feeds on dipterans, small hemopterans, and lepidopterans.

Nycticeius humeralis. Evening bat. Fifty or so years ago, the evening bat often roosted in buildings, but at least in Indiana it now appears to be pretty much restricted to cavities in trees in woods, most often bottomland woods, probably its ancestral habitat. In the southern parts of its range it probably hibernates in hollow trees. It spends much time foraging in open woods. Its food is very similar to that of the big brown bat except that it includes lepidopterans.

Perimyotis subflavus. Eastern pipistrelle (often now called tricolor bat). This species will roost in buildings, but most individuals live in woods where they roost in clusters of dead leaves. Eastern pipistrelles often forage along wooded streams. They hibernate in caves and mines where they are solitary. They feed heavily on small homopterans, dipterans, and lepidopterans.

Myotis sodalis. Indiana bat. This species typically has its maternity colonies under sloughing bark in larger trees, with the sloughing bar exposed to the sun for much of the day. It hibernates in huge clusters in caves. It feeds on small beetles, moths, flies, and "hoppers."

Myotis leibii. Eastern small-footed bat. This species is usually in wooded areas where it often roosts in cracks and crevices in rocks and even under rocks or in the ground. It usually hibernates singly in caves. There is little information on the food habits of this bat.

Myotis austroriparius. Southeastern myotis. This species often roosts in buildings, but it is basically a forest bat in its roosting habits. It roosts in hollow trees, most often in bottomlands, sometimes using an entrance hole near the base of the trees. It feeds mostly on dipterans, small beetles, and lepidopterans.

Lasionycteris noctivagans. Silver-haired bat. This is a northern species and has its young in hollow branches. It migrates south and hibernates usually in caves and mines. It feeds heavily on lepidopterans, trichopterans, and dipterans.

Corynorhinus rafinesquii. Rafinesque's big eared bat. Unlike *C. townsendii*, this species usually forms colonies in hollow trees or buildings. It feeds mainly on lepidopterans.

Lasiurus cinereus. Hoary bat. The hoary bat is solitary and in summer roosts and has its young while hanging among the leaves of trees. It migrates far south for the winter although a few individuals may remain in the north. It is possible that such individuals roost among leaf litter in winter and that it may feed in winter like the red bat. It feeds heavily on lepidopterans.

Lasiurus borealis. Eastern Red bat. The red bat is solitary and in summer roosts and has its young while hanging among the leaves of trees. It generally migrates south for the winter although a few individuals may remain in the north. Red bats remaining in the north in winter roost among leaf litter. They warm passively from the sun on warm winter days and, unlike other species, forage when they awaken. The red bat feeds primarily on lepidopterans, coleopterans, and dipterans.

Lasiurus intermedius. Northern Yellow Bat. This bat is solitary and roosts in summer and has its young while hanging among the leaves of trees. It is closely associated with Spanish moss and its range closely approximates that of Spanish moss. Their food is not well known, but homopterans, beetles, and ants have been recorded.

Lasiurus seminolus . Seminole bat. This species also often roosts in Spanish moss. Food is little known, but homopterans, coleopterans, and dipterans have been reported.

House Bats

We class three species as house bats, as they usually use human structures to raise their young. These species probably used trees for their summer roosts before human structures became common. The Indiana bat may be in the beginning stages of becoming a house bat.

Myotis lucifugus. Little brown bat. This species in the east most often roosts and has its young in buildings in summer. It hibernates in caves and mines. It feeds heavily on dipterans, coleopterans, and lepidopterans.

Eptesicus fuscus. Big brown bat. Most individuals of this species now roost and raise their young in human structures. It is the only species that most often hibernates in human structures as well, although some individuals do hibernate in caves, mines, and tunnels. The big brown bat feeds heavily on beetles and true bugs.

Tadarida brasiliensis. Brazilian freetail bat (Molossidae). Occurs in Florida and the southern part of the other coastal states; Louisiana to North Carolina. In the west it is a cave bat, but in the east it lives in buildings, sometimes in huge colonies. It feeds on a variety of kinds of insects and often flies great distances to forage. The range of this species is moving northward and it is now found across much of North Carolina, even in the mountains (Webster, W.D., pers. communication).

