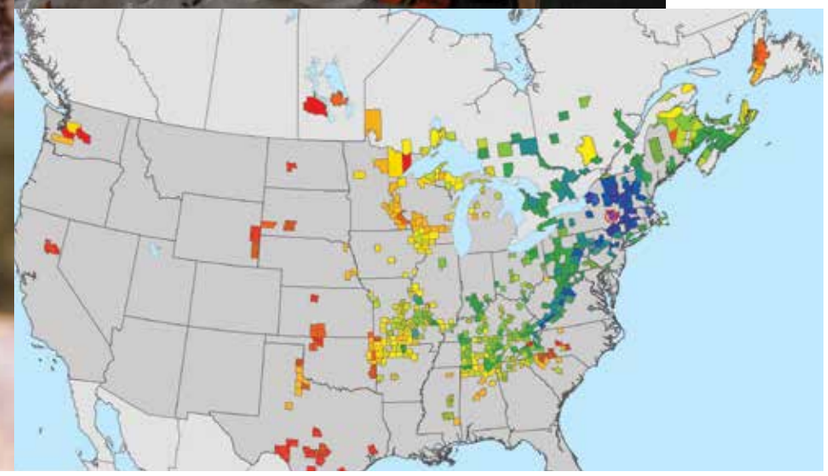
CAN BATS BE SAVED?

In what may be the most devastating wildlife disease ever to strike North America, white-nose syndrome continues to spread, wiping out key bat populations. Biologists are scrambling to come up with an effective practicable response

By Kerry Banks

*Checking the wings of a big brown bat (*Eptesicus fuscus*) for signs of white-nose syndrome*

JASON ONDRIECKA/ALAMY STOCK PHOTO



*Little brown bat (*Myotis lucifugus*) with white-nose syndrome; Biologist entering a Vermont mine through bat gate; Map of white-nose syndrome indicates westward movement*

US FISHERIES AND WILDLIFE SERVICE/RYAN VON LINDEN, NEW YORK DEPARTMENT OF ENVIRONMENTAL CONSERVATION/SCIENCE PHOTO LIBRARY

SCIENCE HISTORY IMAGES/ALAMY STOCK PHOTO; WHITENOSESYNDROME.ORG

"IT was a shocking sight," says biologist Karen Vanderwolf, recalling a 2011 visit to a cave housing New Brunswick's largest population of hibernating bats. "There were dead bats scattered around the snowdrifts at the entrance, and deeper inside there were thousands of bats littering the cave floor. Some were still alive but were just lying there twitching, unable to fly. The awful smell of the rotting carcasses is something I will never forget."

These bats were victims of white-nose syndrome, a fungal infection that many biologists have described as the most devastating wildlife disease ever to hit North America. Familiar to many now, in 2010 the syndrome was unknown in Canada. Vanderwolf, a bat conservation specialist at Trent University in Ontario and a blogger for the Canadian Wildlife Federation, was monitoring 10 caves in 2011 that housed some 7,000 bats. After white-nose swept through, only 13 bats remained. By 2013, the disease had infected every known cave in the region, with similar levels of devastation reported.

A similar scene unfolded in Nova Scotia during the winter of 2012–13, when a population of 17,000 bats at five monitored cave sites was reduced to 250 in just three months. "In terms of wildlife diseases, the speed at which white-nose took hold is basically unheard of," says Hugh Broders, a bat biologist at the University of Waterloo. The carnage was so pervasive that a "99 per cent mortality rate among some species was considered the best-case scenario."

Since then, white-nose syndrome has annihilated upwards of seven million bats and spread into 35 U.S. states and seven Canadian provinces. So far, 13 bat species have been affected. Some, like the little brown bat, once the most ubiquitous species on the continent, are edging toward extinction. Scientists on both sides of the border are now in a desperate race against time to find a way to stop the deadly disease and save those still vulnerable bats that have survived the onslaught.

