US FOREST SERVICE NORTHERN RESEARCH STATION

Research *Review*

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National Interagency Team Mobilizing To Tackle White-Nose Syndrome of Bats

Northern Research Station (NRS) scientists are helping unravel the mysteries of white-nose syndrome (WNS), a fungal disease devastating bat populations in eastern North America. Bats are a vital component of many ecosystems, eating billions of insects, including mosquitos and crop pests. Many bat species could be facing extinction due to the rapid spread of this cold-loving fungus, *Geomyces destructans*, previously unknown to science. Several bat species at risk from WNS are federally designated endangered species, including the Indiana bat (*Myotis sodalis*), gray bat (*Myotis grisescens*), and Virginia big-eared bat (*Corynorhinus townsendii virginianus*).

WHITE-NOSE SYNDROME—A NEW DISEASE

This newly emerging disease is called white-nose syndrome because it was first noticed as white "fuzz" on the noses and faces of hibernating bats. The disease was first recorded during the winter of 2006-2007 in Howe Caverns near Albany, NY, a "show cave" developed for tourists. This cave contains a large underground river, making it particularly cold and extremely damp. Since its discovery, the disease has spread rapidly in caves and mines up and down the Appalachian Mountains and in 14 states and 2 Canadian provinces. The fungus has been detected on bats as far west as the Ozarks and Oklahoma. Colonies of hibernating bats have been reduced 81-97 percent and over 1 million bats have already died.

The mechanism of death is not fully understood. However, recent research has proposed that *G. destructans* may cause unsustainable dehydration in hibernating bats, triggering thirst-associated arousals from hibernation. In addition to direct damage to the wings that would alter flight control,

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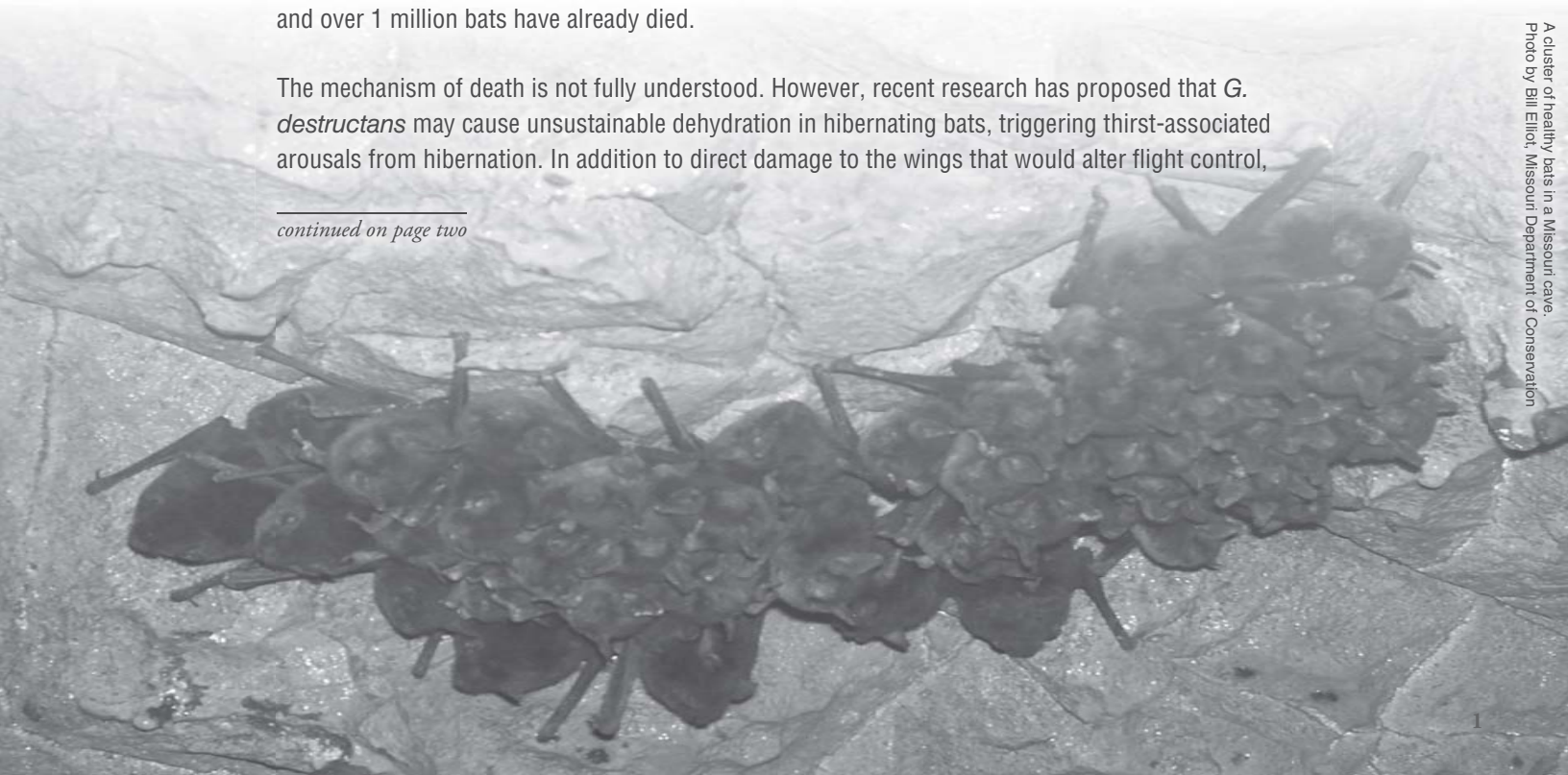