Cave Bats

Cave bats roost in caves during both winter and summer. We have only two true "cave bats" i.e., bats which roost winter and summer in caves.

Myotis grisescens. Gray bat. This bat roosts and has its young in caves in summer and also hibernates in different caves in winter. Gray bats feed on midges and other dipterans especially in spring and fall and feed on beetles and other insects in summer.

Corynorhinus townsendii. Townsend's big eared bat. In the eastern United States, this is a cave species; summer and winter. Like most big eared bats, it feeds primarily on lepidopterans.

Other Bats of the Eastern United States

There are three other eastern species of bats not mentioned above, but are included here for completeness. They are the one fruit bat (Phyllostomidae), *Artibeus jamaicensis*, the Jamaican fruit eating bat, and two free-tailed bats (Molossidae), *Molossus molossus*, the little mastiff bat, and *Eumops glaucinus*, Wagners Mastiff Bat. In the tropics, the Jamaican fruit eating bat roosts in buildings, caves, or hollow trees. It is active year round and feeds heavily on figs. In the United States it occurs rarely and only in Florida. The little mastiff bat also occurs in the US only in the Florida Keys. The three colonies known in the Florida Keys all are in the roof spaces of flat roofed buildings. In the Florida Keys this species feeds mostly on beetles (unpublished data) . The mastiff bat is also found only in southern Florida, especially in the Miami and Coral Gables areas. The few bats found roosting have been under Cuban tiles used for roofing.

However, in greatly disturbed areas such as occur after mining, in homogeneous forest, and in other situations in which there are not adequate roost sites, water, or food, we can often improve the habitat for bats. In the Appalachian Mountains, where mining often results in forest removal, bats often occur in large forest tracts. Strategies for managing forests range from a hands-off approach to very specific alterations to increase the suitability of forests for bats (e.g., creating potential roosts).

1) **Set aside land**. Set aside as much natural habitat as possible especially that which includes roosting, feeding, drinking, and connections for commuting to important foraging areas. Of course, preservation of land benefits other species than bats and is one of the most important steps we can take in wildlife conservation.

2) **Work with foresters**. Work with foresters to determine and implement the best forest management techniques to benefit both forests and bats. Below is a review of different timber harvest practices and how harvested areas might be used by different types of bats (varying ecomorphology) in different seral stages.

    a. **Clearcuts.** Clearcuts are not generally the preferred mode of timber removal, as the land is completely changed and no trees are left. However, clearcuts can serve as foraging areas for bats and regrowth forest may be particularly attractive for larger, less maneuverable bats (Norberg and Rayner 1987). In addition, clearcutting opens forests and may therefore expose some decaying trees to sunlight. If such trees had sloughing bark exposed to the sun, clearcutting could have provided Indiana bats additional roosting areas. Further, the edge of a recent clearcut may be attractive to bats that roost in live trees (e.g., eastern red bats, Perry et al. 2008, O'Keefe et al. 2009). The size of clearcuts is important, as vast areas of clearcutting in the western United States have proven exceedingly detrimental to many species and of course to the forest itself. However, small clearcuts can provide foraging habitat for bats (e.g., Grindal and Brigham 1998). Forest edges formed with clearcuts may also provide foraging habitat for bats. Forming edges between habitats (edge effect) has been a longtime tool of habitat managers. Forest edges may also increase bats' access to different habitat types.

    b. **Shelterwood/2-age cuts –** In traditional shelterwoods, trees are left singly throughout the stand. Some trees left during shelterwood cuts may be damaged during harvest operations, thereby supplying additional potential roosts with high solar exposure. Further, trees left in shelterwoods will develop into larger trees, ensuring a more continuous supply of large trees into the future. An alternative type of shelterwood cut would leave reserves of trees in strips or clumps, which may be more beneficial to bats and other wildlife. Reserve of live trees in shelterwoods should result in more edge habitat than in traditional shelterwoods and may also yield a greater number of suitable roosts for a wider variety of bat species.

