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TITLE: Indiana Bat Hibernacula Surveys

COOPERATING AGENCIES: U.S. Fish and Wildlife Service, Division of Federal Aid; Department of Conservation and Natural Resources, Bureau of State Parks; Pennsylvania Natural Heritage Program, Bucknell University, Temple University and The Nature Conservancy.

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ABSTRACT This report covers spring and fall trapping at entrances to hibernacula, as well as internal surveys conducted during the 2015 calendar year. The disease white-nose syndrome (WNS) has been a focus of investigation for staff across this time period and for the past several years. Currently, the Pennsylvania Game Commission considers all significant hibernacula to be infected across the state and the priority of searching for sites to verify disease has ceased since 2012. Since this time, our focus has switched to locating, monitoring, protecting, and investigating the survivors that do exist. Three WNS research projects were initiated in the fall of 2015 and progress into 2016. They investigate 1) the survival of juveniles and adults from experienced and naïve locations, 2) a treatment experiment using PEG 8000, and 3) measuring the arousal patterns of adult little brown (*Myotis lucifugus*) survivors. Analyses are not complete, but preliminary data suggests that juveniles from both sample groups experience a very high mortality rate, that PEG 8000 may be an effective tool at preventing infection acquired from roost structures, and arousal patterns of survivors are returning to pre-WNS levels. Following the 2015 internal surveys in Pennsylvania, 75 sites have confirmed WNS mortality, 69 of which have comparable survey effort both before and after WNS and are analyzed to determine overall as well as species-specific mortality. Using the most recent survey results following disease-induced mortality demonstrates inter-specific differences in mortality and an overall decline of 99.9% for all cave bats species combined. Species-specific mortality ranged from 33-99%. Members from the genus *Myotis* and genus *Perimyotis* are noted to be relocating into colder sites (38-40°F) where these species had never been observed previously (i.e. site 17-002) as well as shifting within sites to colder areas proximate to openings (i.e. site 14-009-M). We improved airflow and gated an abandoned mine (07-008) in Blair County, which resulted

in dropping internal temperatures from 53°F to 40°F, and provided temperatures suitable for these new preferences. At two sites monitored for both survival and infection rates, banded adults of little brown myotis and Indiana myotis (*Myotis sodalis*) were confirmed surviving WNS and returning to the same sites to hibernate annually, and displayed an increase in body mass in both fall and spring (Turner et al. in prep). Additionally, 100% of little browns captured in spring were infected as diagnosed by UV light (Turner et al. 2016). During the 2015 winter internal surveys, Pennsylvania Game Commission employees, other state employees, and volunteers visited 35 hibernacula and spent 357.5 hours finding and counting bats during internal surveys. Thirty two of the 35 sites contained bats. Of the 3 that had no bats, one site (07-004) was surveyed for the first time. For the other two (50-003 and 31-010), a 100% mortality due to WNS was noted, with the highest bat count and diversity among these two sites being 175 total bats and containing 4 species. Of the sites surveyed, 11 (31%) sites were used by at least one individual classified as a state or federally listed species. Eight sites contained ≥4 species of bats and only 4 (11%) sites contained ≥100 bats. The highest count for little brown bats during this survey year was 81 bats, with only 5 sites having ≥10 bats. The 35 interior surveys accounted for 6 species and 1,175 total bats. These included 243 little brown bats at 23 sites, 90 tri-colored bats (*Perimyotis subflavus*) at 24 sites, 787 big brown bats (*Eptesicus fuscus*) at 21 sites, 15 northern long-eared bats (*Myotis septentrionalis*) at 7 sites, 23 Indiana bats at 2 sites, and 10 small-footed bats (*Myotis leibii*) at 7 sites. During fall and spring trapping surveys, 13 surveys were performed at 5 hibernacula using harp traps placed at or near the entrance resulting in the capture of 171 bats including 143 little brown bats, 13 big brown bats, 0 northern long-eared bats, 3 tri-colored bats (formerly eastern pipistrelle), 10 small-footed and 2 Indiana bats. Site 40-007-N/T has had WNS for 7 seasons and is the largest remaining hibernacula known following WNS infection, and comprised 34.5% of the total bats captured at hibernacula trapping. Twenty Indiana bat hibernation sites are currently recognized within the state. These include 9 limestone mines, 6 limestone caves, 1 clay mine, 3 anthracite coal mines, and 1 railroad tunnel. One limestone mine (07-018M) is currently designated by the U.S. Fish and Wildlife Service as a Priority 2 Indiana bat hibernaculum; 3 are Priority 3 sites, and the remaining 16 sites are all Priority 4. Extant populations of Indiana bats are confirmed at only 3 of the 20 known hibernacula via harp trapping and/or internal surveys. One adult female Indiana bat banded in Berks County, Pennsylvania was found 418 miles to the Southeast in Carter County, Kentucky. This is the longest documented distance between a maternity colony and hibernaculum for this species.

OBJECTIVES

1. To inventory and examine any new site that has the potential to contain hibernating bats and to locate survivors of white-nose syndrome (WNS).

2. To assess the distribution of caves and mines used by bats, and to survey and monitor bat populations in these hibernacula.

3. To protect all hibernacula harboring special concern species, 4 or more species, and large bat populations.

4. To conduct research investigating the causative agent, transmission, detection, survival, and potential techniques to fight the spread and mortality associated with WNS.

5. To analyze the demographic and population changes that may occur as a result of WNS; specifically, to examine any attributes of survivors that provide clues to why individuals are surviving and

how to improve management for the survivors.