The name white-nose syndrome derives from the fuzzy, white growth that sprouts on the muzzles, ears and wings of stricken bats. That growth is produced by a fungus that lives in the cool, moist interiors of caves and mines. It thrives in cool temperatures and attacks bats while they hibernate, their immune systems effectively dormant too.

The disease's scientific moniker is *Pseudogymnoascus destructans* (Pd), and it kills by destroying wing tissue, disrupting body chemistry and inducing dehydration. Infected bats will frequently awaken from torpor to groom themselves and remove the fungal growth, but this has lethal consequences, as bats must carefully ration their energy during hibernation to survive without eating until the spring. Starving and disoriented, some will fly outside in mid-winter in a search for food, a suicidal mission in most of Canada.

The fungus arrived from Europe and crossed the Atlantic Ocean, brought by humans. It first appeared in North America in 2006 in a popular tourist attraction in upstate New York called Howe Caverns, where, it is speculated, foreign cavers carrying fungal spores on their clothing and gear introduced the disease to local bat populations. Once the disease was established on the continent, the main form of transmission became bat to bat, and that has been a major factor in its rapid spread. Bats don't always roost close to their hibernation sites: some fly hundreds of kilometres; others are inadvertent long-distance hitchhikers on trains, trucks and boats.

The fungus seems to kill only hibernating bats and so is a serious threat to more than half of the continent's 47 bat species that hibernate over winter. The hardest hit species are little brown bats, northern long-eared bats and tri-coloured bats, all of which have suffered massive die-offs. In February 2012, the trio were given an emergency assessment by the Committee on the Status of Endangered Wildlife in Canada and recommended for listing as endangered species. Some provinces acted quickly, including Ontario, which moved to protect these species within three months. It took more than two years for the federal government to follow suit.

BRILLIANT BAT FACT

THERE ARE OVER 1,300 DIFFERENT BAT SPECIES, MEANING BATS MAKE UP ONE-FIFTH OF ALL MAMMAL SPECIES

In fact, the initial response to the emerging epidemic was sluggish, with wildlife managers caught off guard by the speed of the outbreak and government agencies slow to recognize the urgency of the situation. Unlike the widespread attention devoted to crashing bee populations, this unfolding bat apocalypse has generated far less media coverage, perhaps because of the nocturnal nature of bats and a negative public image that has been fuelled by movies and books that portray them as evil, blood-sucking creatures.

Public blindness to the reality of bats and their natural history frustrates bat biologists because these mammals play such a pivotal role in the ecosystem, consuming huge amounts of insects (many with the potential to carry disease), including mosquitoes and the moths of crop-damaging caterpillars. Estimates of the pest-control value of bats to the North American agricultural industry range widely, from $3.7 billion to $53 billion a year.

From a scientific perspective, the calamity has also highlighted how little is actually known about bats. "When the crisis hit, we were searching hard to find facts on bat hibernation. We found there was very little data on the subject," says biologist Craig Willis, who operates a bat lab at the University of Winnipeg that is involved in the search for answers for how best to combat white-nose syndrome.

Willis believes it was fortunate that the initial outbreak of Pd took place in the northeastern U.S., because the first bat to be infected — the Indiana bat — is endangered, and its populations closely monitored by wildlife biologists. As a result, the appearance of the disease was quickly documented. Even so, because white-nose syndrome was unknown in North America, it took several years before scientists could identify the fungus and understand its effects.

Finding a way to stop the invader has proved more elusive. An answer did not surface until 2017, when a team of American scientists learned that the fungus is highly sensitive to ultraviolet light, a band of the electromagnetic spectrum found in sunlight and tanning lamps. In lab tests, a blast from a hand-held UV-C light source, lasting only a few seconds, killed an amazing 99 per cent of the fungus.

Daniel Lindner, a plant pathologist with the U.S. Forest Service who was on the team that discovered the killing mechanism, says that unlike other fungi, Pd has no ability to repair damage caused by UV light. "It has evolved over the centuries to truly become a creature of the dark. I have trouble not thinking of vampire movies — when you pull back the shades and it goes up in a cloud of smoke."

