White-nose syndrome draft 4/13/11
Michelle Nijhuis

Inside the gaping mouth of Mammoth Cave, hibernating bats sleep in permanent twilight, each huddled in its own limestone crevice. Every fall, these big brown bats (ScientificNameTK) squeeze their furry bodies into nooks in the cave walls, where they enjoy protection from the waterfall that sprays across the cave entrance and from the bitter wind that rises out of the depths of the cave. But there's little a snoozing bat can do about a persistent biologist.[[nice]]

"Just … let … go … with … your … feet," [[we can just hear and see it—beautifully done]]coaxes Kentucky Department of Natural Resources biologist Brooke Slack as she stands on tiptoes on the floor of the cave[[ok? it's implied, but this might help fill in the positioning]] and points her headlamp upwards, reaching with gloved hands to pry a bat from the wall. The bat lets out a stream of tiny, infuriated shrieks, baring its sharp white teeth in protest. Slack apologizes, but when she gently loosens the bat's miniature claws from the rock, she slips it into a brown paper lunch bag. On this gray December afternoon, Slack and her colleague, University of Northern Kentucky microbiologist Hazel Barton, are pressing this unlucky bat into service to its species.

Mammoth Cave, the longest known cave in the world, stretches for at least 390 miles under the rolling beech forests of southern Kentucky, and its twisting tunnels have fascinated explorers, scientists and tourists for well over a century. Today, Slack and Barton are interested in Mammoth for a different reason: The cave and its bats are on the front lines of [[see below: let's pick some superlative here that doesn't need a caveat. I think "most precipitous" is defensible, and our fact-checker will make sure it is, but if this feels too strong here, feel free to scale it back to whatever descriptor you think is fair]]the most precipitous decline of North American wildlife in recorded history.

With a half-dozen grumpy bats bagged, Slack, Barton and a small group of coworkers lug their gear to the cave's Rotunda Room, where concentric circles[["circles" implies a presence, like a circle of chairs. But this is more an absence, right? The roof has calved away or been eroded or dissolved away in concentric circles?]] of limestone form a grand domed ceiling. On summer days, this natural underground room is packed with tourists, but today the scientists have the place to themselves. Clad in protective white Tyvek suits[[if it's easy to allude to the mechanism, could you do so here: are the white suits disposable? Or sterilized//sterilizable? It's not crucial, but it would be good to know whether the idea is to kill fungus on the suits after they get out of the cave, or put the suits on to prevent themselves from bringing in fungus on their regular clothes]] to check the spread of microbes from cave to cave, Barton and Slack get to work, Slack holding each protesting bat while Barton clips samples of hair and swabs faces and wings.

"Look at you, with your dirty, dusty little face," Barton coos, bending the light on her helmeted head to better illuminate one screaming bat.

Though Barton and Slack are good friends and work together often, Barton is interested in bats because they live in caves; Slack is interested in caves because they're home to bats. (As if to emphasize the contrast, Barton has a map of South Dakota's Wind Cave tattooed on her arm, while Slack has a tiny silhouette of a bat tattooed behind her ear.)[[love this detail]]

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sketches, and then move to a new graf to introduce the evil fungus.

I've been surprised at how many people in our office have never heard of WNS and are horrified when I explain it to them. Assuming our readers are just as unfamiliar with it, could you do a little more drum-banging here to announce that this seems to be a catastrophe? For the first sentence of the next graf, you might transition from Barton and Slack being friends (above) to the idea that they've been working together desperately (or on a desperate case). And to describe the disease, you might use whatever superlatives are legitimate: is it the fastest-killing, fastest-spreading, worst, most devastating, deadliest, etc. disease afflicting North American wildlife? The most dramatic or clearest case of a possible mass-extinction in action? ]]

Both know that somewhere in this cave, even on these bats, may lie spores of the fungus *Geomyces destructans*, which has devastated hibernating bat populations in the northeastern United States.

