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White-Nose Syndrome in Bats: An Overview of Current Knowledge for Land Managers

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Photographs

Cover: Inspecting bat's wing for damage.
(Photo by Ann Froschauer, U.S. Fish and Wildlife Service)

Facing page: White-nose syndrome fungus.
(Photo by Al Hicks, N.Y. Department of Environmental Conservation)

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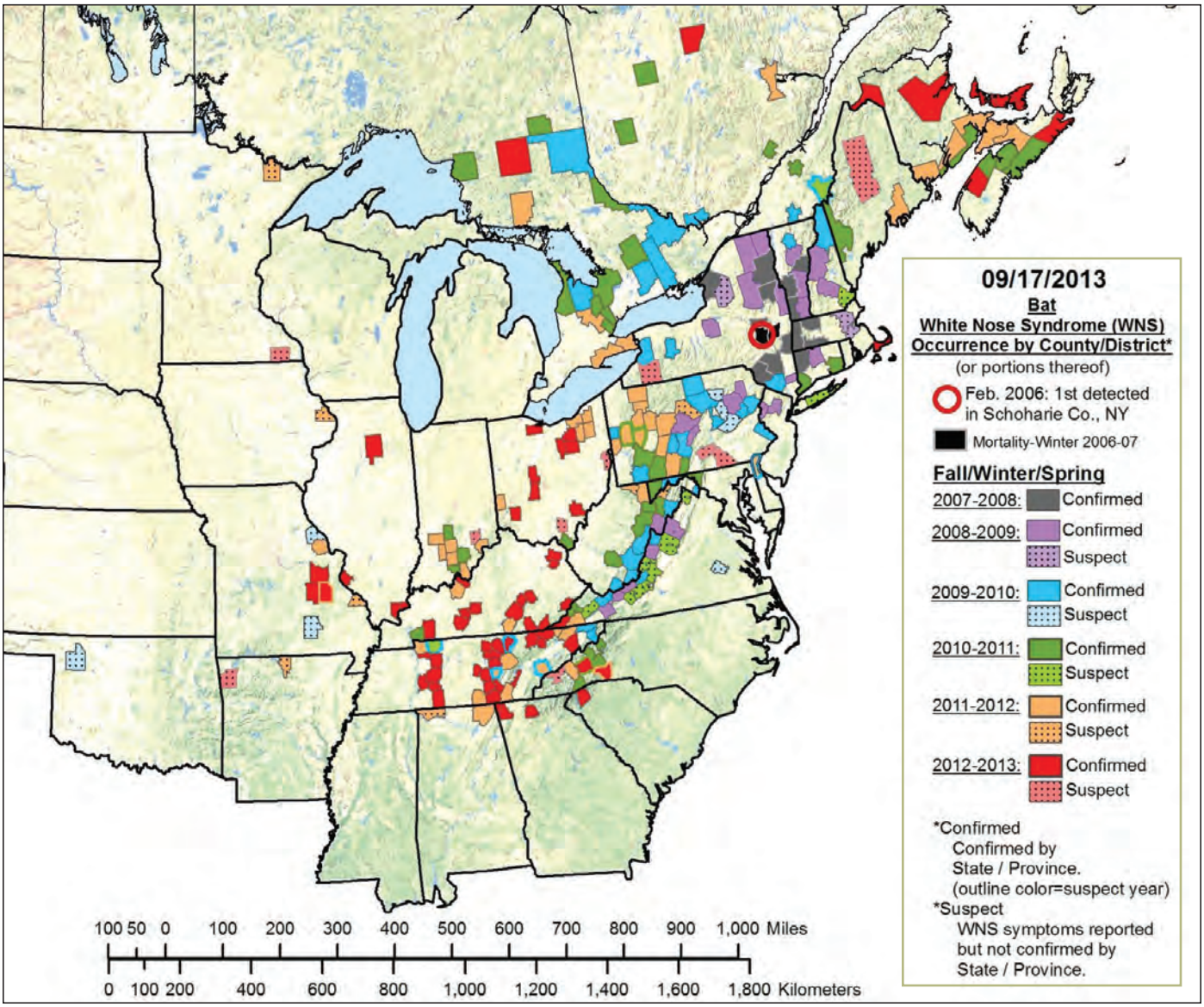
Counties where white-nose syndrome has been identified from 2006 to present. (Map by Carl Butchkoski, PA Game Commission)



