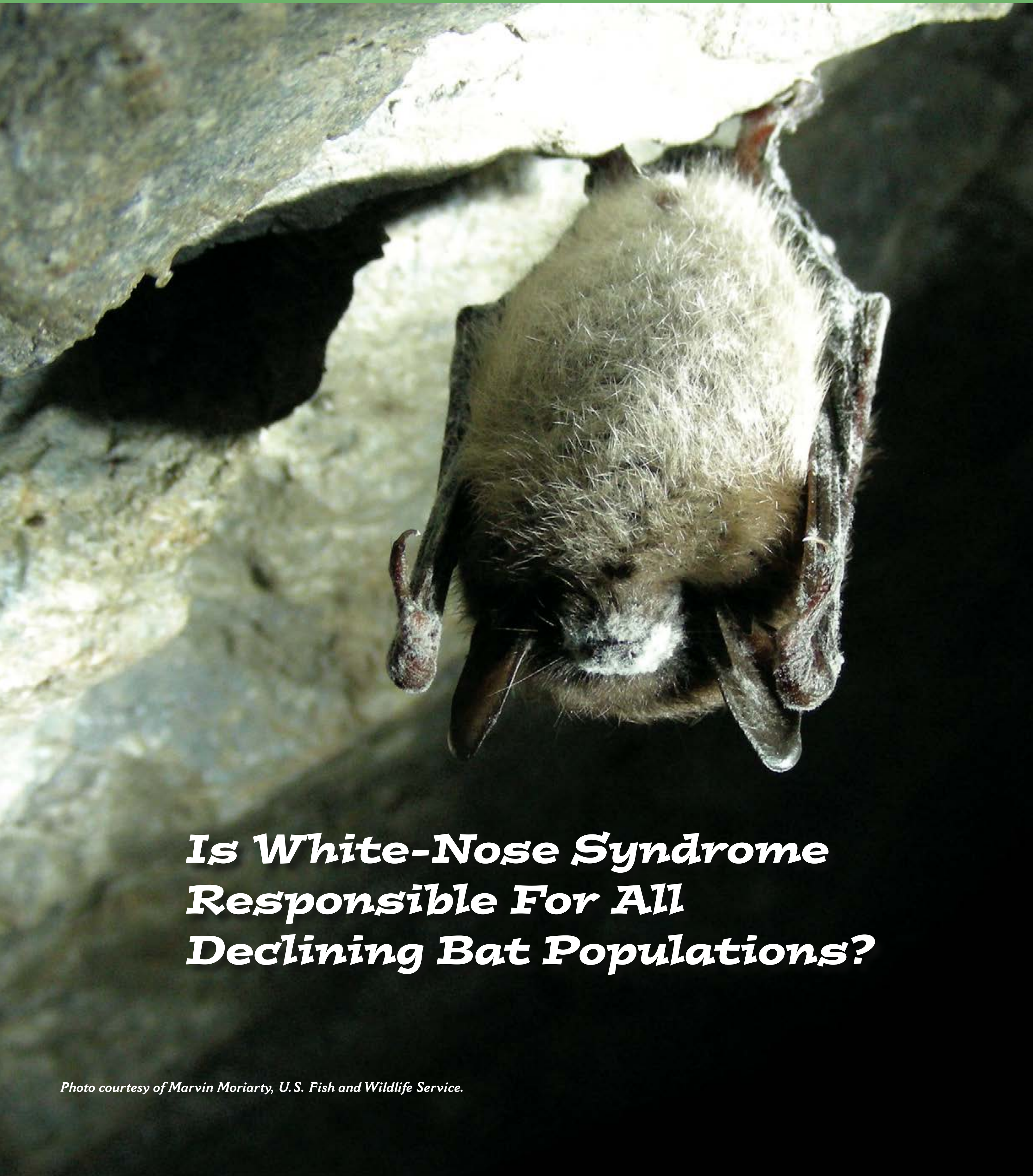
Cave Conundrum:

