

White Nose Syndrome in the United States

Andrew Caven¹, Michael T. Mengak², and Karl V. Miller³

General Overview

White Nose Syndrome (WNS) is a condition responsible for the death of over 5.7 million bats in the contiguous United States within the last decade. The name “White Nose Syndrome” comes from the characteristic white fungal growth appearing on the ears, wings, and nose of infected bats (Figure 1). The fungal growth covers skin membranes and hair follicles where it breaks down the epidermal layer and then penetrates into deeper tissues. The fungus responsible is named *Geomyces destructans*.

WNS was first documented in February 2006 in a photograph by a caver exploring Howes Cave about 30 miles west of Albany, NY. The disease was subsequently found in other caves in New York and surrounding states. Currently, WNS has been confirmed in 15 states, 3 Canadian provinces, and is suspected in 2 additional states (Figure 2) including much of the Appalachians and west to Missouri and Oklahoma. The disease continues to spread rapidly. As new information becomes



Figure 1a-left. Picture of a little brown bat (*Myotis lucifugus*) infected with White Nose Syndrome (WNS).

Figure 1b-right. Spots on bat wing membrane caused by the white-nose fungus.

Source Greg Turner, Pa. Game Comm. & USFWS website.

¹Graduate Student, ²Professor - Wildlife Specialist, and ³Professor - Wildlife Management , Warnell School of Forestry & Natural Resources, University of Georgia, Athens, GA 30602

griseus), the cave myotis (*M. velifer*), and the southeastern myotis (*M. austroriparius*) have tested positive for *G. destructans* without exhibiting the characteristic infection. However, there is some evidence that the southeastern myotis (*M. austroriparius*) may show clinical signs of WNS. Thus, there are likely 7 species of North American bats currently afflicted with WNS.

Despite differing opinions offered to describe the etiological role of *G. destructans* in WNS, there is no definitive explanation for the current outbreak. The fact that the fungus does not kill some North American bat species fails to negate the “novel pathogen theory”. Non-lethal infections may result from climate associations that limit the fungus’s virulence.

Fungal Character of *G. destructans*

Geomyces destructans is a psychrophilic (cold loving), in-vitro proteolytic (breaks down the proteins), and keratinophilic (affinity for keratin, a major component of skin and hair) fungus, able to breakdown skin tissues in cold damp environments. *G. destructans* can be cultured at temperatures from 37° F (3° C) to 68° F (20° C), although optimal growth occurs between 41°-50° F (5° -10° C). All hibernacula where WNS has been detected have annual temperatures varying seasonally between 35° and 57° F (2°-14° C).

Ribosomal gene sequence (RNA) analyses put the fungus associated with WNS into the genus *Geomyces*. Despite this categorization, *G. destructans* differs from other fungi in its genus. For example, *G. destructans* produces morphologically distinct asymmetrically curved conidia (non-motile spores) distinct from other species in the *Geomyces* genus. *Geomyces destructans* also differs from other cold-loving (psychrophilic) fungi existing in the Arctic, Antarctic, and permafrost zones of Russia. There are no known pathogens among other members of the genus.

Spread of WNS

White-nose syndrome was first discovered in the winter of early 2006, and by mid-summer of 2010 the WNS disease, or the fungus associated with it, could be found in Connecticut, Delaware, Massachusetts, Maryland, Missouri, New Hampshire, New Jersey, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia, and the Canadian Provinces of Ontario and Quebec.

Preliminary studies suggest that the disease is spread “bat-to-bat” and “cave-to-bat.” Humans also may be transporting the fungus from habitat to habitat. The rate of spread and distribution of WNS are anecdotal evidence of a possible human factor in the disease movement. Large leaps in the spread have occurred, which do not match natural bat migration patterns. These jumps carried the fungus to Missouri in 2009 while leaving Kentucky unaffected until 2011. Furthermore, when WNS is detected in new geographical areas it has usually been found first in recreational caves. Fungal spores of *G. destructans* have been isolated on clothing and caving gear used in affected sites.

Despite the likelihood that humans are aiding the spread of WNS, humans are not likely the primary vectors of the disease. Bat-to-bat transmission likely accounts for the majority of the disease transmission within caves. Bats are highly social and often exhibit allogrooming, such as nose rubbing, which may push the fungal infection deeper into bat skin tissues.