ABSTRACT

White-nose syndrome recently emerged as a disease affecting bats that hibernate in caves and abandoned mines during winter. This disease is caused by the fungus *Pseudogymnoascus destructans*, and has caused the death of millions of bats in the Eastern United States and Canada. This fungus grows in relatively cold conditions with high humidity, which makes many caves, abandoned mines, and other underground structures optimal growing sites for the disease during winter. A number of treatments for combating white-nose syndrome have been tested, but practical and effective treatments for the disease—for individual bats and/or their hibernacula—have not yet been found. At present, one of the primary management goals is to slow the spread of the disease while researchers work to find effective tools to combat it. Activities that monitor and slow the spread, reduce additional stresses on bat populations, and educate the public are some of the few tools currently available to managers to address white-nose syndrome.

Keywords: Bats, caves, management, mines, *Pseudogymnoascus destructans*, white-nose syndrome.

IMPORTANCE OF BATS

Bats play an important role in ecosystems; they are a major consumer of night-flying insects, including mosquitos and insect pests of forests and agricultural lands. It is estimated that insect consumption by bats provides billions of dollars in savings each year to the agricultural industry (Boyles and others 2011). Although the effects of substantial declines in bat numbers are not fully known, the loss of millions of bats in the Northeast and mid-Atlantic regions since 2006 has likely had substantial ecological and economic impacts in those areas.

EMERGENCE OF WHITE-NOSE SYNDROME

White-nose syndrome (WNS) recently emerged as a disease in hibernating bats of North America. There is no evidence that humans and domestic animals are susceptible to WNS, but this disease has caused the death of millions of bats, and has affected the endangered Indiana bat *(Myotis sodalis*) (USFWS 2012). In bat hibernation sites infected with WNS, up to 95 percent of susceptible bats may eventually die (Frick and others 2010). Because of the severity of this pathogen, species that were once considered secure may become endangered or regionally extirpated (Frick and others 2010). Since its emergence around 2006, WNS has spread at a rate of about 200 miles per year and is now found approximately 1,000 miles west of the original location where it was first detected. WNS affects bats during their winter hibernation period, and it currently affects only those bats that hibernate in caves, mines, tunnels, or similar structures. Updated maps tracking the spread of WNS can be found at http://whitenosesyndrome.org/resources/map.

WNS is caused by the newly discovered fungus *Pseudogymnoascus destructans*, which was previously classified as *Geomyces destructans* (Minnis and Linder 2013). This fungus is associated with cold temperatures. It is found in caves of Europe, where it occurs on bats but does not appear to cause the widespread mortality that it causes in North America (Puechmaille and others 2011). Although the exact origin of *P. destructans* in North America is unknown, it is believed that the fungus may have been introduced to a "show" cave in New York State by a tourist prior to 2006, when it was first documented (Blehert and others 2011).

Little brown bat with white-nose syndrome. (Photo by Marvin Moriarity, U.S. Fish and Wildlife Service)

Since its emergence around 2006, WNS has spread at a rate of about 200 miles per year and is now found approximately 1,000 miles west of the original location where it was first detected.

WINTER HIBERNATION BY BATS

During winter when insects are not available, many bat species hibernate in caves where the temperatures are cold, but above freezing [around 36–50 °F (2–10 °C)] (Perry 2013). During hibernation, bats survive on stored fat that was accumulated the previous late-summer and fall. To save energy, bats lower their metabolism and reduce their body temperatures close to that of their surroundings, with cold, but above-freezing temperatures providing the greatest energy savings (Hock 1951). During hibernation, bats may experience a suppressed immune system (Bouma and others 2010), which likely makes them more susceptible to fungal, viral, and bacterial infections.