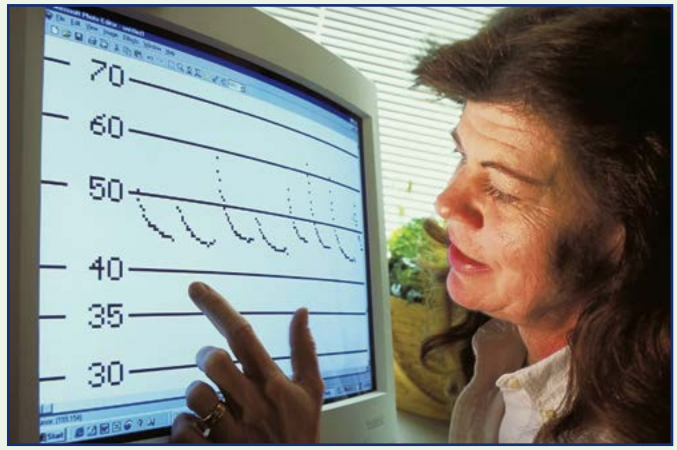


Is White-Nose Syndrome Responsible For All Declining Bat Populations?

Photo courtesy of Marvin Moriarty, U.S. Fish and Wildlife Service.

Meet the Scientist

▶ **Sybill Amelon**, Wildlife Ecologist: My most exciting science experience was discovering that even very small bats that weigh only 10 grams (about one third of an ounce) travel long distances every night. We found some species will travel 30 or more miles, one way, in their quest for food. This includes mother bats that have to feed themselves and return to their roost to feed their young periodically through the night.



▶ **Brent Sewall**, Biologist: My favorite science experience is discovering the secret worlds of animals. Many animals, like bats, are hard to find - they often are small, fly fast, move around in the dark, vocalize in frequencies beyond what we can hear, and hide in difficult-to-reach places like caves. With research, though, we can gain new insights into animals' amazing abilities and how they live their lives. Such insights inevitably lead to a greater understanding and appreciation of the incredible species with which we share the Earth.

What Kinds of Scientists Did This Research?

wildlife ecologist: This scientist studies the relationship of different kind of wildlife with each other and with their living and nonliving environment.

Biologist: This scientist studies living organisms and living systems.

Thinking About Science

Research questions in science often require a large amount of information to get an accurate answer. Sometimes, scientists discover that there is not enough information to get an accurate answer to a research question. To solve this problem, some scientists begin long-term research studies.

For instance, scientists may want to know how drought affects pine tree growth. First, they would want to know how pine trees grow in both non-drought years and drought years. They would need many years' worth of data to understand normal