The disease the fungus causes, white-nose syndrome, has killed more than one million bats at last count, and threatens some of the continent's most abundant[[ok?]] bat species with extinction. Despite energetic[["energetic" seems like almost but not quite the right word to go with "searching." Maybe instead: meticulous//exhaustive//painstaking]] searching by Slack and her crew, the fungus has not yet been found in Mammoth Cave. But it's been confirmed in neighboring Virginia, West Virginia, and, most worrisomely, in Tennessee, in a cave only 40 miles from Mammoth.[[nice job eliciting dread]]

"Oh, look at this," Slack says suddenly[[was there something in her voice that made everyone pay particular attention?]] to the group. The silence is immediate and thick. As headlamps turn toward her, Slack stretches out a bat wing, its thin membrane marked by two half-inch tears. They could be from a run-in with an owl, or a barbed-wire fence. Or they could be a sign that white-nose syndrome [[is taking hold—or something more movement-based, maybe: has reached//has invaded Mammoth]] in Mammoth.

The other bats collected today will be returned, ruffled but unharmed, to their hibernation perches, but this one will be killed for laboratory tests. Reluctantly, Slack and Tim Williams from the U.S. Fish and Wildlife Service euthanize the wounded bat in a vial of toxic isoflourine. "Sorry, little girl," Williams says. One sacrificed, in hopes of saving another million of its kind.[[gave me goosebumps]]

For Hazel Barton, this afternoon in spacious Mammoth Cave is a cakewalk. She's just spent eight days squeezing her lanky frame through unexplored sections of Lechuguilla Cave, a southern New Mexico cave thought to be the deepest and most-decorated[[by people, or with stalactites?]] in the world. Though she's an expert caver, more than a week underground[[it's implicit, but maybe say explicitly that these are narrow or tight or low-overhead passages]] has tested even her stamina, leaving her knees sore and her gait stiff. But she saw a part of the world that's never been seen before — and that may never be seen again, for in delicate[[it's not intuitive to think of caves as delicate—unless the "decorated" above means with crystals or other delicate things? Or does delicate refer to the microbial balance or crumbly walls?]], restricted-access caves such as Lechuguilla, sections are often opened only to be mapped, then shut off to humans.

Barton grew up in Bristol, England, in a family that she describes as "not the slightest bit outdoorsy." When she was 16, she participated in a required high-school

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outdoor course that included rock-climbing, kayaking, horseback riding — and a day of caving, in the iron-rich caverns under the Forest of Dean in southern Wales. “Everything terrified me but the caving,” she says. “In any other environment, I would have been right behind the leader, but in the cave, I stayed in the back of the group thinking, ‘I love this. This is cool.’”[[lovely origins story]]

After the trip, Barton began to explore the caves near her hometown, caving with friends several times a week (“My mother would say, ‘You can’t go caving now! It’s dark!’” she laughs).[[sweet]] Barton at first wore a heavy,[[ok? I assume the difference between construction hat and proper caving hat is size and heft?]] orange construction worker’s helmet — with the brim turned backwards to allow easier passage through tight spots — but as her curiosity and enthusiasm grew, she acquired a proper caving helmet and other gear, and began exploring more difficult and distant caves.

Barton had another unusual interest: As a child, she heard naturalist David Attenborough marvel on the BBC about the complexity of life in a single glass of water, and ever since she’d been fascinated by the endless variety of microscopic organisms. When she was 14, she swept her hair against a petri dish of nutrients in science class. “By the next day, all kinds of disgusting things had grown out of it,” she remembers with a grin. Such quick results appealed to the fast-moving Barton, and after studying biology in college in England, she moved to Colorado to pursue a Ph.D. in microbiology.

Her mentor at the University of Colorado, Norman Pace, suggested that she study the microscopic life in caves, which scientists knew little about. “There aren’t many microbiologists who can go where you go,” Pace told her. Barton didn’t want caving—her hobby—to become a job, but eventually she relented and began to study the different ways in which microbes thrive//survive in dark, nutrient-deprived caves. She’s since plumbed caves in Mexico, Guatemala, Belize, Venezuela and throughout the United States for signs of microbial activity. Caves, she’s found, are swarming with life: She’s identified microbes with antibiotic properties — organisms that she and other researchers are studying for their potential to treat drug-resistant human diseases — and others similar to those that can withstand[[ok? Is the idea that they’re pretty indestructible? Did she happen to find any that can withstand high pH or toxins? If so, that might be an easier thing for readers to grasp]] the antiseptic environments of spacecraft assembly facilities.

Barton’s experience underground and in the lab schooled her in the tenacity of these tiny life forms. For her Ph.D. research, she studied a bacterium that infects the lungs of cystic fibrosis patients, and she came to think of caves as somewhat like human bodies — complex places that host a vast variety of species, each adapted to its environment in a different way.[[nice]] Yet when Barton heard that a bat-killing fungus had managed to spread, in the space of two winters, from caves in New York State all the way to West Virginia, even she was surprised by its velocity.