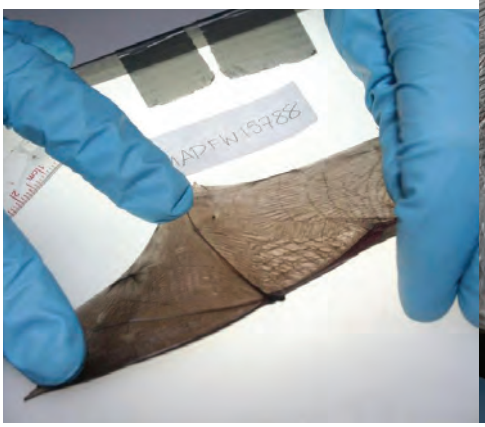
P. destructans grows best at temperatures around 40–64 °F (4.4–17.8 °C) and high humidity (Verant and others 2012); these conditions are similar to those found in suitable bat hibernation sites during winter. During summer, many species of cave bats roost in trees or other structures. Females of some species use caves during summer, but usually roost in warmer caves [generally 56–86 °F (13–30 °C)] or different areas of the same cave where they produce their offspring. However, males of some species may remain in hibernation caves during summer (Hall 1962). Nevertheless, it is believed that the warmer temperatures of summer roost caves and tree roosts, along with the active status of bats (and increased immune responses) may not support substantial growth of *P. destructans* on bats during summer. The fungus may persist during summer in some colonies, but at lower levels (Dobony and others 2012).

Bats may be infected without the visible signs and may display unusual behavior such as leaving the cave during freezing weather or clustering near cave entrances.

EFFECT OF *P. DESTRUCTANS* ON BATS

The fungus grows on the skin of bats and invades their tissues (Blehert and others 2009). The disease irritates the skin, creates holes in their wings, and may lead to dehydration (Cryan and others 2010). Bats with WNS awaken more frequently than normal from hibernation and may deplete their stored fat before insects become widely available in the spring (Reeder and others 2012). The fungus may also cause lethal damage to bat tissues during winter (Cryan and others 2010). Mortality rates of some bat species, such as little brown bats (*Myotis lucifugus*) and tri-colored bats

RIGHT: Fungus on the wing of a little brown bat. (Photo by Ryan von Linden, N.Y. Department of Environmental Conservation)
BELOW: Researcher inspecting bat's wing for damage. (Photo by Ann Froschauer, U.S. Fish and Wildlife Service)



TOP: Scientist inspecting bat's wings for damage. (Photo by Ann Froschauer, U.S. Fish and Wildlife Service) BOTTOM: Characteristic white fungal growth on bat suffering from white-nose syndrome. (Photo by Pete Pattavina, U.S. Fish and Wildlife Service)

(*Perimyotis subflavus*), may be greater than other species (such as big brown bats, *Eptesicus fuscus*) (Turner and others 2011)—but it is currently unknown if this is a result of differences in behavior (temperature or humidity of sites selected for hibernation) or differences in physiological or immune response among different bat species (Cryan and others 2010).

Signs and Symptoms

Visible signs of WNS are white patches on exposed skin such as wings, forearms, ears, and noses; light-colored patches or holes in the wings often occur. However, bats may be infected without the visible signs and may display unusual behavior such as leaving the cave during freezing weather or clustering near cave entrances. Dead bats at cave entrances or nearby during winter may also be a sign of the disease. It is important to note that bats may be in the early stages of infection or be carrying the spores with no apparent symptoms. Thus, other diagnostic tools, such as skin swabs for microscopic analysis and culturing spores, or genetic tests that look for the fungus, may be needed to definitively confirm the presence of *P. destructans*, especially in the early stages of the disease.

MANAGEMENT: CURRENT STATE OF KNOWLEDGE

Although research has made significant strides over a short period in our understanding of this new disease and its impacts on bats, information that can be used directly by managers to help control it is still lacking or speculative. The primary management goal at this time is to slow the spread of WNS to give biologists time to find workable solutions for this disease crisis before it spreads throughout the continent. Biologists also want to ensure that the actions taken to combat WNS will not add additional stresses to bat populations or have detrimental effects on other cave organisms where bats are found.