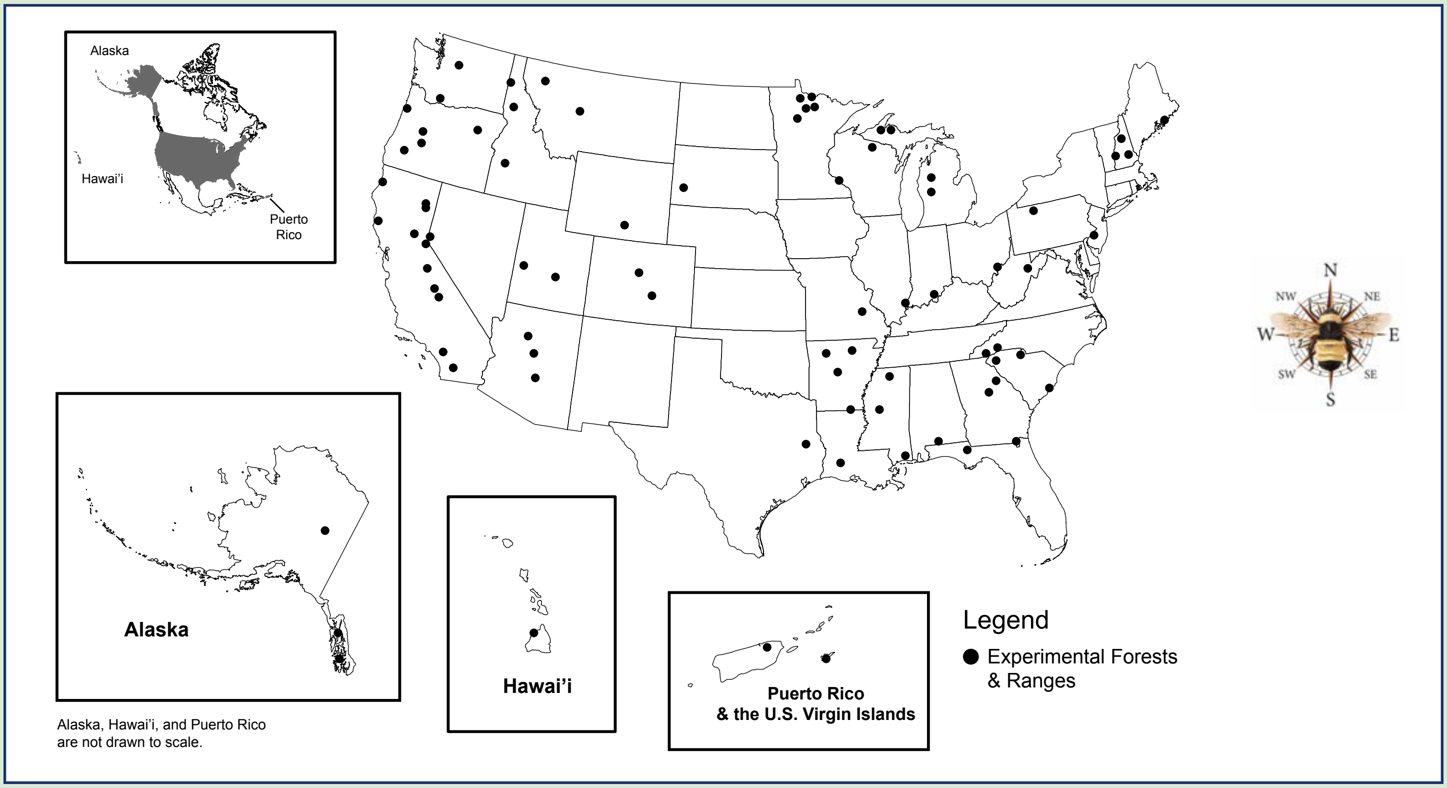


Figure 1. Today, 80 experimental forests and ranges are spread across the United States. Map by Carey Burda and Stephanie Pfeiffer.

pine tree growth before determining how drought might change that growth.

In 1908, the Forest Service recognized the need for long-term research sites. The Forest Service established a system of Experimental Forests and Ranges (EFRs) (**figure 1**). At these sites, scientists regularly collect information about the rainfall, soil, plant and animal populations, and other environmental conditions of the area. By recording these data over many years, EFRs provide a broad range of information that can help scientists answer complex, long-term research questions. Similarly, in this research about white nose syndrome, scientists needed to gather research over a longer period of time.

Thinking About the Environment

White-nose syndrome (WNS) is a disease affecting hibernating bat populations. The disease is named for the white fungus that collects on the muzzle and other parts of infected bats (**figure 2**).

The disease was first introduced in New York in winter of 2006. Since the time WNS was first introduced, the disease has spread to caves and

Figure 2. Scientists can identify WNS on bats from the white fungus that develops on the bat's nose and damaged skin on the bat's body. Photo courtesy of Jonathan Mays, Maine Department of Inland Fisheries and Wildlife, via U.S. Fish and Wildlife Service.