A cluster of healthy bats in a Missouri cave. Photo by Bill Elliot, Missouri Department of Conservation

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the erosion and invasion of skin may also cause significant changes in circulation, body-temperature regulation, and respiratory function. Infected bats seem to break their hibernation torpor earlier than usual. This arousal is energetically demanding and probably leads to a more rapid disappearance of fat reserves, early emergence from caves, and increased mortality due to starvation. Skin lesions are also found on the wings and are an important diagnostic feature. At this time, there is no known cure or treatment for WNS, but antifungal compounds and providing heated roosting areas to reduce energy expenditure are being tested as stop-gap measures.

Many species of bats that hibernate in eastern North America are now known to be susceptible to the disease, including little brown bat (*Myotis lucifugus*), northern long-eared bat (*M. septentrionalis*), and the federally listed (endangered) Indiana bat, all of which have had significant population losses. Emerging infectious diseases are increasingly recognized as direct and indirect agents of extinction of free-ranging wildlife. This has led many wildlife scientists to view WNS an ecological emergency. The rapid progression of this disease in combination with high mortality is unprecedented in North American wildlife species and may have far reaching impacts due to the important ecological services provided by bats to both forest and agricultural systems.

Sybill Amelon, U.S. Forest Service

A healthy northern long-eared bat (*Myotis septentrionalis*).

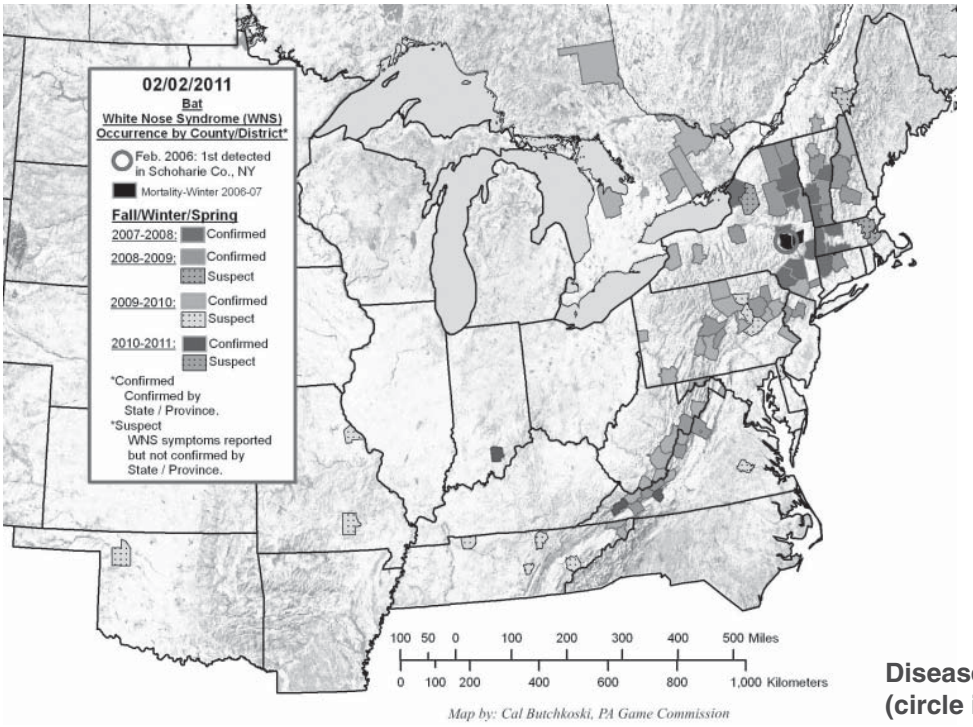
A. Hicks, New York Department of Environmental Conservation