How WNS is Spread

- **BAT TO BAT: The fungus that causes WNS is most likely spread during contact between bats.**
- **CAVE TO BAT: Bats entering infected caves or mines may pick up the spores.**
- **HUMAN TO CAVE: Humans may be able to transport the spores on clothing, boots, or equipment from infected caves to unaffected caves.**
- **HUMAN TO BAT: Exposing bats to equipment that has come in contact with the fungus, such as unsterilized gloves, nets, or holding facilities could transfer the spores to unaffected bats.**

RIGHT: A gated and partially flooded abandoned mine used as hibernacula for southeastern myotis (*Myotis austroriparius*) and tri-colored bats. BELOW: Many caves are gated to protect the cave resource and prevent humans from disturbing bats.

Cave Closures to Slow Down Spread

Bat-to-bat contact is likely the primary way in which the fungus spreads. However, humans entering caves, mines, or other hibernation sites have the potential to pick up fungal spores and translocate them. It has been shown that equipment (including clothing) used in infected caves may be contaminated with the spores of the fungus. Although relatively short-distance spread of the disease is likely attributed to the natural migrations and movements of bats (e.g., Norquay and others 2013), longer-range movements of the disease could be facilitated by humans, especially to areas of the Western United States where the fungus and disease are not currently known to occur. Therefore, many Federal and State agencies have closed caves on their lands to the public to slow down the spread of WNS. The scientific consensus is that clothing or equipment used in caves located in States where WNS is known to occur should not be used in currently non-affected regions. Because *P. destructans* could be present in caves or mines even though there is no visible evidence of WNS, most agencies require decontamination by their personnel after exit from caves or mines. Current decontamination procedures are available at http://whitenosesyndrome.org/topics/decontamination.

Monitoring and Reporting

Monitoring the spread of WNS provides important information to researchers and other managers, and identifying WNS-positive sites that have not been previously reported is important information for State wildlife agencies and the U.S. Fish and Wildlife Service.

Monitoring caves, abandoned mines, or other hibernacula may involve entering these sites. Effective monitoring of caves or mines for the presence of WNS typically occurs near the end of the hibernation period (February to March, depending on how far north the sites are) when the growth of the fungus is most detectable on bats and dead bats that have not survived hibernation are evident. Some bat species (e.g., tri-colored bats) often remain attached to cave walls after death, making their mortality less obvious. Monitoring that includes cave or mine entry should be coordinated with State wildlife agency personnel prior to initiation to avoid redundancy and unnecessary disturbance to bats.

During winter, bats naturally arouse from hibernation at intervals from days to weeks, and these arousals account for the majority of winter energy use (Thomas and Geiser 1997). However, people entering caves or mines during hibernation may cause unneeded arousals in bats (Thomas 1995), which could lead to additional use of vital fat stores. Therefore, frequent and unnecessary disturbances to hibernating bats may add additional stresses to already stressed populations.

BELOW: Solar powered acoustic monitoring (SPAM) device used to monitor bats. BOTTOM: A biologist inspects bats in a cave. (Photos by Ann Froschauer, U.S. Fish and Wildlife Service)

Land managers should be familiar with all applicable Federal, State, and local laws; agency regulations; and safety risks prior to engaging in management activities that include entering caves or mines. A number of Federal and State laws may pertain to caves and bats, such as the Federal Cave Resources Protection Act and the Federal Endangered Species Act. State wildlife agencies typically have the statutory authority to manage bats, but the U.S. Fish and Wildlife Service also has statutory authority for endangered bats. Thus, any monitoring should be coordinated with these agencies. Caves or mines that harbor endangered species may have additional limitations on the frequency or timing of entry as determined by the U.S. Fish and Wildlife Service. Landowners and land managers may be restricted from disturbing endangered bats during critical times such as the maternity or hibernation periods, as that may be considered "take" of endangered species by the U.S. Fish and Wildlife Service,[1] and entering caves or mines during these times is believed to "harm" those species.

Entering abandoned mines, and to a lesser extent caves, may pose dangers to personnel, including toxic or explosive gasses, low oxygen, collapse or trapping hazards, falling dangers, and steep drop-offs (Tuttle 2003); these sites should only be entered by experienced and trained personnel using proper personal protective equipment. Because of the potential dangers associated with abandoned mines, some agencies have specific regulations regarding personnel and qualifications of individuals entering abandoned mines. Further, many State and Federal agencies require their personnel, cooperators, and permit holders to use appropriate, disinfected personal protection equipment when entering caves or mines.