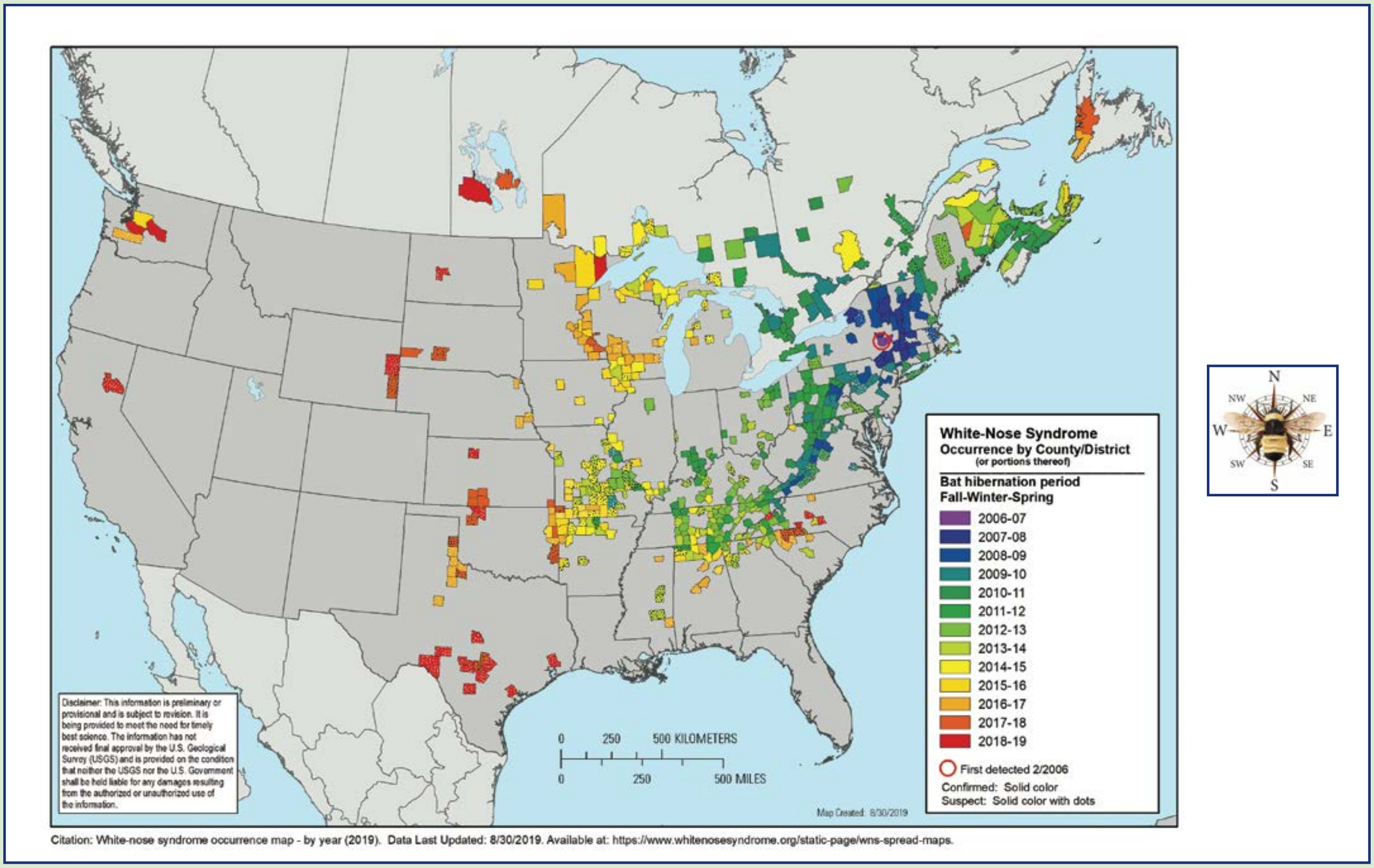


Figure 3. Since its introduction in New York in 2006, WNS has spread across the Eastern United States as well as other areas. Map courtesy of U.S. Fish and Wildlife Service, via https://www.whitenosesyndrome.org.

mines across 33 States and 7 Canadian provinces. WNS has killed an estimated 6 million bats in the Eastern United States and Canada (**figure 3**). At some sites, 90 to 100 percent of bats have died from WNS infection.

Scientists are dedicated to understanding and combatting WNS because bats are important to the ecosystems in which they live. In some ecosystems, plants rely on bats to pollinate flowers or spread seeds. Bats, the only free-flying mammal, are also an important **indicator species** that signal changing conditions in an ecosystem. Some bat species are **insectivores**, and act as a natural method of pest control in their environment.

Number Crunches

- How many years has it been since WNS was first introduced in New York?
- Write out 6 million in numeric form.

Introduction

Hibernating bat populations across the Eastern United States have suffered declines since the 2000s. Little brown bat populations have declined 70 percent or more. Populations of the northern long-eared bat and tricolored bat have declined by 30 percent **(figures 4, 5, and 6)**. The scientists studied these three bat species in their research.

The cause of bat population declines is often assumed to be WNS, a deadly disease caused by a fungal **pathogen.** Evidence suggests WNS is a serious threat to bat populations. However, research has not yet supported WNS as the only cause of bat population

Figure 4. The little brown bat is small, usually weighing less than half an ounce. Photo courtesy of Marvin Moriarty, U.S. Fish and Wildlife Service.

Figure 5. Northern long-eared bats are known for their especially long ears. Photo courtesy of U.S. Fish and Wildlife Service.

declines. Therefore, the scientists in this study asked: Is WNS the sole cause of these bat population declines, or is there something else causing bat populations to decline?

The scientists hypothesized that if WNS is the sole cause of decline in bat populations, then the following conditions will be true:

- Only bat populations infected with WNS will experience declines;
- Declines in bat populations will happen later at caves farther from where WNS was discovered; and
- Bat populations will begin declining shortly after WNS infects a colony.