INTRODUCTION

In Pennsylvania, the construction and abandonment of mines and tunnels, along with high levels of human-induced disturbances in natural caves, have likely contributed to the relocation of most winter bat populations from caves to mines. Disadvantages of this shift include bats relocating into less stable hibernacula, making monitoring and protecting these hibernacula increasingly more difficult and labor intensive. Many manmade sites are structurally unsafe for internal surveys. Bats hibernating in unstable hibernacula are susceptible to mortality due to collapses, or reclamation of hazardous openings. Possible advantages resulting from bats spreading out into thousands of abandoned mines include lower predation and disturbance risks, possibly lower exposure thresholds to the pathogenic fungus causing White-nose Syndrome (WNS), and that with bats occupying so many different temperature and humidity regimes some sites may not be as conducive for fungal spread or growth.

There are over 2,000 recognized caves and over 4,000 mine openings in Pennsylvania. For decades, our management objective has been to search for new sites when possible and to monitor, no less than once every 5 years, those caves or mine openings that are classified as special concern hibernacula. In some instances, such as sites where bats roost over standing water, we may elect to monitor at lower frequencies to reduce the potential for incidental mortality that may occur as active bats disturb and dislodge torpid bats.

In order for a hibernaculum to be considered a special concern hibernaculum it must contain 1 of the following: either currently or historically, presence of a state or federally listed bat species, 4 or more species of bats, $\geq$1,000 bats historically or $\geq$25 total bats (excluding numbers of the big brown bat) currently, or an exceptional population of a special concern species. Following the point when mass mortality associated with WNS is over in the majority of Pennsylvania sites and many of the well-monitored sites have been assessed, these qualifications may need to be revised further. In addition to monitoring hibernating bats, the condition of the hibernaculum itself is assessed. Any change that might adversely affect the welfare of bats is noted (e.g., changes in airflow or temperatures, evidence of repeated entry by humans). If possible, special concern hibernacula are gated to exclude people, yet admit bats. Collecting baseline environmental data for all special concern hibernacula is also a priority.

White-nose Syndrome has quickly become the most devastating wildlife disease ever documented to impact Pennsylvania's native fauna. The North American epicenter lies just outside Albany, New York, where it was first photographed in Howe's Cave in February 2006 (Blehert et al. 2009). Following its assumed introduction to Pennsylvania via human-assisted movement during the 2007-2008 hibernating season, WNS has spread across Pennsylvania. The fungus *Pseudogymnoascus* [=*Geomyces*] *destructans* has been confirmed to be the causative agent of WNS (Lorch et al. 2011) and the disease is formally diagnosed in the laboratory by confirming the presence of characteristic skin lesions where *P. destructans* actively invades and digests live cells within the wing membrane or other areas of exposed skin with minimal hair (Meteyer et al. 2009). Currently, UV light provides a method to identify and collect small biopsy punches of lesions for further histological confirmation of disease, but in a non-lethal manner (Turner et al. 2014). Late-stage WNS impacts include altered electrolyte, water balance and blood chemistry (Cryan et al. 2010, 2013, Willis and Wilcox 2014, Verant et al. 2014), along with increased arousal patterns (Warnecke et al. 2012, Reeder et al. 2012) that ultimately result in a severely emaciated

condition at time of death (Blehert et al. 2009; Storm and Boyles 2011; Boyles and Willis 2010; Cryan et al. 2010). Although it is likely the fungus has been present in Europe for a very long time, photographic records extending back nearly 2 decades indicate WNS infected bats present through the entire period (Martinkova et al. 2010) and pre-dating documentation in the United States by at least 10 years. The European fungus has been shown to be practically identical in genetic sequence to the United States strains, further supporting Europe as the point source (Wibbelt et al. 2010). However, recent discoveries (Hoyt et al. 2016, Zukal et al. 2016) at multiple sites in Asia broaden the area from which the North American source could have come. With visible fungal conditions so rare in Europe, UV light has aided the confirmation of 11 infected European bat species (Zukal et al. 2014), but no mass mortality has been noted to date (Puechmaille et al. 2011). The recent introduction of the disease and reported clonal nature to North American hibernating bats demonstrates its high virulence to a naive population. An analysis of mortality at 42 North American sites that have had WNS infected bats for a minimum of 2 years but not exceeding 4 years indicates the regional mortality of all bats combined at these sites is 88% (Turner et al. 2011). There does appear to be species-specific variation in mortality (Turner et al. 2011) and some bats surviving infection (Turner, unpublished data). Unpublished data suggests that survivors are getting less infection annually and they are compensating for the increased arousals by increasing the storage of energy in fall. However, with the very low reproductive rate of bats, the high mortality of adults that is occurring from WNS and other factors, the long-term existence of these species within Pennsylvania will depend greatly on whether or not the juveniles born to these survivors will be passed a trait offering protection from the disease.

METHODS

Two techniques were used to assess the status of cave-roosting bats: 1) visual inspection of caves and mines for hibernating bats from December through March and 2) sampling of bats “swarming” at cave or mine entrances using harp traps or mist nets (Tuttle 1974) during spring (April to May) or fall (August to November). For each visit to a cave, tunnel or mine, a bat hibernaculum survey form was completed and all decontamination protocols were followed. All data was transferred to a Pennsylvania Game Commission bat hibernacula database.