Some evidence for the presence of WNS can be obtained without entering hibernation sites, such as noting the presence of dead bats at the entrance, or bats flying around the entrance during cold winter periods. Additional information can be collected using ultrasonic bat recorders at cave or mine entrances during winter to determine if bats are exhibiting unusual behavior such as exiting during cold periods. Non-wildlife professionals should not handle bats (alive, sick, or dead) because of the potential risk of rabies infection; anyone handling bats must have been vaccinated for rabies and have current, sufficient titers.

[1]The term "take" means to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 USC § 1538 and 1532).

A biologist taping her boot in preparation for conducting a WNS survey in a mine. (Photo by Gary Peeples, U.S. Fish and Wildlife Service)

Importance of bats

- **Bats are the second most diverse group of mammals (behind rodents), with over 1200 species. Simmons (2005).**
- **A single insectivorous bat may consume thousands of insects each night, resulting in billions of dollars in savings to the agriculture industry each year.**
- **Bat droppings serve as the basis of the food chain in many cave ecosystems. Harris (1970).**
- **In the desert Southwestern U.S., bats are major pollinators of cacti and agaves. Cole and Wilson (2006).**

Managing Infected Caves

Currently, there are no practical treatments for hibernation sites or bats infected with *P. destructans*. Once a cave is infected with *P. destructans*, the cave may harbor the fungus in cave sediments, but it is unknown for how long (Lorch and others 2013). The ability of the fungus to be transferred in the air of a cave is unknown, but preliminary research suggests this may be limited (Lorch and others 2011). Cave environments are complex ecosystems, containing diverse arrays of fungi, bacteria, invertebrates, and other organisms, many of which have not been identified by scientists. Furthermore, many caves harbor Federally endangered species (such as fish and crayfish) that might be impacted by broadcast spraying of fungicides or other chemicals, which further limits treatment and management options. Because many hibernation sites are large and complex cave systems, widespread treatments may also be impractical. Infected bats entering the cave may reintroduce spores of this fungus and could re-infect a cave soon after it is disinfected.

Treating only the spots where bats hibernate in the cave with fungicide will not likely affect fungal growth if one individual bat carrying the spores enters the cave and clusters with other bats, as they often do in midwinter. Experiments are currently under way that are evaluating alternative hibernation structures such as decommissioned military bunkers or artificial caves that have controlled temperatures and that can be more easily disinfected (e.g., Brunkhurst and others 2011).

Treating infected individuals with anti-fungal agents is being tested, but the results of those studies are thus far inconclusive. Moreover, some antifungal agents and medications have been shown to be toxic to bats (Robbins and others 2012). Treatments using other chemicals (e.g., vinegar) have been examined but their effectiveness has not shown promise (Meteyer and others 2011). Currently, multiple studies are being conducted that are examining different native fungal and bacterial species that could potentially be used as biocontrol agents. Possible vaccines against the disease are also being studied (Osorio and others 2012). However, it is unknown if some individual bats within a species may be more immune to WNS due to their genes or their specific behaviors, and treating individuals could reduce the passing of resistant genes or behaviors to future generations.

Public Education

A key goal of WNS management is educating the public about the importance of bats and the potential for spread of this disease by transferring fungal spores, especially across long distances. In areas where caves are closed to the public, it may be beneficial to post signs around cave entrances explaining the reasons for these closures. Communicating the clinical signs of WNS to animal control professionals, caving groups, and the public—as well as what to do if they suspect WNS—may also help monitor the spread of the disease. A brochure on WNS suitable for public dissemination is available at http://static.whitenosesyndrome.org/sites/default/files/resource/battle_for_bats_update-7-30.pdf.