Reflection Section

- Diseases like WNS are one cause of decline in animal populations. What are some other things that might cause an animal's population to decline?
- WNS is caused by a fungus. What are some other types of fungi you know of?
- How do you think WNS spreads between bats?

Figure 6. Tricolored bats, like the one pictured, rest in dead leaves or the needles of trees. Photo courtesy of Pete Pattavina, U.S. Fish and Wildlife Service, via https://www.flickr.com/.

Figure 7. Many species of bats hibernate throughout winter in caves, mines, and other cold, dark places. These sites are called **hibernacula** (**hī** bər **na** kyə lə). Photo courtesy of Keith Shannon, U.S. Fish and Wildlife Service, via http://www.flickr.com.

Methods

To test their ideas, the scientists needed to know how bat populations have changed before and after WNS was introduced. They needed a large amount of information about bat populations over a period of many years to understand population trends. They used data collected by State wildlife agencies in New York, Pennsylvania, West Virginia, and Tennessee. These data were gathered during regular surveys of bat hibernacula during winter every 2 years between 1999 and 2011 (**figure 7**). Biologists visited the same hibernacula to collect data on the location of caves, the number of bats, and presence or absence of WNS (**figure 8**)

Figure 8. During the surveys, biologists found WNS present in approximately 44-48 percent of the routes they surveyed for all three species. Photo courtesy of Gary Peeples, U.S. Fish and Wildlife Service, via http://www.flickr.com.

Reflection Section

- Biologists collected the same data every 2 years. Why is it important to have routine methods in an experiment?
- Why do you think the scientists used scientific models in this study instead of designing an experiment to do in the field or in a lab?
- If the scientists' models were different from the real trends in bat populations, what might that tell you about the relationship between bat population declines and WNS?

The scientists graphed the population trends of each bat species in each State using the data. They also graphed the expected scenarios, or models. These models illustrated how the bat populations would change over time if all three of the hypothesized WNS conditions were present. By comparing the results of the models with the graphs of actual population trends, the scientists were able to evaluate whether the hypothesized conditions were true.

How Do Scientists Detect WNS?

When scientists survey caves, they look for signs of WNS. Visible signs of WNS include skin damage, white fungus on the bats' noses, and the number of dead bats in the cave. However, these visual methods are not always an accurate way to detect WNS. New research has found a way to detect a WNS infection using a certain range of light. Ultraviolet light, which is invisible to the human eye, makes the skin damage caused by WNS glow an orange-yellow color. A study showed this method was 98.8 percent effective at positively detecting WNS, and it provides a new, reliable way to identify WNS on bats.

Source: "Black-Light Detects White-Nose Syndrome in Bats," by U.S. Geological Survey. For more information, visit https://www2.usgs.gov/envirohealth/cbp/headlines/2014-09-11-uv_tool.html

How Do Scientists Make Models?

You probably have seen toy cars and airplanes that look just like the real thing, only smaller. These toys are actually models, or simplified **representations** of a larger item. Models are used frequently in our day-to-day lives to help people see and understand large objects, concepts, and processes.

Scientists also use models when a scientific research question is too big or too complicated to answer. In these situations, scientists may use scientific modeling. A scientific model uses data to represent complex scientific concepts in a simpler way. In the case of this study, the scientists used models to better understand how a disease, like WNS, affects bat populations.

Models are useful tools for scientists, but they are only as good as the data that are put into them. The scientists in this study used data taken from four States across 11 years. Using this quantity of data helped the scientists increase the likelihood that their model would give them an accurate representation of the bat populations they were studying. In the table below, the total numbers of surveys conducted, routes traveled, and individual bats counted are shown. The scientists used this information to build their model (**table 1**).

Table 1. This table shows the set of data the scientists in this study used to make their model.

	Number of Surveys Conducted	Number of Routes Traveled	Number of Individual Bats
Little brown bat	577	145	982,974
Northern long-eared bat	460	109	5,206
Tricolored bat	576	145	68,148

Findings

The scientists compared the modeled and real population patterns. The data showed all three of the bat species met at least one of the three hypothesized conditions. However, none of the species met all three conditions (**table 2**).

Results indicate that certain bat populations were declining before WNS was discovered in those populations. Other bat populations were experiencing a population increase that continued despite WNS infection.

Table 2. This table shows whether or not the modeled bat populations met the three hypothesized conditions.