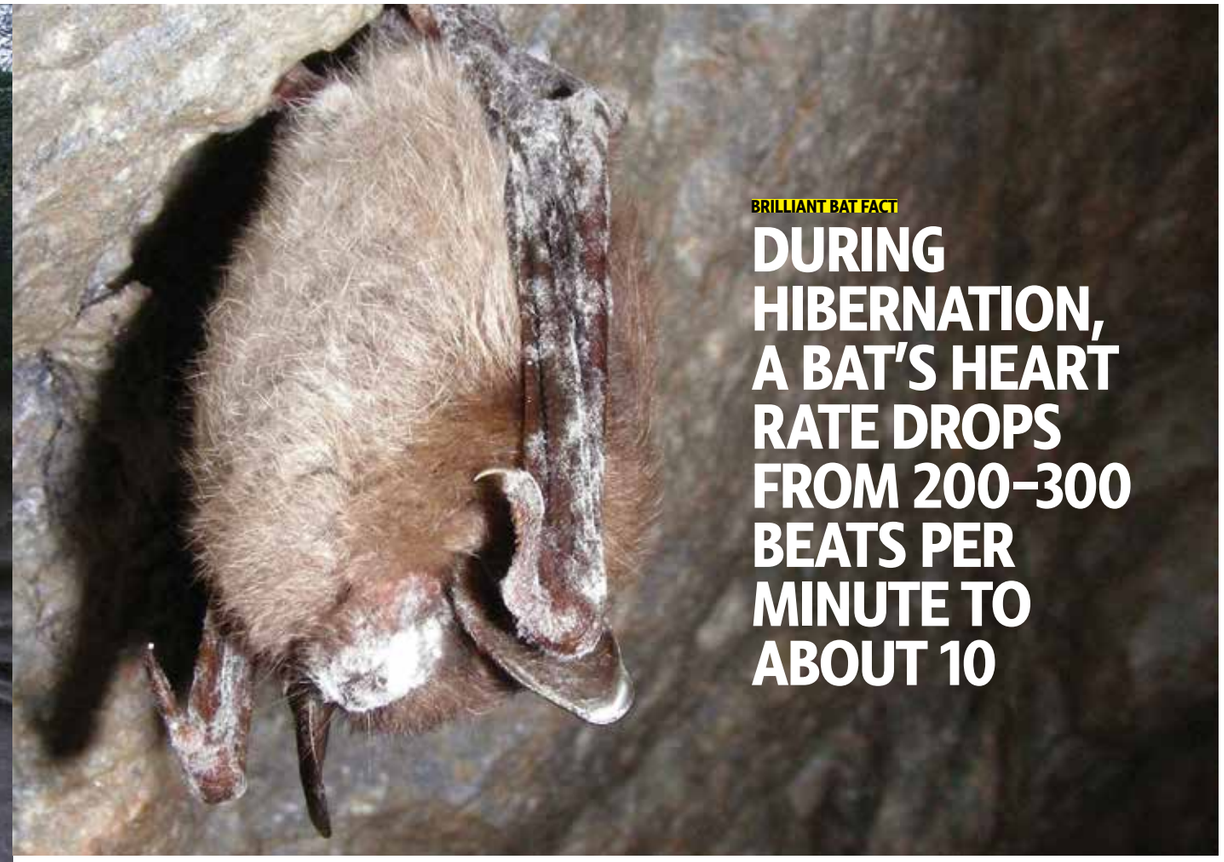
BENJAMIN OLSON/MINDEN PICTURES. SCIENCE HISTORY IMAGES/ALAMY STOCK PHOTO. DANIEL BORZYNSKI/ALAMY STOCK PHOTO.