At the end of the 2014-15 hibernating season the disease was confirmed in 25 states and 5 Canadian provinces, with detection of the fungus in a several other states where the disease has not been confirmed. Visible symptoms include: 1) presence of white fungus surrounding the muzzle, 2) white fungus on exposed skin, 3) bats that are unable to arouse several hours after initial disturbance, 4) bats flying within and exiting large hibernacula in the winter season, 5) bats flying in daytime in proximity to large hibernacula, 6) staging near the coldest locations (often near day-lighted areas of hibernacula) and 7) evidence of mass mortality. *Pseudogymnoascus destructans* had been identified as the causative agent, with diagnosis only coming from histological confirmation that the fungus has invaded the epithelial layer of the skin and has begun to digest live cells (Meteyer et al. 2011). To confirm a site in this manner, a collection of 2-3 live specimens must be euthanized and shipped refrigerated, overnight to the U.S. Geological Survey (USGS) laboratory. The first several sites in Pennsylvania were all confirmed via this method. Once Pennsylvania was confirmed and the symptoms were seen routinely in affected areas, the decision was made to call sites confirmed if 2 clinical signs were seen and mortality was noted. Before the end of the hibernating season, a protocol was issued by USGS and the U.S. Fish and Wildlife Service (USFWS) that recommended 1 site per county should be confirmed by histology; the protocol was followed after that time.

Entrance area examinations or abbreviated interior examinations that did not go much beyond the day-lighted area was 1 method used to confirm presence of the disease with minimal disturbance or contamination risk. Examinations at the entrances involved searching for daytime flying bats above ground level and searching for signs of mortality from the entrance perimeter to within the day-lighted section of the hibernaculum. Some sites associated with research or already confirmed with WNS received full surveys. Optimally, these occurred late in the hibernation season to minimize stress to infected individuals low on fat reserves and to overlap the timing with warmer weather periods, should that disturbance result in emergence from hibernation. Sites chosen for WNS surveys were prioritized by multiple characteristics including: research requests and needs, species presence and abundance within hibernacula, proximity to an affected area, the need to determine WNS distribution or at the request of the USFWS to examine the known movements of cavers from affected sites to clean sites.

Initial county-level confirmation typically occurs by euthanizing and shipping a specimen to the National Wildlife Health Center for histological analysis and necropsy. Field confirmation of contaminated sites in confirmed counties occurred by documenting clinical signs associated with the disease (i.e. fungus, daytime flying). Work continued to document the use of long wave ultraviolet (UV) light as a diagnostic and non-lethal tool for immediate indication of the disease. Because the wing membrane is thin, UV light passes through and causes the actual areas of lesions to fluoresce. The wing can be photo-documented in this manner, providing a much more reliable field sign than fungus visible under white light, as the fluorescence can last many days as opposed to several minutes for visible fungus.

RESULTS

Table 1 is an overview of the status of bats commonly hibernating in Pennsylvania and their summer habitat use. In addition to the endangered Indiana bat, Pennsylvania's special concern species include the state threatened eastern small-footed bat and the northern long-eared bat. The northern long-eared bat was designated as federally threatened in May 2015.

During winter 2015 internal surveys, Pennsylvania Game Commission employees, other state employees, and volunteers visited 35 different hibernacula and spent 357.5 hours finding and counting bats during internal surveys. Thirty two of the 35 sites contained bats. Of the 3 that had no bats, 1 site (07-004) was surveyed for the first time. The remaining 2 sites (50-003 and 31-010) represent a 100% decline with the highest total bat count among these sites at 175 bats and 4 species. Of the sites surveyed in 2015, 11 (31%) sites were used by at least 1 individual classified as a state or federally listed species (Indiana, small-footed, and N. long-eared). Eight sites contained $\geq$4 species of bats and only 4 (11%) sites contained $\geq$100 bats, with 3 of those having big brown numbers in >100 individuals. The 35 interior surveys accounted for 6 species and 1,175 total bats. These included 243 little brown bats (*Myotis lucifugus*) at 23 sites, 90 tri-colored bats (*Perimyotis subflavus*) at 24 sites, 787 big brown bats (*Eptesicus fuscus*) at 21 sites, 15 northern long-eared bats (*Myotis septentrionalis*) at 7 sites, 23 Indiana bats (*Myotis sodalis*) at 2 sites, and 10 small-footed bats (*Myotis leibii*) at 7 sites.

Following the 2015 surveys in Pennsylvania, 75 sites have confirmed WNS mortality and 69 of these have comparable survey effort both before and after WNS, have surveys conducted at least 2 years following the onset of mass mortality, and are subsequently analyzed to determine overall as well as species-specific mortality. Using the most recent surveys results for these 69 sites demonstrates inter-

specific differences in mortality and an overall decline of 99.9% for all cave bats species combined. However, species-specific mortality ranged from 33-99%. Members from the genus *Myotis* and genus *Perimyotis* are noted to be relocating to colder sites (38-40°F) where these species has never been observed previously (i.e. site 17-002), as well as shifting within sites to colder areas proximate to opening (i.e. site 14-009-M). At site (07-008) in Blair County, we had an opportunity to manipulate and gate the site. Specifically, we stabilized an air shaft and created a second, large sinkhole opening to both funnel cold air inside in winter and trap it inside in summer. These alterations reduced internal temps from 53°F to an average of about 40°F. At sites monitored for disease persistence via UV light, banded adults of both species are captured exiting in spring following infection, banded individuals are returning to the same sites to hibernate annually, and that every spring all captured *Myotis* are infected annually.