Habitat Management to Reduce Additional Stresses to Populations

Locations of many sites used by bats for hibernation, including many caves and abandoned mines, are unknown. Thus, identifying and protecting these sites may provide additional secure hibernation habitats. Protecting known bat hibernacula via gating may also reduce unnecessary disturbance to bats. It may also be important to identify and protect caves that currently do not support bats because we do not yet understand how climate change may affect those cave microclimates in the future. Detailed information on gating of caves and mines can be found at http://www.mcrcc.osmre.gov/MCR/Resources/bats/pdf/Bat_Gate_Design.pdf and http://www.batcon.org/pdfs/sws/AgencyGuideCaveMineGating2009.pdf.

Reducing disturbance at maternity sites may reduce stresses on populations. For species that use caves or mines during summer to raise their offspring, protecting those sites is also important. For species that produce their offspring in forests, it may be beneficial to reduce activities that may disturb bats (such as timber harvest or burning) near maternity sites during the summer reproductive periods.

Bats that have greater fat accumulation at the onset of hibernation could have better survival. Consequently, abundant optimal habitats during summer and fall may help maximize the fat accumulations of bats and could potentially reduce mortality from WNS. Although regions differ in forest type and bat species present, reviews on forest management for bats in different areas can be found in Hayes (2003), Fisher and Wilkinson (2005), Hayes and Loeb (2007), and Perry (2012).

In areas containing endangered species such as Indiana bats, guidance on forest management surrounding hibernation and maternity sites is provided by the U.S. Fish and Wildlife Service and may be obtained from their field offices. Many national forests have guidelines in their forest plans concerning activities and timing of those activities in areas where endangered bats occur. On these lands, buffer zones may be established around caves used by endangered bat species where activities such as logging and burning may be restricted. Consultation with the U.S. Fish and Wildlife Service may be required before certain activities can be conducted by federal agencies in these zones. There may also be guidelines on summer activities in areas where endangered bats occur. For example, the U.S. Fish and Wildlife Service recommends limiting the cutting of trees and prescribed fire to between December 1 and April 15 to minimize the risk of "take" during summer within the range of the Indiana bat.

An abandoned mine gated for public safety and to protect hibernating bats.

Some bats species that were once relatively abundant are declining quickly due to WNS and may soon be added to the Federal endangered species list.

CONCLUSIONS

Although ongoing research has shed light on the causes, spread, and effects of WNS on bats, management recommendations to combat the disease are still in their infancy. In light of these limitations, biologists hope to slow the spread of the disease long enough to come up with effective treatments and management before the disease spreads across the continent. Additional information, including the national response plan, state response plans, and the latest updates on the disease can be found at http://whitenosesyndrome.org/.

Little brown bats with white-nose syndrome.

Once the most common bat in the Northeastern U.S., the little brown bat may be extinct in that region within the next 15 years.

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LITERATURE CITED

Blehert, D.S.; Hicks, A.C.; Behr, M. [and others]. 2009. Bat white-nose syndrome: an emerging fungal pathogen? Science. 323: 227.

Blehert, D.S.; Lorch, J.M.; Ballmann, A.E. [and others]. 2011. Bat white-nose syndrome in North America. Microbe. 6(6): 267-273.

Bouma, H.R.; Carey, H.V.; Kroese, F.G. 2010. Hibernation: the immune system at rest? Journal of Leukocyte Biology. 88(4): 619-624.

Boyles, J.G.; Cryan, P.M.; McCracken, G.F.; Kunz, T.H. 2011. Economic importance of bats in agriculture. Science. 332(6025): 41-42.

Brunkhurst, E.; Von Oettingen, S.; Philibosian, S. 2011. Can bunkers be refuges from WNS for hibernating bats? Preliminary results from New Hampshire. Abstracts of presented papers and posters for the 2011 White-Nose Syndrome Symposium, May 17-19, 2011. Little Rock, AR. http://whitenosesyndrome.org/sites/default/files/resource/2011wnssymposiumabstracts.pdf. [Date accessed: September 2013].

Cole, F.R.; Wilson, D.E. 2006. *Leptonycteris yerbabuenae.* Mammalian Species. 797: 1–7.

Cryan, P.M.; Meteyer, C.U.; Boyles, J.G.; Blehert, D.S. 2010. Wing pathology associated with white-nose syndrome in bats suggests life-threatening disruption of physiology. BMC Biology. 8: 135.