Hypothesized Condition	Little brown bat	Northern long-eared bat	Tricolored bat
1. Only bat populations infected with WNS will experience declines	**No**; Bat colonies with and without WNS experiences similar population changes	**No**; Bat colonies with and without WNS experiences similar population changes	**Yes**; Bat colonies with WNS declined more severely than bat colonies without WNS
2. Declines in bat populations will happen later at caves farther from where WNS was discovered	**No**; Patterns varied greatly by region, though most areas experienced declines	**Yes**; Declines were slower and less severe further from the point of WNS introduction	**No**; Declines did not vary with distance from the point of WNS introduction
3. Bat populations will begin declining shortly after WNS infects a colony	**Yes**; Onset of bat population declines matched local detection of WNS within 1 year	**No**; Bat population declines began before local detection of WNS by 10+ years	**No**; Bat population declines began before local detection of WNS by 3-7 years

Reflection Section

- The results for two populations of northern long-eared bat showed little or no negative impact since WNS was detected in those areas. What do you think are some potential explanations for these results?
- Think about the methods the scientists used to get these results. What are some potential sources of error that could affect the results?
- What do you think it means that several of the populations were experiencing declines for years before WNS was discovered near them?

Discussion

The results of the study support the idea that WNS is an important cause of decline of bat populations in the Eastern United States. However, the results indicate that WNS is not the only cause of decline. Most efforts to aid bat populations have focused on preventing **transmission** of WNS by humans (**figure 9**). However, WNS also is often transmitted through non-human means, like one bat contacting and infecting another bat.

The findings in this research also suggest that there are other important causes of decline that may be overlooked. Other potential sources of **mortality** include agricultural pesticides and chemicals, climate change, collisions with human-built structures and vehicles, and habitat loss or **degradation** of habitat. These results suggest that scientists should continue to combat WNS while also addressing other threats to bat populations.

Figure 9. Federal and State agencies close caves where endangered bats hibernate to prevent disturbance from human visitors. Photo courtesy of Ann Froschauer, U.S. Fish and Wildlife Service, via https://www.flickr.com/.

Reflection Section

- How might humans contribute to the spread of WNS?
- How does habitat degradation affect hibernating bats?
- What are some ways scientists could combat the other threats to bat populations?

Glossary

degradation (**de** grə **dā** shən): The act of impairing or bringing to a lower level of quality.

hibernacula (**hī** bər **na** kyə lə): Shelters occupied during the winter by a hibernating animal.

indicator species (**in** də **kā** tər **spē** shēz): Type of plant or animal that serves as a measure of the environmental health of an area.

insectivore (in **sek** tə vȯr): An organism that feeds mainly on insects.

mortality (mȯr **ta** lə tē): Death of an organism or organisms.

pathogen (**pa** thə jən): An organism or other agent that causes disease.

representation (re pri zen **tā** shən): A likeness, picture, image, etc.

route (**rau̇t**): An established, selected, or assigned course of travel.

transmission (tran(t)s **mi** shən): The process of transferring from one person, animal, or place, to another.

*Accented syllables are in **bold**. Marks and definitions are from http://www.merriam-webster.com.*

Definitions are limited to the word's meaning in the article.

Adapted from Ingersoll, Thomas E.; Sewall, Brent J.; Amelon, Sybill K. 2016. Effects of white-nose syndrome on regional population patterns of 3 hibernating bat species. Conservation Biology. 30(5): 1048-1059.

FACTivity

Time Needed

One class period

Materials

(for each student or group of students)

- Cave Conundrum Graphic Organizer
- Writing utensil

In this FACTivity, you will predict and observe how diseases spread in populations. Over one class period, you will simulate the spread of the "flu" in your class over 5 days of school.

Methods

Your teacher will divide the class into small groups of four to five students. Your teacher will select one student to "have the flu," and designate a "sick" area where students will go if they become "sick." You will participate in two simulations with five rounds each. In each simulation, you will predict and simulate how the flu will spread throughout your class over the course of 1 "week." When a classmate becomes "sick," he or she should move to the designated "sick" area of the room at the beginning of the next round. Cross out each day on the chart as the round ends.

Before you begin, discuss how you think the "flu" will spread throughout the class over the course of 1 week. How many and which students will be left in class by Friday? We can hypothesize what will happen using these three assumptions:

1. Only students who interact with the "sick" student will get the "flu,"
2. The students who sit nearest to the "flu" student will contract the "flu" first, and
3. Students who interact with the "sick" student will have the "flu" the next day.