Twenty Indiana bat hibernation sites are currently recognized within the state. These include 9 limestone mines, 1 clay mine, 3 anthracite coalmines, 1 railroad tunnel, and 6 limestone caves (Fig. 1). The USFWS Indiana bat recovery plan categorizes Indiana bat hibernacula into 4 categories - Priority 1: >10,000 Indiana bats current or historic; Priority 2, >1,000-10,000 current or historic bats; Priority 3, 50-1,000 current or historic bats; and Priority 4, <50 bats current or historic (USFWS 2007). Of the 20 sites, 1 limestone mine is a Priority 2 Indiana bat hibernaculum, 4 are Priority 3 hibernacula, and the remaining 15 are all Priority 4. The high count of Indiana bats for the Priority 2 mine after the site was gated in 1986 is 765, with the Priority 3 and 4 sites ranging from 1 to 139 Indiana bats. Movement of banded Indiana bats has been confirmed, with 2 bats banded at Canoe Creek prior to WNS being found in post-WNS timeframes hibernating; 1 at site 56-012 in 2012 and 1 in Hellhole cave in Pendleton County, West Virginia. Additionally, a bat captured during spring emergence and banded prior to WNS at site 56-012 was also found in Hellhole Cave during the same survey as above. Most recently, a bat banded at its maternity colony in Berks County, Pennsylvania was found hibernating in Carter County, Kentucky in 2015 (Fig. 2). The 418 mile distance between the summer and winter grounds represents the largest movement known for this species

At the end of 2015, extant populations of the endangered Indiana bat are confirmed at 3 sites previously documented with populations of Indiana bats. Within 7 years of WNS being first confirmed in Pennsylvania (2008-09 winter), it has been documented in 18 of the 20 known sites harboring the federally listed species. Of these 18 sites, 16 sites have been surveyed internally following at least 1 year of confirmed WNS mortality. At these 16 sites, only 2 sites are confirmed occupied by Indiana bats, with a total of 23 Indiana bats following WNS mortality. Table 3 lists the original and most recent survey for the 8 Indiana bat sites sampled during the period covered by this report.

During fall and spring trapping surveys, 13 surveys were performed at 5 hibernacula using harp traps placed at or near the entrance resulting in the capture of 171 bats including 143 little brown bats, 13 big brown bats, 0 northern long-eared bats, 3 tri-colored bats (formerly eastern pipistrelle), 10 small-footed and 2 Indiana bats. Site 40-007-N/T has had WNS for 7 seasons and is the largest remaining hibernacula known following WNS infection, and comprised 34.5% of the total bats captured at hibernacula trapping. The property containing the opening of this site is currently in the process of being purchased. Site 40-007-N/T and site 07-018-M are both sites of long-term monitoring of survivors. Analysis of the demographic data has not been completed to date, but several preliminary findings can be reported. First, we continued to record the presence of Indiana bats at three mines known to have contained them in the past. Second, through banding, we have documented specific individuals persisting at this site. Third, the average body mass of surviving adult bats has increased significantly in both the fall and spring periods.

Fourth, preliminary analysis of infection load via UV photography of bats emerging in spring, the amount of fluorescent load decreases annually after just 5 years, appears to have gone from an area covering about 45% of their wing membrane to an area covering about 10%. Additionally, 100% of the little brown bats captured during emergence have been infected with WNS since each site was contaminated (7 and 6 years, respectively).

As of this reporting period, surveys for WNS in Pennsylvania have resulted in 75 sites in 27 counties are confirmed to be contaminated, but surveys for the sole purpose of seeking confirmation of WNS have ceased for years. Since 2012, we presume that every bat site has been contaminated by the causative agent of WNS. Multiple factors such as the timing of introduction, humidity, temperature, total number and species composition of bats, and loading dose likely play a large role in first year mortality. Following recommendations in Turner et al. 2011, we analyze mortality only following a second confirmed season. Following 2015 surveys, we analyzed the mortality by species and overall declines at 69 sites (Fig. 3) with comparable survey effort before and following confirmation of WNS mortality. Following the 2015 surveys in Pennsylvania, the total bat mortality for all species combined was -99.9%. Differential survival is noted, with big browns and small-footed bats displaying declines of 33.3% and 36.8%, respectively, when compared to the averaged counts for these species from all prior surveys before WNS (n = 374 surveys). Mortality for the other 4 species is more severe, with little brown bats declining 99.5%, long-eared bats declining 99.2%, Indiana bats declining 76.4%, and tri-colored bats declining 98.8%. Site 56-012 stood out as having a 99% decline overall, but only a 28% decline of Indiana bats and unique among the 20 sites with Indiana bats. Due to the lower initial counts for this site and shorter duration of surveys, the average number of Indiana bats for this site declined. However, this factor is not solely responsible for lower decline in this species, as it now contains the greatest number of surviving Indiana bats as well (Table 3). Small-footed and big brown bat counts are typically smaller sample sizes with high variation that appears correlated to average temperature of the winter, with very cold winters having the highest counts. Hence, we took the conservative approach of averaging all surveys before WNS to yield the most accurate changes in these populations that could be ascertained, but still caution reading too much into the declines for these 2 species. This approach may yield more accurate declines for these 2 species, but yield more conservative declines for the other 2 species.