“If you sat down and thought, ‘What would I design to kill bats, and how would I design it?’ and you took time to think about the worst possible combination of factors that a pathogen would have, this would be it,” says Barton.[[excellent quotes throughout]]

Because *Geomyces destructans* thrives in cool temperatures, it’s able to attack bats while they hibernate for the winter, when their immune systems are effectively shut down. The fungus spreads from bat to bat when they cluster in caves, and when the bat colonies disperse in the spring[[ok, they pass it along mostly in winter, and then disperse?

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Or can they pass it along and disperse at any time?]], the fungus can persist in cave soils, poised to infect new arrivals[[in the winter or throughout the year?]]. Bats with white-nose syndrome rouse more frequently from their winter torpor, which causes them to waste precious body fat at the coldest time of the year. (Exactly why the bats wake up isn't certain, but some scientists posit that the bats' breathing is disturbed by the white spores of the fungus, which can cover the bats' muzzles.) The fungus also infects the bats' delicate wing membranes, literally eating away at the skin until the wings resemble torn, crumpled tissue paper.[[your imagery is so vivid throughout—I think of bats now whenever I'm walking over pine needles]]

In the winter of 2007, bats in upstate New York started behaving oddly. Instead of hibernating through the winter, they began to fly into neighborhoods during the day, wandering dangerously far from their caves. "There would be three feet of snow and it would be twenty degrees — not bat-flying weather — and you'd see bats flying out and taking off into the distance," says Al Hicks, then a wildlife biologist for the New York State Department of Environmental Conservation. "You'd know every darn one of them was going to die. It was awful."[[like I said, great quotes]]

Later that winter, during a routine cave survey, New York state biologists found thousands of dead bats in a limestone cave near Albany, many encrusted with a strange white fuzz. During the winters that followed, the epidemic expanded: Dead bats piled up in caves throughout the Northeast, sometimes so thickly that researchers had to literally crawl over them in order to assess the damage. The scientists would emerge filthy and saddened, with bat bones — each tiny bone as thin and flexible as a pine needle — wedged into the treads of their boots.[[shudder—this is so well-told]]

By the end of 2008, wildlife disease researchers had identified the white fuzz as the spores of a fungus new to North America. [[since the intro is about big brown bats, and the prediction is about little brown bats, add a sentence, probably here, saying that scientists found the fungus in TK# species of bat, and/or name the species if there aren't many]] Two years later, *Geomyces destructans* had spread to 14 states and three Canadian provinces, and a study in the journal *Science* predicted that the little brown bat — once the most common bat species in North America — will be extinct in the eastern United States within 20 years.

"When it first hit, I thought, 'OK, is there anything we can do to keep it within this cave?'" remembers Hicks. "The next year it was, 'Is there anything we can do to secure our largest colonies?' And then the next year it was, 'Can we keep any of these colonies going?' Now we're asking if we keep these species going." [[ouch]]

*Geomyces destructans* also infects[[ok?]] European bats — but it doesn't kill them, at least not in large numbers. Researchers can't yet explain the difference between continents, but they hypothesize that since European bats are generally larger and don't hibernate in groups, they experience the fungus as only a mild, easily contained irritation. (*Geomyces destructans* may well have swept through European caves in the distant past, leaving only bats that could withstand the fungus.) Researchers also don't know when and how the fungus made its way across the Atlantic, but speculate that it may be one of several recent examples of so-called "pathogen pollution," the inadvertent human transport of diseases into new and hospitable habitats.

Bats, with their undeserved association with creepy folktales, don't have much of a constituency. But bat biologists say the consequences of the North American bat dieoff

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stretch far beyond the bats themselves. For instance, one million bats — the number already felled by white-nose syndrome — consume some 700 tons of insects, many of them pests, every year. Fewer bats likely means more backyard mosquitoes, more garden aphids and more food-crop failures. A study published in *Science* this spring estimated that bat declines due to both white-nose syndrome and wind-energy development (bats often collide with fast-revolving windmills)[[or some quick explanation in case anyone isn't familiar with the mechanism]] could lead to $3.7 billion in U.S. agricultural losses every year.[[I forget, was this for current years, or some set time in the future? Or potentially, if WNS and Wind progress as they are expected to do?]]