Pinpointing Pd's fatal vulnerability is encouraging, but destroying the fungus in a Petri dish is only the first step. Treating millions of bats individually with UV light in difficult-to-access caves and mines across the continent would be a mind-boggling task. Flashing an entire bat colony with UV probably would not be effective either, since the fungus is present in the armpits of their closed wings and would not be affected by the light. One possible strategy is to set up UV lights at cave entrances and flash the bats as they come and go before hibernation. But even if this worked, it would likely only save a small percentage of bats.

As scientists grapple with the challenge of utilizing UV light, other methods of combating the disease, including vaccines and antifungals, are being tested. "I think we should be investigating a number of treatments," says Willis, noting that Pd was discovered in Manitoba's largest hibernaculum, a cave with 10,000 bats, in March

JOSIP BALABAN.

Biologist setting up mist net to capture bats; anti-fungal shoe washing to prevent the spread of the disease; a little brown bat shows the effects of white-nose syndrome



BRILLIANT BAT FACT

DURING HIBERNATION, A BAT'S HEART RATE DROPS FROM 200–300 BEATS PER MINUTE TO ABOUT 10

OLD MINES BECOME NEW HOMES

Innovative work in the north; because bats need all the help we can give them

SCATTERED ACROSS THE RUGGED TERRAIN OF northern Ontario are countless abandoned mines. No one knows for sure how many, though estimates are as high as 5,000. They are a significant hazard to the public and to some wildlife. Many remain exposed because rehabilitation can be a costly liability and challenging undertaking for the mining companies responsible. Left unrehabilitated for decades, even longer, many of these abandoned mines have become naturalized and are now crucial habitats for local species. As a result, biologists are beginning to ask important questions about the ecological factors that should come into play when rehabilitating lands ravaged by mining.

Consider the Edison mine in northern Ontario. It was developed by the legendary American inventor (and cutthroat businessperson) Thomas Edison. While he is better known for inventing an early functional light bulb (though not the first, which may have been invented by a Canadian), Edison distinguished himself in the mining industry as well, pioneering new mining techniques and technologies, including a battery-powered miners' lamp. In Ontario, Edison was a key player in the discovery of nickel at Falconbridge, and he had a hand in the local silver rush near the present-day town of Cobalt, Ontario. It wasn't silver he was after but cobalt, a byproduct of silver-mining, for a new battery type he had invented. In 1905, he acquired his own mine near Latchford, Ontario, about halfway between North Bay and Timmins. Over two years, Edison's employees sank two shafts to 45 metres,

connected by an adit (a horizontal passage) and several exploration drifts and crosscuts, with eight holes in total. Over that time, five to seven tonnes of ore of unknown grade were extracted. It does not appear that commercial production ever resulted. The mine was abandoned.

Now, more than a century later, innovative thinking has returned to the mine.

In 2016, the mine was owned by the massive multinational electrical firm Eaton Corp., which acquired Edison's corporate assets nearly 100 years ago. (They have since sold it to a mining concern based in B.C.) To eliminate any liabilities associated with the mine, Eaton hired an engineering firm named Golder Associates Ltd. to complete a "progressive rehabilitation" of the site.

In the meantime, Ontario's Ministry of Natural Resources and Forestry identified the underground portions of the Edison mine as potential bat habitat. When a survey was completed, it confirmed the presence of two bat species, both at risk of extirpation: the little brown bat and the northern long-eared bat. The Edison mine was then designated as a protected habitat for a species at risk, and three physical mine hazards (adit, shaft and open-cut) were to be left open and preserved to allow the bat population to remain. The rehab project's mission had changed: as an important component of the local ecosystem, the mine would still need to be closed off to ensure public safety but would also have to ensure the embattled bat population could stay.