Following WNS expanding to all known significant hibernacula in Pennsylvania, the focus of the Game Commission and its research has been on survivors. To that effect, 3 new WNS research projects were initiated in 2015 and wrapped up in 2016. Analyses for these 3 projects are underway, but some key preliminary findings can be discussed briefly here. The first study, was investigating the survival of both juvenile and adult age classes among male little brown bats from 2 populations, 1 naïve population from Pierce County, Wisconsin and 1 experienced population from Ulster County, New York. For this study, it was evident that juveniles from both populations are highly susceptible to WNS, and it seems apparent that survival of juveniles in the wild is low. A second project examined the use of PEG 8000 as a means to apply directly to bats as well as to apply to roosting structures to inhibit or prevent spores from germinating and infecting hibernating bats. This substance applied to wings of bats via a liquid substrate did not result in preventing bats from becoming infected, but application to the roost structure did prevent infection. The third study examined arousal patterns of adult little brown bats at a site that has been contaminated for 6 years. The arousal patters of the half dozen bats that were downloaded, indicate that these patterns have returned to rates similar as those before WNS arrived.

DISCUSSION

Some researchers hypothesize that the more robust big browns are responsible for the majority of the spread from site to site when the vector is a bat. However, unpublished UV sampling (Turner, unpublished) show only a proportion of big browns become infected, and none heavily infected. With near 100% of the little browns being heavily infected, along with them comprising over 90% of all hibernating bats historically, it would seem these species are more likely the ones responsible for the majority of site-to-site spread. These species have also been documented to swarm at multiple hibernacula. Therefore, it would seem more plausible that the more abundant species, with significantly higher fungal loads when emerging in the colder seasons, are the primary vector in the spread of WNS. If this hypothesis is correct, there may be density-dependent factors for this species that may affect regional spread to, and once present, within a hibernacula. Supporting evidence for this theory may be seen as WNs spreads westward into areas with a lower abundance of both little brown bats and lower use of caves and mines by this species.

During surveys of sites with infected bats, we commonly see little brown bats with a lot of visible fungus. We see tri-colored and northern long-eared bats with fungus at a much lower frequency. To date, we have seen a single Indiana bat potentially with some minor fungus and have never seen an eastern small-footed or big brown bat with any fungus or displaying any clinical signs. We have confirmed 5 of the 6 species dead from WNS in Pennsylvania, with a dead eastern small-footed and a dead Indiana bat being found just outside of WNS-confirmed sites. Both of these species were UV positive. The species in which we have not confirmed any direct mortality to date is the big brown. With on-going UV research, we have confirmed this species does incur infection, but at a much lower degree. Investigations to confirm that there is a difference in mortality and growth rate of the fungus on different bat species may prove valuable in the future.

Some small sites, such as 44-008 and 44-027, single-year declines of 99.9% were observed, while other sites of similar population size (44-011 and 44-009) declined 80-85% in the first year. By the second year following site contamination, the declines were consistent with other, smaller sites. Thus, for some large sites it appears to take at least 2 years of mortality to approach the point where the mortality rate slows. Multiple factors such as density, site size, humidity, and timing of the initial loading dose are likely factors influencing this first year variation.

RECOMMENDATIONS

1. Continue to survey bat hibernacula, concentrating on previously unsurveyed mines and caves. The emphasis should be on those sites with environmental conditions conducive to habitation by the federally endangered Indiana bat and the state threatened eastern small-footed bat. Most new surveys will focus on abandoned manmade structures, such as mines and tunnels.

2. Continue to update the winter bat hibernacula survey database. Maintain separate databases (or distinct fields in a single database) for mist netting and trapping at or near hibernacula entrances, and for bat surveys in summer habitat that are at least 0.5 km away from the entrance to known hibernacula.

3. Review the Hibernacula Management Plan; specifically revise the implementation schedule for possible inclusion in the annual report, increase its utility as a working document, and include recommended buffer sizes for protection from large-scale industrial or residential development

4. Continue to revise survey and reporting protocol for bat-sampling permits issued through the Pennsylvania Game Commission. Revisions made to date reflect conditions tailored to wind energy development and decontamination protocols for WNS.

5. Both male and female Indiana bats should be radio-tagged during fall pre-hibernation swarming to determine habitat use near hibernacula. Female Indiana bats should be radio-tagged when captured emerging in spring to identify locations of maternity colonies.

6. White Nose Syndrome sites should be monitored to follow the changes in hibernating populations across time, to examine potential transmission mechanisms. Monitoring should incorporate attempts to prevent the future spread to clean sites, if possible.

7. Sites with WNS survivors should be monitored to determine if the same individuals are returning in subsequent years, to see if these survivors are still getting infected each winter, and to see if any demographic changes have occurred as a result of WNS (i.e. sex ratio, body mass).

8. Sites with WNS survivors should be monitored to determine if juveniles are being born and to determine the over-winter fate of these juveniles after their first exposure to WNS.

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Table 1. The status and primary/secondary roosts of bats commonly hibernating in Pennsylvania.

Species	Common Name	Status[a]	Primary/Secondary Summer Roosts
Myotis lucifugus	little brown bat or little brown myotis	Common[b*]	Manmade structures/trees
Myotis septentrionalis	northern long-eared bat or northern long-eared myotis	Federal threatened[a]	Trees/manmade structures
Myotis leibii	small-footed bat or small-footed myotis	State threatened[a*]	Trees/rocks/highway rock-cuts or manmade structures
Myotis sodalis	Indiana bat or Indiana myotis	Federal endangered[a]	Trees/manmade structures
Eptesicus fuscus	big brown bat	Common	Manmade structures/trees
Perimyotis subflavus	Tri-colored or Eastern pipistrelle	Common[b*]	Trees/manmade structures

[a] Special concern species.