With *Geomyces destructans* leaping further each winter, Barton, Slack and an array of other biologists are racing to understand the fungus in time to contain it. Since scientists aren't sure how easily humans can spread the fungus, many states have closed caves to cavers, and all are advising cavers to clean their gear between trips underground. Barton and her students have developed a solution of household cleaners[[can you give a sense of some of the ingredients? No need for a recipe, just a mention of one familiar element]] that kills *Geomyces destructans* without weakening caving ropes or harming clothing — a brew in use today at the Mammoth Cave visitor center.

But even as Barton, Slack and their colleagues patrol the perimeter of the disease, they acknowledge that white-nose syndrome is likely to continue its spread across the continent. To find out if and how bats might survive the epidemic, Barton has teamed up with another accidental white-nose expert — and ventured deep into infected territory.

"Who's going to live, and who's going to die?" asks DeeAnn Reeder. "That's the big thing I think about all the time." Reeder, a biology professor at Bucknell University in central Pennsylvania, spends her days surrounded by white-nose syndrome. *Geomyces destructans* thrives in nearby caves and mines, on many of the bats in her campus laboratories, and even on a set of petri dishes secured in an isolated laboratory refrigerator. Up close, the white-nose epidemic is more complicated than it first appears, for some bat species — and some individual bats — are proving more resistant than others. Reeder wants to figure out why.

Reeder never expected to study white-nose syndrome, but like Barton, she was perfectly prepared for the job. Fascinated by mammals since her childhood summers in the Sierra Nevada, she studied primate physiology early in her career, then switched to bats. At first, the reasons were practical — bats were easier to catch and sample in large numbers — but "I just fell in love with them," Reeder says. "They're so tough. I've always said that nothing will take them down, that they're completely resilient. And then we got this *fungus*," she says, shaking her head. "It caught us all off guard — and it caught them off guard, too."[[nice]]

After Reeder came to Pennsylvania in 2006, she outfitted her laboratory with a set of climate-controlled chambers, custom-designed to precisely mimic natural cave conditions. She and her students had just begun to collect data on bat hibernation patterns when white-nose syndrome emerged. Suddenly, biologists all over the continent had questions about how bats behaved during hibernation, and Reeder was one of the only researchers with anything close to answers. "They'd say, 'What do we know about hibernation?' and I'd say, 'Well, we know *this* much,'" says Reeder, holding a finger and thumb close together.[[excellent positioning of the characters]]

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Like Barton and the rest of the small corps of researchers pursuing white-nose syndrome, Reeder abruptly reoriented her career to deal with the disease. She and her students picked up the normally stately pace of science, running experiments in the field and lab as quickly as they could devise them. These days, the hallway outside her laboratory is crowded with worn backpacks and other well-used field gear, poised for the next trip underground. “Sometimes, I feel like a rat on an electrified grid,” she laughs.

[[If it is the case that the experiments you’re about to describe are the first attempts to protect bats from WNV, maybe take a sentence or graf here to say so. Emphasize that even though the disease just emerged, they’re already trying to find a cure. And this year, they ran the first crucial tests... something to add some tension-building background music and say, hey, this is really happening fast and it is really cutting-edge.]]

In Kentucky, Barton was also working overtime on white-nose syndrome, sampling skin secretions and hair from bats in Mammoth Cave and caves throughout the state. In her laboratory, she and her students cataloged naturally occurring antifungal compounds[[are these things secreted by bacteria or other microbes? Or the bats themselves? And does she know what sorts of compounds they are—certain enzymes, maybe? No need to go into detail, but maybe allude to the sort of compound that they had high hopes for]], identifying some that might protect vulnerable bats from the disease. But to test the most promising compounds, she needed something Kentucky didn’t yet have: sick bats.

Last fall, in southeastern Pennsylvania, Barton and Reeder donned Tyvek suits and belly-crawled into the depths of one of the oldest limestone mines in North America. There, they trapped more than 100 white-nose-infected bats and confined them in mesh enclosures, spraying each cage//bat with a different concentration of the antifungal compounds. They then left the bats alone to hibernate, hoping that some would survive until spring. They also repeated the experiment in Reeder’s lab, applying the compounds to infected bats in her hibernation chambers.