Write your predictions about how the "flu" will spread in your class in the "Simulation One" section of the graphic organizer before each round. As the activity progresses, remember to write down what did happen in each round.

Simulation 1

1. **Monday (Round 1):** The student with the "flu" will shake hands with two students nearest them, "infecting" them. The original "sick" student should go to the designated "sick" area.
2. **Tuesday (Round 2):** The students who shook hands with the original "sick" student with the "flu" are "infected." These two "sick" students should shake hands with two more students closest to them, then go to the designated "sick" area with the original student.
3. **Wednesday and Thursday (Rounds 3 and 4):** Repeat the process for these two rounds. The "sick" students from previous rounds will stay in the designated "sick" area. The newly "infected" students should shake hands with the two students nearest them, then go join others in the designated "sick" area.
4. **Friday (Round 5):** Repeat the process one more time. Those four students "infected" in this last round can go immediately to the "sick" area.

At the end of Round 5, observe how many students are in the designated "sick" area and where they sat in relation to the original "sick" student. Record these observations in the "Simulation One" section of your graphic organizer. Write down what happened in each round.

▶

Simulation 2

Before starting Simulation Two, all students will close their eyes. Your teacher will secretly tap five students on the head, and if you are selected, you need to keep it a secret from other students. If you were tapped on the head, you received a "flu shot."

What do you think will happen during Simulation Two if some students have a "flu shot?"

Repeat the steps of Simulation One. However, in Simulation Two the kids with "flu shots" do not get "sick" or go to the "sick" area when they shake hands with an "infected" student. Instead, these students will remain in the game as if nothing happened.

Also, "sick" students can now choose to infect any student in the room, not just those nearest to them.

Once again, keep track of the results of each round in your graphic organizer. How many kids are "sick" at the end of the last round? Where did those "sick" students sit in relation to the original "sick" student?

Now, compare and contrast the results of Simulation One with those of Simulation Two. Were there more healthy students in one simulation than in the other? Did you notice any different patterns between the two simulations? Write your answers and observations in the graphic organizer.

This simulation is similar to how scientists create and use models. They use known facts to create logical predictions about a situation, the spreading of disease in this case, to predict what will likely happen. However, like the students with "flu shots," exceptions create differences between the modeled result and the actual result. We would expect students who sit near the "sick" students to be "infected" first, but a sick student may choose to go visit and "infect" a friend who doesn't sit close by in class. This interaction creates another difference between the assumption we used to make our predictions and the real number of students left at the end of the simulation.

What does this activity tell you about the use of models in science? How can models be helpful? What are some challenges of using models? How does this FACTivity compare with what you learned in the "Cave Conundrum" article?

Name: ______________________________

Cave Conundrum Graphic Organizer

Simulation One	Day 1	Day 2	Day 3	Day 4	Day 5
What do you think will happen?					
What happened?					

Simulation Two	Day 1	Day 2	Day 3	Day 4	Day 5
What do you think will happen?					
What happened?					

Compare and contrast the results of Simulation One and Simulation Two:

Natural Inquirer Connections

You may want to reference these *Natural Inquirer* resources for additional information and FACTivities:

- For more information on bats, read "The Trees Have Gone Batty! How Bat Scat Helped Restore a Tropical Forest" in the *Natural Inquirer* Tropical edition.
- For more on fungal pathogens, read "Moving Spore-adically: The Spread of Sudden Oak Death in California Forests" in the *Natural Inquirer* Invasive Species edition.

These resources, along with others, can be found at http://www.naturalinquirer.org/all-issues.html.

If you are a trained Project Learning Tree educator, you may use "Life on the Edge," "Dynamic Duos," "Our Changing World," and "Earth Manners" as additional resources.

What's in a Name?

This article's title, "Cave Conundrum," refers to the conundrum WNS presents to scientists. A conundrum is a confusing or difficult problem.

Web Resources

Science News for Students: An enemy in the cave *https://www.sciencenewsforstudents.org/article/enemy-cave*

USDA Forest Service: Fighting the Battle for the Bats Story Map *https://usfs.maps.arcgis.com/apps/MapJournal/index.html?appid=82d483795c1e45c89f3378554e062ad2*

USDA Forest Service: Battle For Bats: Surviving White-Nose Syndrome (video) *https://vimeo.com/76705033*

National Geographic: These Bats Mysteriously Survived a Killer Fungus (video) *http://video.nationalgeographic.com/video/news/150527-bats-whitenose-survivors-vin*