A little brown bat (*M. lucifugus*) showing symptoms of white-nose syndrome.

Wildlife biologists and mycologists from government agencies, including the New York Department of Environmental Conservation, the U.S. Fish and Wildlife Service (USFWS), the U.S. Geological Survey (USGS), and the U.S. Forest Service (USFS), as well as scientists in academia and industry, are all now cooperating to study this disease. Caving enthusiasts (spelunkers) are also greatly concerned and are cooperating by implementing disinfection protocols, conducting public outreach, and offering their services for monitoring unusual behavior of bats outside caves.

FOREST SERVICE BAT RESEARCH

Wildlife biologist Sybill Amelon of the USFS Northern Research Station (NRS) in Columbia, MO, has specialized in bat biology since 1995 and is the Forest Service's research liaison to the interagency task force mobilized to deal with WNS. She is currently evaluating genetic viability of Indiana bat based on current population losses. Amelon has genotyped hundreds of Indiana bats at up to 21 different DNA loci (microsatellites) from samples collected throughout their natural range. Preliminary population analyses suggest this species may have already have had reduced genetic diversity pre-WNS, so that high mortality from WNS in the Northeast will make this species particularly vulnerable. To date there is no indication of resistance to the disease. Modeling the possible trajectories of declining populations should provide information needed to identify management options for conservation of this species.



Disease progression from epicenter (circle in upstate New York).

NRS mycologists Jessie Glaeser and Daniel Lindner of the NRS Center for Forest Mycology Research (CFMR) in Madison, WI, are normally not bat researchers, but they too joined the national research effort in 2009 because of their expertise in identifying fungi through DNA sequencing. (The CFMR is home to a large fungal culture collection and herbarium with living cultures and dried specimens of over 2,500 species of forest fungi.) Lindner and Glaeser have been working with David Blehert of the USGS National Wildlife Health Center (who led the team that first identified the WNS fungus) to develop DNA detection methods for screening cave soils and debris for the pathogen. They were successful in finding *G. destructans* in cave sediments from states within the affected region, showing that the pathogen can survive in the environment. Their research has also shown that the DNA regions most commonly sequenced to differentiate among fungi cannot be used to detect *G. destructans* because this region is very similar genetically to that found in other nonpathogenic species of *Geomyces* normally found in the cave environment. Lindner and Glaeser recently received a grant from the U.S. Fish and Wildlife Service to develop more specific genetic techniques that can be used to detect the pathogen in the environment or in infected bat tissue.

Although *G. destructans* infection appears to be limited to skin, its severe invasion and destruction of skin structures is not characteristic of any known cutaneous fungal pathogens in terrestrial mammals. The most similar disease among vertebrates is chytridiomycosis, a fungal disease of amphibians, caused by *Batrachochytrium dendrobati*, that has spread globally since it was identified in 1993. Recent studies showed that infection by this fungus impairs the ability of frog skin to regulate hydration and homeostasis, causing electrolyte imbalance and ultimately cardiac arrest. Like WNS in hibernating bats, chytridiomycosis has caused sudden and severe declines of multiple species of wild amphibians. Although uncertainty still exists as to the source of the WNS pathogen, as well as why a soil fungus would be so successful in colonizing a mammal, there is evidence that the same fungus (or one very closely related) occurs on bats in Europe. Genetic studies on the fungus are under way on both continents to unravel these issues.

The mobility of bats, the rapid spread of WNS, and the severity of its consequences have led to the mobilization of a national effort on multiple scales mounted to avoid irreversible losses to bat populations, and associated ecological impacts, throughout North America. The national plan outlines actions necessary to coordinate Federal and State efforts and identifies actions in support of State, Federal, and Tribal WNS management efforts to try to slow or control this disease before it reaches western North America or farther. Many scientists are now working toward the goal of stopping this disease and providing for the conservation and recovery (if necessary) of this very important group of mammals.