Converting Thomas Edison's old Ontario mine into a bat cave is an example of the innovative solutions bats will need

Bat-friendly progressive rehabilitation of physical mine hazards is pretty new to Ontario, and the Edison mine provided significant logistical challenges due to the rugged terrain, remote forested location and difficult (and quite short) summer working conditions. Given that conventional rehabilitation options (fencing, backfilling and engineered caps) would prevent the bats from freely using the underground workings to hibernate, lead engineer Josip Balaban and colleagues designed and constructed three bat-friendly structures that protect the public while also allowing the bat population to remain. The task required more than 40 helicopter lifts and several barge trips up the Montreal River to transport materials. A complex bat gate with two cupolas made of stainless steel lets bats fly in while keeping people out. Several non-bat-habitat mine hazards were backfilled using local materials.

Completed in 2018, the rehabilitation project, which won a prestigious mine reclamation award that year, shows how incorporating public safety and environmental protection can lead to innovative long-term solutions. It also raises important questions about the role environmental protection should play in mine rehabilitation. Although mines disrupt the landscape and destroy the local ecology in their initial stages, sites like the Edison mine have evolved into important habitats for their surrounding ecosystems. Through innovation, creativity and investment, mine rehabilitation can play a big role in saving bats in Canada.—**SARA HARVEY**

*Eastern small-footed bat (*Myotis leibii*)*

BRILLIANT BAT FACT

BATS EAT VAST AMOUNTS OF AGRICULTURAL PESTS, SAVING FARMERS BILLIONS

SHERRI AND BROCK FENTON

*Tricolored bat (*Perimyotis subflavus*)*

WHAT YOU CAN DO TO STOP WHITE-NOSE SYNDROME

- Cavers, geocachers and people frequenting mines or other hibernacula locations can spread the fungus by transmitting spores on boots, clothing and equipment or by stowing infected bats. So avoid entering bat hibernation sites if your clothing or equipment has been used in other underground places. Follow decontamination protocols.
- Avoid disturbing bats: stay out of hibernation sites in the winter; respect closures at mines and caves.
- Provide homes for bats: build and monitor a bat box. Visit CanadianWildlifeFederation.ca to learn more.
- Spread the word in your community and to politicians.

2018. "We knew it was coming, but that doesn't prepare you for the horror show of an affected cave," he says, recalling the bizarre sight of bats frantically flying to and fro in mid-winter and the corpses piled in the snow at the cave entrance.

Willis's students, in collaboration with American researchers, are now testing the effectiveness of using both UV light and an antifungal spray on cavern walls in northern Ontario, Arkansas and Alabama. Although the antifungal agent doesn't kill the fungus, it does halt its growth.

His team is also experimenting with different methods of enhancing habitats to increase the bats' chances of surviving. "The bats that survive the disease come out in the spring in really terrible shape," he explains. "They have huge tears in their wings and have to heal and at the same time go out and forage for food and then initiate reproduction." As Willis notes, reproduction in bats is a slow process even at the best of times, with females typically giving birth to only one pup per year. To help the bats recover more quickly and fatten up for the winter, his team is trying to get insects to concentrate in higher numbers in areas near roosts with lures and lights.

Mark Bingham, a bat biologist at the University of Regina believes that habitat management for the survivors is the best use of money and research. "We're not going to be able to fix this with a cure. The genie is out of the bottle. Half the continent is infected," says Bingham, who views the application of UV light and antifungal sprays as impractical. "Even if you kill all the fungus in a cave, bats can get re-infected." He also wonders what other organisms the sprays and the UV light might kill.

Meanwhile, the disease continues to move. It is now found in 15 counties in Texas, the state with the greatest bat diversity in the U.S., and there are fears it could travel south to Mexico and even perhaps to Central and South America. Pd also recently appeared over the Rockies in Washington State and northern California, some 2,000 kilometres from Nebraska, the pathogen's previous westernmost identification. Undoubtedly, humans aided this geographical leap. "It's a very alarming development," says Willis. "We thought we had at least a decade, if not forever. The Rocky Mountains present a significant barrier to bats."