Dobony, C.A.; Langwig, K.E.; von Linden, R.L. [and others]. 2012. White-nose syndrome: lessons learned at Fort Drum Military Installation. Abstracts of presented papers and posters for the 5th Annual White-Nose Syndrome Symposium, June 4-7, 2012. Madison, WI: . http://whitenosesyndrome.org/sites/default/files/resource/wns_symposium_abstracts_2012_final.pdf. [Date accessed: September 2013].

Fisher, J.T.; Wilkinson, L. 2005. The response of mammals to forest fire and timber harvest in the North American boreal forest. Mammal Review. 35(1): 51-81.

Frick, W.F.; Pollock, J.F.; Hicks, A.C. [and others]. 2010. An emerging disease causes regional population collapse of a common North American bat species. Science. 329(5992): 679-682.

Hall, J.S. 1962. A life history and taxonomic study of the Indiana bat, *Myotis sodalis*. Scientific Publication 12. Reading, PA: Reading Public Museum and Art Gallery. 68 p.

Harris, J.A. 1970. Bat-guano cave environment. Science. 169: 1342–1343.

Hayes, J.P. 2003. Habitat ecology and conservation of bats in western coniferous forests. In: Zabel, C.J.; Anthony, R.G., eds. Mammal community dynamics: management and conservation in the coniferous forests of western North America. New York: University of Cambridge Press: 81-119.

Hayes, J.P.; Loeb, S.C. 2007. The influence of forest management on bats in North America. In Lacki, M.J.; Hayes, J.P.; Kurta, A., eds. Bats in forests: conservation and management. Baltimore, MD: Johns Hopkins Press: 207-235.

Hock, R.J. 1951. The metabolic rate and body temperature of bats. Biological Bulletin. 101(3): 289−299.

Lorch, J.M.; Lindner, D.L.; Gargas, A. [and others]. 2013. A culture-based survey of fungi in soil from bat hibernacula in the Eastern United States and its implications for detection of *Geomyces destructans*, the causal agent of bat white-nose syndrome. Mycologia. 105(2): 237-252.

Lorch, J.M.; Meteyer, C.U.; Behr, M.J. [and others]. 2011. Experimental infection of bats with *Geomyces destructans* causes white-nose syndrome. Nature. 480: 376-378.

Meteyer, C.U.; Valent, M.; Kashmer, J. [and others]. 2011. Recovery of little brown bats (M*yotis lucifugus*) from natural infection with *Geomyces destructans*, white-nose syndrome. Journal of Wildlife Diseases. 47(3): 618-626.

Minnis, A.M.; Lindner, D.L. 2013. Phylogenetic evaluation of *Geomyces* and allies reveals no close relatives of *Pseudogymnoascus destructans*, comb. nov., in bat hibernacula of Eastern North America. Fungal Biology. 117(9): 638-649.

Norquay, K.J.O.; Martinez-Nuñez, F.; Dubois, J.E. [and others]. 2013. Long-distance movements of little brown bats (*Myotis lucifugus*). Journal of Mammalogy. 94(2): 506-515.

Osorio, J.E., B. Stading, D. S. Blehert, [and others]. 2012. Potential vaccine for white-nose syndrome and other bat diseases. Abstracts of presented papers and posters for the 5th Annual White-Nose Syndrome Symposium, June 4-7, 2012. Madison, WI (abstract). Available at: http://whitenosesyndrome.org/sites/default/files/resource/wns_symposium_abstracts_2012_final.pdf. [Date accessed: September 2013].

Perry, R.W. 2012. A review of fire effects on bats and bat habitat in the eastern oaks region. In: Dey, D.C.; Stambaugh, M.C.; Clark, S.L.; Schweitzer, C.J., eds. Proceedings of the 4th Fire in Eastern Oak Forests Conference. Gen. Tech. Rep. NRS-P-102. Newton Square, PA: U.S. Department of Agriculture Forest Service: 170-191.

Perry, R.W. 2013. A review of factors affecting cave climates for hibernating bats in temperate North America. Environmental Reviews. 21: 28-39.