c. **Group selection cuts**. With group selection cuts we would expect that there might be potential roosts (damaged or large trees) left in uncut areas immediately after harvest, while cut areas (skid trails and small nonlinear clearings) should serve as desirable foraging habitat for most bats. As the cut areas begin to succeed to a mid-successional state, higher stem densities will likely inhibit bats' movements within the cut areas but will result in hard horizontal edges above the tree tops where bats could forage under the shelter of the surrounding mature trees (and there will be many horizontal and vertical edges for foraging). As mature trees in uncut areas undergo senescence, more trees will become suitable for roosting and small canopy gaps will form in places where over mature trees have died.

d. **Prescribed fire**. Prescribed fire is an important management tool for the restoration of oak and pine forests (Waldrop and Brose 1999). Cyclical prescribed burns yield very low clutter in the under- and mid-stories of mature stands and also enable the maturation of fire-dependent tree species like pines and oaks (Guldin et al. 2007). Opening up a cluttered forest with prescribed fire should make it more suitable for foraging and roosting by bats. Further, suppressed trees "released" by prescribed fire may eventually develop into suitable roost sites. The relationship between prescribed fire and bats is not well understood (Dickinson et al. 2009). When fire has been excluded from an area, prescribed fire may result in a net loss of dead trees (Horton and Manann 1988, Bagne et al. 2008) which could decrease the number of available roosts for bats. However, in West Virginia, male Indiana bats did not seem adversely impacted by prescribed fire; almost a third of roosts found were in stands burned 1–3 years prior (Johnson et al. 2010). Prescribed burning programs should pay attention to timing and ignition methods to minimize the threat of fire to newly formed maternity colonies of bats (Dickinson et al. 2010).

e. **Roads.** Logging roads or other open linear areas through woods may be particularly beneficial by forming commuting corridors among roosts and foraging grounds. Logging roads are frequently maintained in early successional grasses and forbs, so they likely also serve as optimal foraging habitat for bat species.

Roads for vehicular traffic of course pose a threat to bats from collisions with vehicles and the larger the roads, the more difficult they are for bats passing over them. However, roads for vehicular traffic can also provide some benefits to bats, as travel corridors (especially when roads are small and vehicular traffic is light), sometimes as roosting areas, and open grassy or marshy areas along the edges of roads can supply additional roosting and foraging areas (e.g., Zimmerman and Glanz 2000).

f. **Wildlife openings.** Edge habitat for roosting and foraging: Construction of openings in the forest for wildlife is not used as much as earlier because it tends to open the habitats to cowbirds which can be detrimental to bird species that nest in forest. However, there are many such openings in some areas and they can benefit bats as they provide additional foraging area, and also along their edges increasing the possibility of trees with sloughing bark hollows which can serve as roosting areas for bats. If the wildlife openings are maintained in early seral stage (grasses and forbs) they can serve as foraging areas and possible roosting areas can occur both in the woods (northern bats, eastern pipistrelles, species of *Lasiurus*) and along the edges (Indiana bats, northern bats, *Lasiurus*).

g. **Riparian management**: Bats use streams as flight paths from one place to another, particularly from roosts to foraging areas and back, and they often forage as they move along these pathways.

Significance of streams as foraging habitat: Some species of bats feed heavily over streams (Little brown bats, Gray bats are good examples) where they feed on midges and other flies associated with water, mayflies, and sometimes odonates (citations).

Streamside management zones (SMZs): Some streams have essentially no wooded area along their edges, and some have agricultural areas nearly to their shores. Other streams have a single line or few trees along their edges, whereas still others have a strip of bottomland woods along their edges. On public and industrial forests, SMZs are left in which harvesting is limited or absent (Wigley and Melchiors 1994). Particularly if they have large trees, SMZs provide excellent habitat for bats, as the streams themselves provide water and foraging areas for bats, the woods provide roosting habitat, much of it along edges, and the open areas beyond the forested strip provides foraging areas, especially if the open areas are of mixed types of open field. A good way to enhance bat habitat under some circumstances would be to plant native trees along waterways if they are not already present. Additional research is needed to determine the significance of SMZs to bats (e.g., Lloyd et al. 2006, O'Keefe 2009) and how wide SMZs should be to be most effective for bats (e.g., Lloyd et al. 2006).