The emergence of the disease in Washington State poses a direct threat to the 16 bat species in B.C. (compared with just seven in all of Eastern Canada). Discovered in bats near Seattle in 2016, it was just recently located in an area south of B.C.'s Columbia River Valley, a major bat migration route. Although biologists don't believe that bats in Western Canada gather in large groups to hibernate like their eastern cousins, exactly where they hibernate is largely a mystery.

SHERRI AND BROCK FENTON

CWF ACTION ON BATS... AND HOW YOU CAN HELP

NOTICE EVICTIONS
In an ongoing project in the national capital, CWF is tracking bats that have been evicted. This research, funded in part by the Ottawa Community Foundation, is working with local homeowners, a wildlife control company, bat researchers, students and community groups to ensure safe havens for the bats. In one key initiative, volunteers are testing and monitoring two types of bat houses placed in 150 locations throughout the Ottawa-Gatineau area. You can track their progress at **blog.cwf-fcf.org**.

MONITOR POPULATIONS
CWF is calling on all concerned Canadians to report bat sightings and help monitor bat houses. The simple act of adding photos and observations to iNaturalist.ca will help build our understanding of bat population and disease trends and offer insight into Canada's biodiversity. Search "monitor a box" on the CWF website to learn more, to download a "monitoring cheat sheet" and to get full instructions for contributing to **iNaturalist.ca**.

UNDERSTAND BATS
Hinterland Who's Who has all kinds of information about bats, including a special fact sheet about the little brown bat and white-nose syndrome. Visit **hww.ca** for more.

NIX NEONICS
CWF is a leader in the effort to restrict the use of neonicotinoids, the insecticides that are so harmful to pollinators. Studies show that neonics could be harming bats as well, by depleting a main food source and by poisoning bats that eat affected insects, thus weakening their immune systems and making them more vulnerable to disease. Visit the **CWF website** to learn about neonics and what you can do.

For more on how to help these creatures in distress, visit **HelptheBats.ca**.

In an attempt to deal with the looming danger to B.C.'s bats, researchers from Thompson Rivers and McMaster universities have been working with the Wildlife Conservation Society Canada to gauge the effectiveness of a probiotic bacterium that scientists were able to isolate after swabbing hundreds of bats. In lab tests, it stopped the fungus, and the team thinks it could work in the wild, replicating itself on the skin of bats, spreading through colonies as they migrate.

Tests on captive Yuma myotis (a small bat found throughout much of western North America) in roosting boxes at B.C. Wildlife Park in Kamloops have been promising, and the plan calls for scattering a powdered clay infused with the probiotic at known roost entrances so that it sticks to the bats and gives them a small dose each time they enter and exit. Half a dozen sites around Vancouver were treated with the bacteria this summer, and many more will be targeted in 2020. "We decided to target our vulnerable building-roosting bats because we know where thousands of them roost in summer," says Cori Lausen, a conservation research biologist with WCS Canada.

The fact that western bats don't congregate in tightly packed groups like bats in the east do during winter may help slow the advance of Pd in the west, but that, like much else about the future of this biomedical battle, remains cloudy.

Precisely what effect the loss of millions of bats will have on agriculture is another unknown. Recent experiments conducted in Illinois on cornfields indicate it won't be good. Fields protected from bats by enclosures at night suffered a dramatic increase in crop damage, with nearly 60 per cent more larvae from the destructive corn earworm moth inside the enclosures than in the open control areas. The crops were also struck with a toxic fungal growth that takes hold in plants already damaged by the earworm larvae.

One of the few bright spots in this grim tale is that some colonies of severely affected bats in Ontario and the Maritimes appear to be stabilizing — perhaps those with a gene mutation that gives them a type of immunity. Biologists hope that by using various treatments, they will be able to get bats through this "population bottleneck" without losing any individual species before they can evolve natural defences.

Hugh Broders believes natural selection is the best chance for Canadian bat species that have suffered large declines. "If they can weather the consequences of being such a small population, they might be able to make a comeback, but it's going to take a long time."

*Northern long-eared bat (*Myotis septentrionalis*)*

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