Impact of WNS

There are over 1,000 bat species in the world. They account for nearly one out of every five mammalian species. Bats provide many ecosystem services including pollination, seed dispersal, and insect control. The loss of these important creatures would alter the ecosystems that they inhabit.

Furthermore, even if populations of all bat species persist through the initial losses produced by WNS, bat populations will recover slowly due to their naturally low reproductive rates.

Because WNS is a new phenomenon, estimates of the average losses in infected hibernacula vary widely, but all estimates are high. Hibernacula populations in all infected species have declined an average of 75% within 2 years of being affected, with losses ranging between 30 and 100% for different hibernacula. Currently, White Nose Syndrome affects only “cave-bats”, especially those species that share large maternity roosts. Some bat species utilize trees instead of caves for torpor periods. Tree-bats have not yet been found to contract WNS.

Because of its susceptibility to WNS, the forecast for the long-term survival of the endangered Indiana bat is not good. However, almost all of the bats species in the Northeast face potential extinction as a result of WNS. Based on data over the last 30 years, there is a high probability of extinction of *M. lucifugus* (little brown bat) although it is the most abundant bat in the Northeast United States. Before White-nose Syndrome, little brown bat population numbers were estimated at 6.5 million bats in the Northeastern regional population. However, given the current rate of decline there is over a 99% chance that the little brown bat will be regionally extinct within the next 20 years

Hibernation and Bat Immunology

Of the 46 species of bats that occur in the United States, more than 50% hibernate during winter. These bats are overwhelmingly insectivores. Hibernation is a series of torpor phases in which metabolism is depressed and body temperature is lowered. Torpor periods are separated by relatively brief periods of arousal. To save fat reserves these bats lower their metabolic rate and body temperature to very low levels. All bat species thus far affected by WNS are hibernators.

White-nose Syndrome can disturb normal patterns of arousal from torpor during hibernation. These repeated arousals cause bats to burn fat reserves too quickly to survive the winter. Hence, emaciation and a lack of fat stores are common symptoms of WNS. Bats that deplete fat reserves are often forced out of torpor to look for food in the winter.

Torpor reduces the number of circulating white blood cells - called leukocytes - by up to 90% in small mammals. Leukocytes are an important part of the immune responses. Neutrophils are specific leukocytes that are a component of the immune response to infection which recognizes foreign bodies or antigens and attacks them. Neutrophils and lymphocytes are retained in the gut, spleen, and lungs during hibernation thereby leaving external tissues' immune response weakened. During arousal periods, the immune system releases neutrophils and lymphocytes back into the blood stream. However, the lymphocytes only increase to about 50% of summer values in the blood stream during arousal. Bats infected with WNS frequently demonstrate no sign of inflammation, which is suggestive of suppressed immune function.

Scientific Interventions to Stop WNS

One of the major processes by which WNS induces mortality is starvation. A potential method of reducing bats starvation and therefore mortality is to create small, well-insulated, heated boxes for bats in WNS afflicted hibernacula. When bats arise from torpor they naturally find a warm spot in their hibernacula to increase their metabolic rate and raise body temperature. Raising the ambient temperature for bats during arousal periods may help bats conserve energy and avoid starvation. Computer models suggest that creating heat enclaves with a temperature of 82° F (28° C), could increase survival rates by as much as 75%. Although the heated enclaves' method has not yet been practically tested it shows potential.

Other potential methods of conserving WNS infected bat populations include the use of “non-invasive” anti-fungal treatments of bats and their hibernacula. Anti-fungal treatments to individual animals can avoid the potentially negative ecological impacts of applying blanket fungicides to caves. Researchers are investigating one anti-fungal drug “terbinafine” that will effectively boost survival rates among infected bats. However, this treatment is time consuming and costly and it may prove not to be a viable method to halt bat population declines. Various fungi are common in caves and mines and such a treatment could disrupt the beneficial relationships fungi have with their cave ecosystems.