REFERENCES AND RESOURCES

Websites:

NGO websites for information

www.batcon.org
www.batworld.org
www.batmanagement.com
www.caves.org/WNS/

Animated map of WNS spread

www.biologicaldiversity.org/campaigns/bat_crisis_white-nose_syndrome/animated_map.html

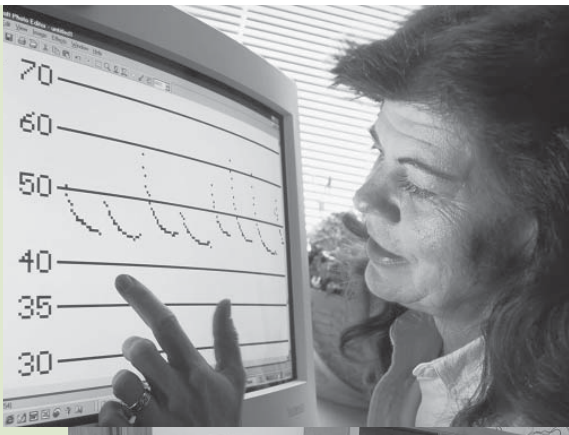
Federal websites

U.S. Forest Service:
www.fs.fed.us/biology/resources/pubs/tes/wns-brochure8310.pdf
www.fs.fed.us/r9/wildlife/wildlife/bats.php
U.S. Geological Survey:
www.nwhc.usgs.gov/disease_information/white-nose_syndrome
www.fort.usgs.gov/WNS/
U.S. Fish & Wildlife Service:
www.fws.gov/WhiteNoseSyndrome

References:

Cryan, Paul M.; Meteyer, Carol Uphoff; Boyles, Justin G.; Blehert, David S. November 2010. **Wing pathology of white-nose syndrome in bats suggests life-threatening disruption of physiology.** BMC Biology. 8:135 doi:10.1186/1741-7007-8-135

Lindner, Daniel L.; Gargas, Andrea; Lorch, Jeffery M.; Banik, Mark T.; Glaeser, Jessie; Kunz, Thomas H.; Blehert, David S. 2010. **DNA-based detection of the fungal pathogen *Geomyces destructans* in soil from bat hibernacula.** Mycologia. doi:10.3852/10-262



U.S. Forest Service

Dr. Sybill Amelon is a research wildlife biologist stationed at the Columbia, Missouri, NRS laboratory associated with the University of Missouri. She received her Ph.D. in Wildlife Ecology from University of Missouri. She has a long career with Forest Service and recently was named as the US Forest Service's Research & Development liaison to the interagency task force developed to respond to white-nose syndrome (WNS) in hibernating cave bats. She is one of few licensed bat rehabilitators in Missouri and uses bats that cannot be returned to the wild in educational programs. She is working in conjunction with Bat Conservation International (Austin, TX) and Bat World Sanctuary (Mineral Wells, TX) to educate the public on the importance of bats and conserving them as an integral part of natural ecosystems and native plant communities. Her usual research focuses on the ecology and behavior of bats and their interrelationships with habitat features. Dr. Amelon's earlier work was featured in an article that can be found at the following website:

"All in a night's work—bats in the Mark Twain National Forest, Missouri"
www.forestrycenter.org/headlines.cfm?refID=74748

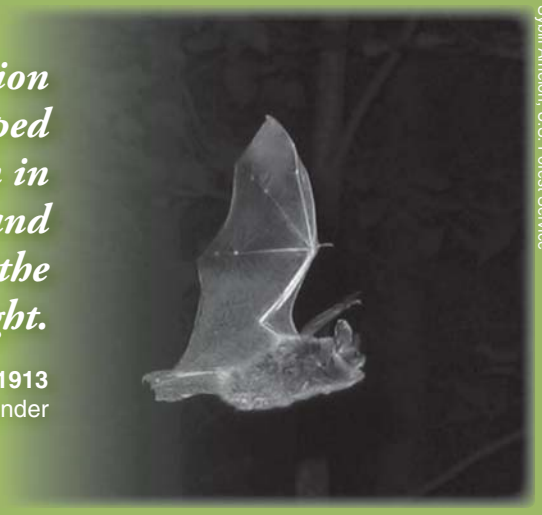
U.S. Forest Service

Dr. Daniel Lindner was a post-doctoral fellow at the Swedish University of Agricultural Sciences (SLU) in Uppsala, Sweden, before he joined NRS in 2004. He received his Ph.D. degree in plant pathology (2000) and a B.S. in botany (1996) from the University of Wisconsin at Madison. His current research examines how human actions can affect fungal communities and how the resulting changes can affect ecosystem function, especially carbon cycling. He is also studying wood-inhabiting fungi and biosystematics of fungi, with an emphasis on using DNA-technology to detect and identify fungi in environmental samples.