Puechmaille, S.J.; Wibbelt, G.; Korn, V. [and others]. 2011. Pan-European distribution of white-nose syndrome fungus (*Geomyces destructans*) not associated with mass mortality. Plos One. 6(4): e19167.

Reeder, D.M.; Frank, C.L.; Turner, G.G. [and others]. 2012. Frequent arousals from hibernation linked to severity of infection and mortality in bats with white-nose syndrome. Plos One. 7(6): e38920.

Robbins, A.; Tseng, F.; Beck, E. [and others]. 2012. Enhancing survival of WNS infected bats; update on antifungal treatment trials. Abstracts of presented papers and posters for the 5th Annual White-Nose Syndrome Symposium, June 4-7, 2012. Madison, WI. http://whitenosesyndrome.org/sites/default/files/resource/wns_symposium_abstracts_2012_final.pdf. [Date accessed: September 2013].

Simmons, N.B. 2005. Order Chiroptera. In: Wilson, D.E.; Reeder, D.M., eds. Mammal species of the World: a taxonomic and geographic reference. 3rd ed. Vol. 1. Baltimore, MD: Johns Hopkins University Press: 312-529.

Thomas, D.W. 1995. Hibernating bats are sensitive to nontactile human disturbance. Journal of Mammalogy. 76(3): 940-946.

Thomas, D.W.; Geiser, F. 1997. Periodic arousals in hibernating mammals: is evaporative water loss involved? Functional Ecology. 11: 585-591.

Turner, G.G.; Reeder, D.M.; Coleman, J.T.H. 2011. A five-year assessment of mortality and geographic spread of white-nose syndrome in North American bats and a look to the future. Bat Research News. 52: 13-27.

Tuttle, M.D. 2003. Estimating population sizes of hibernating bats in caves and mines. In: O'Shea, T.J.; Bogan, M.A., eds. Monitoring trends in bat populations of the United States and territories: problems and prospects: Information and Technology Report USGS/BRD/ITR-2003-0003. Fort Collins, CO: U.S. Geological Survey, Biological Resources Discipline: 31-39.

U.S. Fish and Wildlife Service (USFWS). 2012. North American bat death toll exceeds 5.5 million from white-nose syndrome. USFWS News Release. January 17, 2012. http://static.whitenosesyndrome.org/sites/default/files/files/wns_mortality_2012_nr_final_0.pdf. [Date accessed: September 2013].

Verant, M.L.; Boyles, J.G.; Waldrep, W., Jr. [and others]. 2012. Temperature-dependent growth of *Geomyces destructans*, the fungus that causes bat white-nose syndrome. Plos One. 7(9): e46280.

Little brown bat with white-nose syndrome. (Photo by Jonathan Mays, Maine Department of Inland Fisheries and Wildlife)

What can managers do now?

- **Protect and reduce disturbances at winter hibernation and summer roost sites used by bats.**
- **Follow the national WNS decontamination protocols @http://whitenosesyndrome.org/topics/decontamination to disinfect clothing, footwear, and equipment when entering caves or mines.**
- **Provide optimal foraging and summer roosting habitat in forests for bats.**
- **Monitor bats, and report bats showing symptoms of WNS to your State wildlife agency.**
- **Help educate the public about WNS—its signs and symptoms—and the importance of bats.**

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To File an Employment Complaint
If you wish to file an employment complaint, you must contact your agency's EEO Counselor within 45 days of the date of the alleged discriminatory act, event, or in the case of a personnel action. Additional information can be found online at http://www.ascr.usda.gov/complaint_filing_file.html.

To File a Program Complaint
If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at http://www.ascr.usda.gov/complaint_filing_cust.html, or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter to us by mail at U.S. Department of Agriculture, Director, Office of Adjudication, 1400 Independence Avenue, S.W., Washington, D.C. 20250-99410, by fax (202) 690-7442 or email at program.intake@usda.gov.

Persons with Disabilities
Individuals who are deaf, hard of hearing or have speech disabilities and you wish to file either an EEO or program complaint please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

Persons with disabilities who wish to file a program complaint, please see information above on how to contact us by mail directly or by email. If you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.) please contact USDA's TARGET Center at (202) 720-2600 (voice and TDD).