[b] Nominated for state endangered listing by the Pennsylvania Biological Survey and submitted to the Pennsylvania Game Commission for evaluation.

*USFWS petitioned to list federally, formal decision to not list the small-footed announced in 2014 and threatened status announced in May 2015 for the northern long-eared bat

Table 2. Date, type of hibernacula, person hours, and bat species observed during 2015 winter surveys.

Site Code	Survey Date	Hiber Type	Person Hours	Species: Indiana	Small-Footed	Little Brown	Long-Eared	Big Brown	Tri-Colored	Total: Bats	Species
07-049	06-Jan-15	LM	0.47	0	0	0	0	5	0	5	1
07-005-M	06-Jan-15	LM	0.67	0	0	2	0	5	3	10	3
07-004	06-Jan-15	LM	0.33	0	0	0	0	0	0	0	0
40-002	07-Jan-15	RR	8.75	0	0	0	0	26	2	28	2
17-002	09-Jan-15	RR	32	0	0	40	4	213	1	258	4
13-003	12-Jan-15	CM	14	0	0	3	0	0	4	7	2
18-008-M	13-Jan-15	OM	7.75	0	0	0	0	0	1	1	1
56-004-M	16-Jan-15	LM	16.5	0	1	2	2	266	15	286	5
56-005	29-Jan-15	LM	30.75	0	0	3	2	8	8	21	4
37-001	04-Feb-15	LM	12.9	0	0	0	0	0	1	1	1
50-003	04-Feb-15	RR	3	0	0	0	0	0	0	0	0
37-005-M	05-Feb-15	LM	13.4	0	0	4	0	4	4	12	3
37-004-M	06-Feb-15	LM	16	0	0	1	0	0	3	4	2
37-010-M	06-Feb-15	LM	1	0	0	1	0	4	0	5	2
07-018-M	09-Feb-15	LM	19.1	8	1	54	1	1	4	72	6
56-012-M	10-Feb-15	RR	21.6	15	0	1	0	0	1	17	3
29-004-M	11-Feb-15	LC	7.5	0	0	0	0	1	1	2	2
09-001-M	12-Feb-15	LM	13.5	0	1	5	0	1	6	13	4
09-004	12-Feb-15	OS	0.4	0	0	0	2	0	0	2	1
67-003-M	17-Feb-15	OM	3.5	0	0	2	0	1	1	4	3
67-006-M	17-Feb-15	OM	4.6	0	0	1	0	0	0	1	1
44-017-M	20-Feb-15	LC	3.85	0	0	2	0	0	5	7	2
18-006-M	21-Feb-15	LC	18.2	0	0	11	0	0	1	14	2
26-002-M	23-Feb-15	LC	12.2	0	0	1	0	3	5	9	3
26-009-M	24-Feb-15	LC	33	0	0	0	0	15	1	16	2
65-004-M	26-Feb-15	LC	8.3	0	0	8	0	0	0	8	1
44-009-M	27-Feb-15	LC	6	0	1	4	1	13	4	23	5
29-001	03-Mar-15	OS	12.5	0	0	0	0	22	0	22	1
26-027-M	05-Mar-15	OM	8.8	0	0	3	0	123	1	127	3
26-034	05-Mar-15	SC	0.13	0	0	0	0	6	0	6	1
31-010-M	06-Mar-15	LC	1.75	0	0	0	0	0	0	0	0
31-017-M	06-Mar-15	LC	3.5	0	2	1	0	10	0	13	3
31-001-M	07-Mar-15	LC	15	0	1	81	3	10	13	110	5
07-018-M	12-Mar-15	LM	4.5	0	0	10	0	0	1	11	2
14-032-M	16-Dec-15	RR	2	0	3	3	0	50	4	60	4
		Total	357.45	23	10	243	15	787	90	1175	

[a] First pair of numbers refers to county, second is the hibernaculum of record for the county, and the "M" indicates the hibernaculum is periodically monitored.

Table 3. Records for 2015 surveys of documented Indiana bat (*M. sodalis*) hibernacula.

Site Code[a]	Survey Date	Year Gated	First PGC Survey Total Year	Bats	M. sodalis	2015 PGC Survey Total Bats	M. sodalis	Site Ownership
37-005-M	05-Feb-15	2005	1994	3	0	99	0	PVT
56-004-M	16-Jan-15		1993	336	0	286	0	PVT
56-012-M	10-Feb-15	2012	1999	2202	23	17	15	DOT
07-005-M	06-Jan-15	2000	1985	1	0	10	0	PGC
44-009-M	27-Feb-15	1998	1986	162	0	23	0	PVT
07-018-M	09-Feb-15	1988	1987	3656	297	72	8	DCNR
26-027-M	05-Mar-15	2000	1996	3031	0	127	0	PVT
31-001-M	07-Mar-15	1981	1985	117	0	110	0	PVT

[a] First pair of numbers refers to county, second is the hibernaculum of record for the county, and the "M" indicates the hibernaculum is periodically monitored.

Table 4. Mist net and harp trap bat surveys at the entrances of hibernacula during 2015.