Dr. Jessie Micales Glaeser joined the Forest Service in 1985. Previously, she was a post-doctoral research associate at Cornell University stationed with the USDA Agricultural Research Service at Fort Detrick, Frederick, MD. She was awarded her Ph.D. in plant pathology from Virginia Polytechnic Institute and State University, Blacksburg, VA (1985) and a B.S. in agronomy from Delaware Valley College of Science and Agriculture, Doylestown, PA (1979). Her usual research involves the ecology, taxonomy, and identification of wood-decay fungi as related to climate change, invasive species, and hazard/danger trees.

The bat is the climax of creation in many things, highly developed in brain, marvelously keen in senses, clad in exquisite fur and equipped, above all, with the crowning glory of flight.

Ernest Thompson Seton, 1913
Boy Scouts of America founder



Sybill Amelon, U.S. Forest Service

BAT FACTS

Bats are the only mammals that can truly fly, not just glide. They belong to the mammalian order Chiroptera (Greek for "handwing"). A bat's wing is analogous to the human arm and hand. The bones of the hand and the four fingers are greatly elongated, light, and slender to provide support and manipulate the wing membrane, which is called the patagium. The membrane is an extension of the skin of the body. It is made up of external epidermis and an internal layer of dermis, which contains blood vessels, muscles, and the elastin fibers that increase flexibility.

There are about 1,100 bat species worldwide, making up 20 percent of all classified mammal species. About 70 percent of bats eat insects, making them enormously important ecologically. Other bats, mostly tropical species that drink nectar and/or eat fruit, act as pollinators and seed distributors. Some species eat fish, frogs, and small mammals. There are only three species of blood-eating bats; two consume the blood of birds and the other, the common vampire bat, consumes the blood of mammals, mostly cattle. Bats are long-lived, as much 20-30 years, and usually have only one or two offspring (pups) per year.

Bats range in size from the bumblebee bat of Southeast Asia (measuring 1.14 to 1.3 inches long and weighing 0.07 ounces) to the giant golden-crowned flying-fox of the Philippines, which has a wing span of 4 feet, 11 inches and weighs about 3 pounds. During warm weather, bats hang by their feet (roost) from the ceilings of caves, mines, bridges, attics, or in trees using branches, bark, or cavities to sleep during the day, emerging at dusk to hunt. In cold weather, they either migrate or hibernate.

Within the four families of bats living in the United States there are 47 different species—each one performing a vital function within its own environment. Of these, 5 are leaf-nosed bats (Family Phyllostomidae), 1 is a ghost-faced bat (Family Mormoopidae), 7 free-tailed (Family Mollosidae), and 34 are vesper bats (Family Vespertilionidae). Of these, at least 25 hibernate during winter months, the others either live in or migrate to warmer areas. Hibernating species must nearly double their body weight in preparation for hibernation. During hibernation, their metabolism drops to a near-dead state of torpor, with near-freezing body temperatures and very slow breathing and heart rate to conserve their fat stores to get them through the entire winter.

In Texas, the emergence of Mexican free-tailed bats each summer night from their roosts in caves and under bridges has become famous. Millions of bats fly out and devour corn earworm and fall armyworm moths in the night sky. The larvae of these two insects are major pests of the south-central Texas cotton and corn crops, and the estimated 1.5 million bats in southwestern Texas eat an estimated 6 to 18 thousand metric tons of insects annually. These clouds of bats are so dense that they can be tracked by radar!

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Our research themes are (1) Forest Disturbance Processes, (2) Urban Natural Resources Stewardship, (3) Sustaining Forests, (4) Providing Clean Air and Water, and (5) Natural Resources Inventory and Monitoring.

There are 135 NRS scientists working at 20 field offices, 24 experimental forests, and universities located across 20 states, from Maine to Maryland, Missouri to Minnesota.