Coordinated Response

Federal and state agencies are leading a coordinated response to counteract the spread of WNS. The cooperation of conservation organizations and the caving community has been essential to its implementation. The main actions thus far taken include cave closures, issuing voluntary decontamination protocols for cavers, funding research, and monitoring bat populations. On July 27, 2010 the Rocky Mountain Region of the US Forest Service issued an emergency order to “close all caves and abandoned mines on National Forests and National Grasslands in the Rocky Mountain Region.” This action was taken preemptively, as there has yet to be any confirmed cases of WNS in the Rocky Mountains, or the neighboring plains. However, *Geomyces destructans* has been located on bats within 300 miles of Colorado in Northwestern Oklahoma. In 2009, the Forest Service closed their caves in the Northeastern and Southeastern United States when it became clear that humans were a conduit through which the disease could be spread. The efforts to restrict cave access by the Forest Service have been matched by the dedication of conservation organizations such as the Northeastern and Southeastern Cave Conservancies.

Managing the anthropogenic transmission of WNS is dependent upon effective communication with, and engagement of, the caving community. Some state agencies provide decontamination protocols, information on regional caves and infection status, information on statewide bat populations, independent research, and statewide management plans.

The decontamination protocol includes recommendations to geographically isolate equipment, chemical treatments for clothing and gear to eliminate fungal spores and fungal materials after each use, and other general practices to prevent WNS transmission. Current (March 2012) decontamination procedures and state cave closure information can be accessed via the Internet at <http://www.fws.gov/WhiteNoseSyndrome/cavers.html>.

Cooperation between state and federal agencies will be very important in the effort to handle WNS. Federal agencies, such as the USGS National Wildlife Health Center (NWHC), have the scientific expertise and technology to perform diagnostic tests. State agencies have regional knowledge and the ability to coordinate people locally. The initial confirmation of WNS in Tennessee is an example the importance of communication and cooperation between state and federal agencies. The TN Wildlife Resources Agency suspected the presence of WNS and submitted samples to the USGS NWHC, which eventually confirmed the diagnosis. The result of this finding was a TN bat monitoring effort partially coordinated at the state level, which includes non-governmental, as well as state and federal agency biologists.

State and federal agencies also are providing grants to academic institutions to answer specific questions about WNS's treatment and prevention. The National Plan for Managing White-Nose Syndrome focuses on creating a system of information management that would ideally aid in the coordination and production of scientific information on WNS. The plan has several cooperating parties including 7 national agencies, 6 states, and 1 Native American Indian Tribe.

Further Reading

Bat Conservation International. 2012. White-nose Syndrome. <http://www.batcon.org/index.php/what-we-do/white-nose-syndrome.html> Accessed 22 June 2012.

National Geographic Daily News. 2010. "Deadly Bat Fungus Spreading in U.S.: White-Nose Syndrome Confirmed Farther South and West." By Ken Than, February 16, 2010.
Retrieved at: <http://news.nationalgeographic.com/news/2010/02/100216-bats-white-nose-fungus-tennessee/>

National Speleological Society. 2012. White Nose Syndrome Page. <http://www.caves.org/WNS/>. Accessed 22 June 2012.

Science Daily. 2009. White-Nose Syndrome Death In Bats: First Prevention Proposed by Ecologists. March 5, 2009. <http://www.sciencedaily.com/releases/2009/03/090305102709.htm>

US Fish and Wildlife Service. 2012. White-Nose Syndrome: A devastating disease of North American bats. Current News. <http://www.fws.gov/whitenosesyndrome/> Accessed 22 June 2012.

US Geological Survey (USGS). 2012. National Wildlife Health Center - White-Nose Syndrome (WNS). http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/. Accessed 22 June 2012.

Warnell School of Forestry and Natural Resources
Athens, Georgia 30602-2152
Telephone 706.542.2686 Fax 706.542.8356

In compliance with federal law, including the provisions of Title IX of the Education Amendments of 1972, Title VI of the Civil Rights Act of 1964, Sections 503 and 504 of the Rehabilitation Act of 1973, and the Americans with Disabilities Act of 1990, the University of Georgia does not discriminate on the basis of race, sex, religion, color, national or ethnic origin, age, disability, or military service in its administration of educational policies, programs, or activities; its admissions policies; scholarship and loan programs; athletic or other University-administered programs; or employment. In addition, the University does not discriminate on the basis of sexual orientation consistent with the University non-discrimination policy. Inquiries or complaints should be directed to the director of the Equal Opportunity Office, Peabody Hall, 290 South Jackson Street, University of Georgia, Athens, GA 30602. Telephone 706-542-7912 (V/TDD). Fax 706-542-2822.