Site Code	Date	Site Type	Trap Hours	Species: Little Browns	Long-Eared	Small-Footed	Indiana	Big Brown	Tri-Colored	Total Bats	Total Species
07-018-M	01-Apr-15	Mine	285	1	0	1	0	3	0	5	3
40-007-N/T	03-Apr-15	Mine	300	10	0	5	0	2	0	17	3
07-018-M	06-Apr-15	Mine	300	14	0	2	0	0	1	17	3
40-007-N/T	09-Apr-15	Mine	225	2	0	0	0	2	0	4	2
07-018-M	13-Apr-15	Mine	270	36	0	2	1	1	1	41	5
13-003-M	14-Apr-15	Mine	270	9	0	0	0	0	0	9	1
40-007-N/T	15-Apr-15	Mine	300	5	0	0	0	1	0	6	2
07-018-M	27-Apr-15	Mine	150	1	0	0	0	0	0	1	1
07-018-M	05-Oct-15	Mine	300	19	0	0	1	0	0	20	2
07-018-M	06-Oct-15	Mine	240	14	0	0	0	0	1	15	2
40-007-N/T	07-Oct-15	Mine	315	28	0	0	0	4	0	32	2
14-001-M	13-Oct-15	Cave	300	0	0	0	0	0	0	0	0
44-018-M	14-Oct-15	Cave	300	4	0	0	0	0	0	4	1
		Total	3555	143	0	10	2	13	3	171	

[a] Site code same as referred to in previous table; N/T refers to site codes within the Netting and Trapping Database only. N/T sites have never been entered during winter hibernacula surveys due to safety or size limitations.

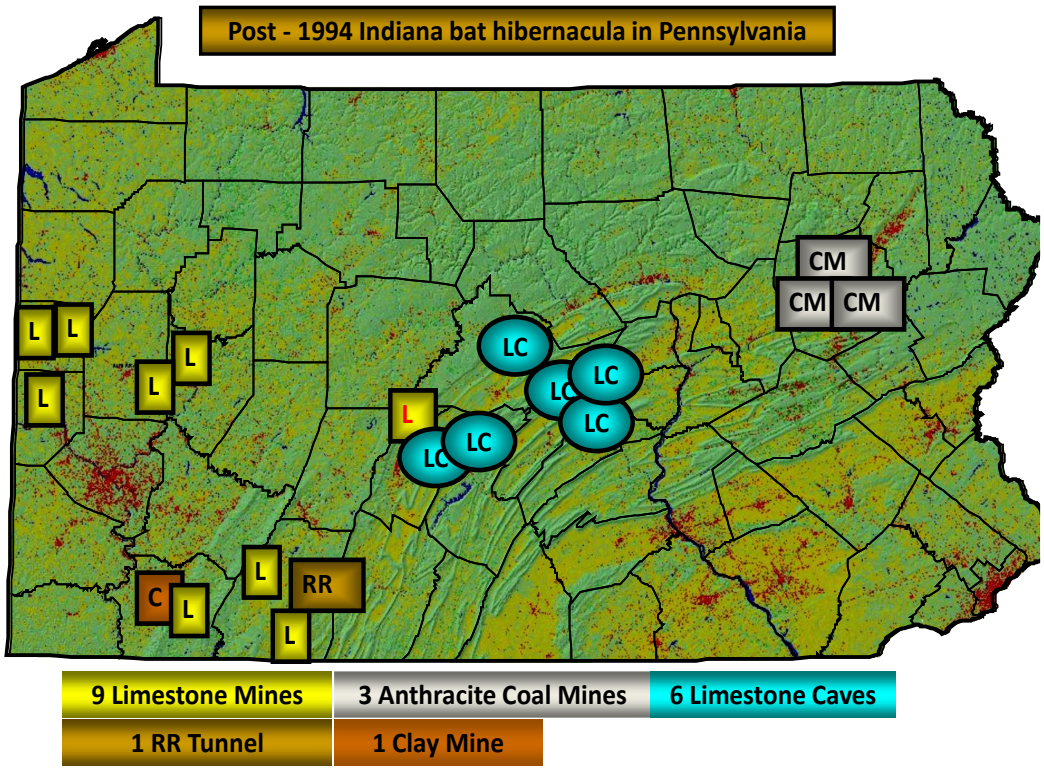

Figure 1. Location and hibernacula type for 20 Indiana bat hibernacula in Pennsylvania. The limestone mine in red and located in Blair County is Pennsylvania's only Priority 2 hibernaculum.