Riparian forest is more productive than upland forest because it forms a natural flyway. Also, it generally has larger trees which favors better roosting habitat. The water and larger trees may support greater insect diversity and abundance (Gibbs et al. 2007), thus also benefitting bats.

h. **Ponds.** Ponds probably function similar to canopy gaps in that they are an opening where bats can fly with ease. In addition, ponds within forests may supply good foraging areas for bats. Ponds that occur in open areas, especially near forests supply a source of water and additional foraging habitat.

i. **Management activities that specifically target snags.**

Keeping snags in harvested areas: It is always good wildlife management practice to retain snags in forests. We suggest keeping them in clumps with buffers of live trees surrounding them. For safety and forest health, foresters often want to remove snags during harvest operations. However, large snags through woods, including snags near the edges, provide habitat for many forest species such as squirrels and raccoons, as well as bats. We know of one forest in which no Indiana bats were present. However, many of the larger trees were girdled and four years later Indiana bats had colonized the area. We would normally not recommend that trees be girdled for this purpose. If large trees and especially snags are left in forests, they will eventually fall (and add to the nutrients in the soil) and other larger trees will die and replace the snags that have fallen. Thus there should be an endless supply of such trees, which, if there are enough of them, will continue to provide roosting areas for bats. Uneven aged management strategies (shelterwood and group selection cuts) can result in this type of forest.

Creating snags (girdling or injecting): As we said above, we would not generally want to kill trees in order to produce bat habitat. In old forests, snags will continue to occur as trees die off and are replaced by new snags. Also, quite a bit of habitat has been created when previously low forest has been flooded. The trees die in that case, often providing dead trees with sloughing bark, and also hollow trees and trees with hollow limbs.

j. **Providing bat houses to serve as roosts.** Bat houses and other artificial roosts attached to tress are being used to enhance habitat for bats. Bat houses work best (at least in the east) for house bats i.e., big and little brown bats but also for northern bats. A large number of bat houses and other bat structures were established for Indiana bats as an experiment at the Indianapolis International Airport. It took about 10 years for any of them to be inhabited by Indiana bats, and then only about 5 were. However, many of these houses were often used by northern bats. Bat houses can be used in areas where adequate roosts are lacking, but then, will only work for certain species, and often it is some time before they are inhabited. However, the little brown bat is a species that can benefit from bat houses. It is declining in the east, radically so, in the northeast, due to White-nose syndrome. Artificial bat roosts attached to Ponderosa pines in the southwest were occupied by bats within one year, but they did not contain many bats (Mering and Chambers – no citation available yet). Species in the east that might most likely benefit from bat boxes are the Little brown bat, the big brown bat, the northern bat, and the Brazilian freetail bat. Other bats that have not been documented using bat houses but possibly could use them are the southeastern bat, Rafinesque's Big eared bat, and the little mastiff bat.

k. **Education.** Education might seem out of place in a paper on forest management of woodlands for bats. However, educating the public about bats and their benefits is one of the best ways to get people to think about helping to save bats and to provide permanent habitat for them.

Summary

Bats need summer and winter roosting areas, foraging areas including adequate food, water, and adequate means to migrate between summer and winter roosts. Managing forests for bats means providing for the above, this can be achieved through hands-off practices or via management strategies like timber harvesting, prescribed fire, creating ponds and other openings, and snag creation. Roads for vehicular traffic and logging roads can be beneficial to bats, serving as flyways. Bat houses or other artificial roost structures can be useful in areas where natural roosts are few or none. Finally, education of the public about the value of bats and how to preserve them can be a powerful tool to promote sustainable forest management strategies.

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PROTECTING THREATENED BATS AT COAL MINES:
A TECHNICAL INTERACTIVE FORUM
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