On a mid-March afternoon, while Barton is caving in China, Reeder makes a routine visit to the four laboratory hibernation chambers that house the treated bats. The chambers, which resemble bulky refrigerators, held 128 bats last fall. Now, three of the four chambers are empty and quiet, shut down after the last of their bats died last month. In the corner of the dimly lit room, in the only operating chamber, a single bat survives. Through a small window, it’s possible to see its silhouette, hanging motionless from the metal rack inside. Its furry body is no larger than a human thumb.[[your tone and choice of detail throughout are just haunting]]

Early the next morning, Reeder and her students travel through the rolling Pennsylvania countryside, headed for the limestone cave where Reeder and Barton caged bats last fall. The roadsides are dotted with gray stone houses and churches, reminders of the time when the area’s limestone caves provided shelter for people as well as bats.[[nice]] The mouth of the cave itself, tucked into a steep hillside above a two-lane highway, is blocked with a forbidding metal gate, designed to keep out vandals. Still, the entrance is littered with beer bottles, and just inside the cave, unevenly spray-painted on the clammy rock, is a message: “This is great.”

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Life is not so great for the bats in this cave, whose numbers have dropped from an estimated 10,000 two years ago to roughly 180 today. Reeder and her students zip up their Tyvek suits and pick their way through the fallen rocks on the floor of the cave, the beams of their headlamps cutting through the cool, misty half-dark. Little brown bats are hanging to the rocks, some alone, some in twos and threes, their fur glistening with moisture. Here and there, a dead bat lies on the ground, their bodies hardly more substantial than dried leaves. The crew counts 35 live bats hanging just inside the mouth of the cave, almost half with visible signs of white-nose syndrome. All are far closer to the outside world than they should be this time of year. Later, a few even flutter out of the cave, pale brown and reeling in the daylight.[[stunning imagery]]

The crew slips through a narrow horizontal slot on the side of the cave, crawling headfirst down a boulder-filled slope. There, more bad news awaits: The mesh cages Reeder and Barton set up last fall have been vandalized by raccoons, and all the treated bats inside have either escaped or been eaten. An entire season of data, lost to — raccoons! Among the researchers, the frustration is palpable, and the reactions are unprintable.[[nice—so human]]

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By the time she returns to the mouth of the cave, Reeder is philosophical. “I don’t do mopey very well,” she says. From her laboratory experiments, she already knows that the treatments they used can’t save bats from white-nose syndrome; at best, they may allow them to die more slowly. Perhaps different compounds, or higher concentrations of the same compounds, might boost survival, but those are questions for the next study.

In their ongoing search for patterns in the white-nose epidemic, Reeder and her students have found that bats in cooler conditions have significantly better survival rates. So it’s possible that humans could alter the climate in some Pennsylvania mines — by changing the shape of entrances to direct airflow, for instance — and create some white-nose refuges for bats. In Tennessee, conservationists are already planning to build an artificial cave for the same purpose, and in New Hampshire, biologists are studying bats that live in abandoned World War II-era bunkers, hoping that climate conditions in the bunkers might help some bats survive. And efforts have begun to breed rare bat species in captivity — so far with no success.[[just right to introduce all these other efforts here to take the sting out of the raccoon study]]

Even with such heroic measures, many species of North American bats will take generations to recover from white-nose syndrome — if they recover at all. “On my worst days, I feel like we’re working our tails off just to document an extinction,” says Reeder. “But somehow in really teasing apart all of this, in really understanding how they die and why, we may find something really important, something we didn’t predict, something that might help. So we just keep working.”

In Kentucky, Brooke Slack and her crew spent the winter repeating[[not sure what this means: they did it once, then a year later did it again? Or it’s an annual survey that takes many passes to complete? You might mean “completing//conducting their annual survey”]] their annual survey of nearly 100 Kentucky caves. The bat she had euthanized in Mammoth Cave tested negative for white-nose syndrome, and all their cave surveys came up clean. It looked like Kentucky bats had, against the odds, made it through another winter fungus-free. But in March, white-nose syndrome showed up in southern Ohio, and Slack decided to recheck a few sites near the Kentucky border — just to be

sure.

On April 1, in a cave in southwestern Kentucky, she found a bat with white fuzz on its muzzle. She sent it to a laboratory[[right, that's the cause of the week-later news?]] and a week later she got the news she'd anticipated, but dreaded, for the past three years: White-nose syndrome had finally arrived in Kentucky.

ENDER: BRING BACK TO BARTON AND WHAT'S NEXT.

[[if you do have a new ender, feel free to add it – but this one does work as-is.]]

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