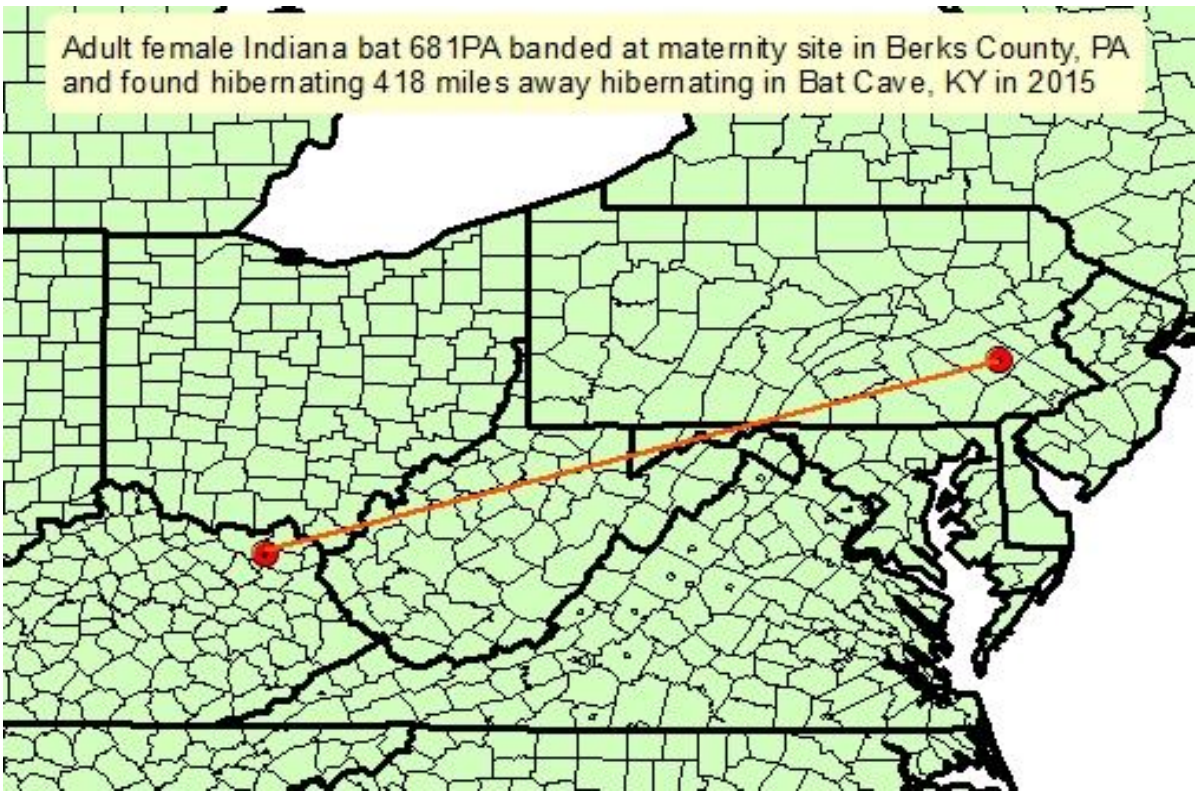

Figure 2. Straight line distance of 418 miles between summer banding location of Indiana adult female 681 PA and its recovery in hibernation surveys in 2015 in Carter County, Kentucky.

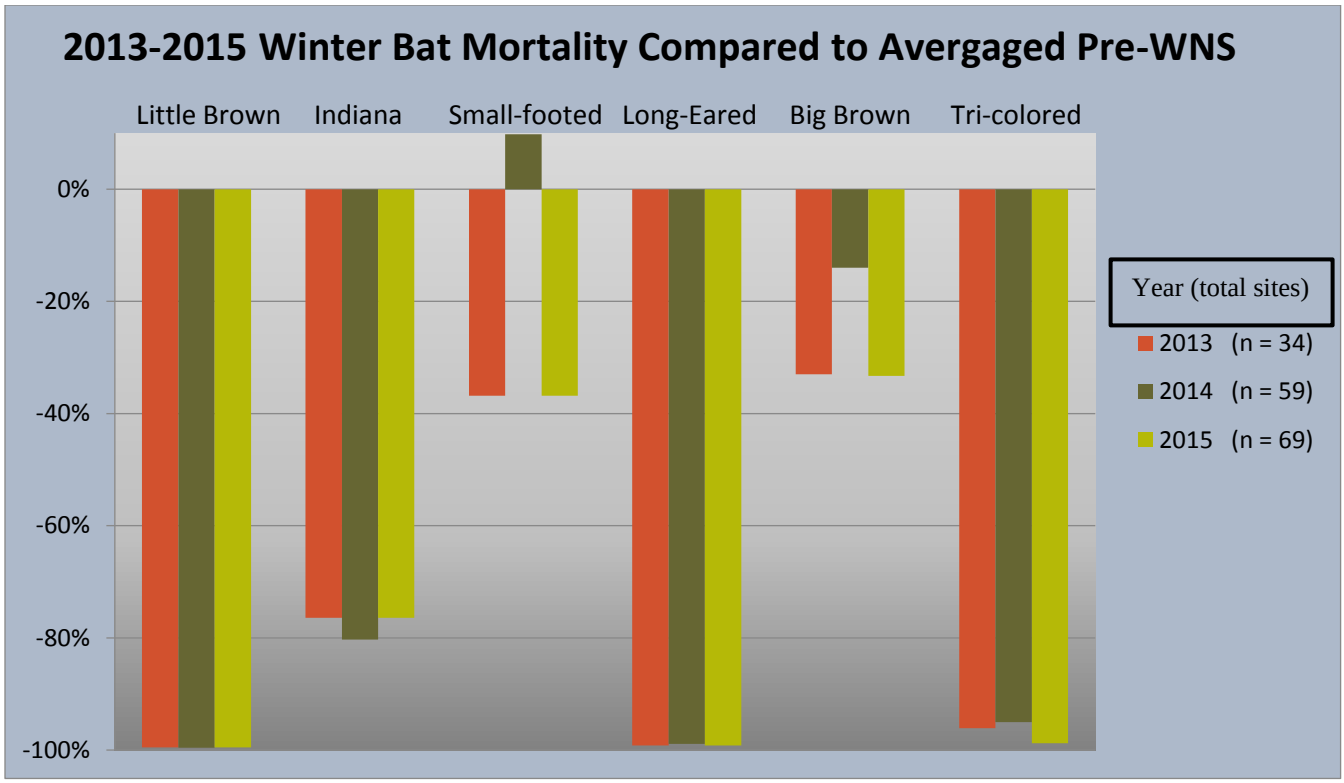

Figure 3. Cumulative declines of 6 cave-hibernating bat species using the most recent survey per site, with each site having at least 2 years of disease-induced mortality and multiple surveys prior to site contamination. All surveys before WNS are averaged and compared to the most recent surveys.