Last Bat Standing – Protecting Threatened and Endangered Species

EXPLORATION QUESTIONS

What changes in the environment can disrupt an ecosystem and threaten the health and survival of wildlife populations? What makes it important to conserve species that are threatened or endangered?

MATERIALS

- Copies of Fact Sheets (Northern Long-eared Bat and White-Nose Syndrome) and Student Worksheets (Part One and Part Two)
- Working as a large group (up to 140 students) - 140 small counting chips (or paperclips, popsicle sticks, plastic bat rings, or other small items) that can be easily spread out and collected
- Working in small groups (5 students or more) 140 counting chips for each group

OVERVIEW

Students will review a brief history of the northern long-eared bat and its drastic population decline due to White-Nose Syndrome (WNS). They will participate in a simplified simulation of how WNS contributes to the decrease of the bat's population and discuss the results of the simulation.

Students will research an additional threatened or endangered bat species from their area and develop their own model to illustrate the decline of their selected species. They will also present an argument for conserving the species.

VOCABULARY

Anthropogenic, biodiversity, ecosystem, endangered, extinction, habitat, model, simulation, threatened

GROUP SIZE

5-140

AGE

13 and above

Background

Read the fact sheets on the northern long-eared bat and White-Nose Syndrome included in this packet. As illustrated by the northern long-eared bat's story, it is sometimes possible to identify a single threat (White-Nose Syndrome) that plays the most significant role in reducing a wildlife population. However, rarely would a single factor be solely responsible for a population decline. Typically, a combination of factors, with some factors having more weight than others, contributes to a decline. Such factors can be natural or anthropogenic (caused by humans). An example of a natural threat to a bat species would be the collapse of a cave entrance which blocks access to the cave. An anthropogenic threat would be the removal of trees or other habitat components for the development of a shopping center or housing complex.

Scientists might initially consider factors individually, attempting to understand the impact that the single factor has on a population. However, it is ultimately necessary to combine these factors into a more complex model to predict how the population will fare over time.

In this lesson, students develop and use models that can explain and predict changes to populations that are influenced by multiple factors. The lesson is begun by presenting students with an already-developed simulation of a single, isolated factor (White-Nose Syndrome) which has caused a precipitous decline of the northern long-eared bat.

Following the use of this simulation, students will discuss its accuracies and limitations. Students will then research a different threatened or endangered bat species (preferably from their local area) that is of current conservation concern. After completing their research, they will design a more accurate, complex model that considers the role of multiple factors, focusing on their selected bat species.

Sixth Mass Extinction

There is a need for fast action to conserve threatened wildlife species, populations, and habitats and our window of opportunity may be quickly closing. Although scientists cannot say exactly how many species have gone extinct in any time interval, we can confidently conclude that modern extinction rates are exceptionally high, they are increasing, and they suggest a mass extinction of plants and animals is under way—the sixth of its kind in Earth's 4.5 billion years of history. Of course, this is the first one to be driven by human activities.

Extinction is a natural part of life on Earth. Over the history of the planet, most of the species that ever existed, evolved, and then gradually went extinct. Typically, species go extinct because of natural shifts in the environment that take place over long periods of time, such as ice ages. Yet, today, **species are going extinct at an accelerated and dangerous rate**, because of environmental changes caused by human activities. Human actions may have direct effects on species and ecosystems (directly taking an organism's life) or indirect effects (not directly taking an organism's life, but impacting the organism's ability to survive; e.g. reducing suitable habitat).

Although extinction is a natural phenomenon, it occurs at a natural "background" rate of about one to five species per year. Scientists estimate that we are now losing species at 1,000 to 10,000 times the natural "background" rate. Literally dozens of species are going extinct every day and as many as 30 to 50 percent of all species could be headed towards extinction by mid-century.

Importance of Biodiversity

Biodiversity is a term that refers to the variety of life on Earth at all levels. Biodiversity includes all species – not just those that we consider rare. Biodiversity also includes the variation of genes that exists within species, as well as the diversity of entire habitats and ecosystems.

Biodiversity is extremely important for human health and the health of ecosystems. As species disappear, so do crucial ecosystem services such as crop pollination by honeybees, consumption of agricultural insect pests by bats, water purification by wetlands, and the potential for new medical discoveries with the loss of plant and animal species. At the current rate of species loss, people will lose many biodiversity benefits within three generations.

Threatened and Endangered Species

Congress passed the Endangered Species Act in 1973 to provide a means for listing native plant and animal species as threatened or endangered to provide them protection. "Endangered" means a species is in danger of extinction throughout all or a significant portion of its range. "Threatened" means a species is likely to become endangered within the foreseeable future. All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened.

Congress recognized that our rich natural heritage is of "esthetic, ecological, educational, recreational, and scientific value to our Nation and its people." They further expressed concern that many of our nation's native plants and animals were in danger of becoming extinct. The purpose of the Endangered Species Act is to protect and recover imperiled species and the ecosystems upon which they depend.

Species may become threatened or endangered for many reason. Some possible causes include:

1. Destruction or modification of habitat or range;
2. Overuse for commercial, recreational, scientific, or educational purposes;
3. Disease or predation;
4. Restriction to a relatively small area, such as an island;
5. Specialized diet or habitat requirements; or
6. Being a long lived species with low reproductive rates.

Bats are in decline nearly everywhere they are found. In the United States, nearly 40 percent of our bats are endangered or are considered at risk. For example, gray bats were among our most abundant mammals just a century ago. Now, they are federally endangered which means they are in danger of extinction within the foreseeable future.

<u>Get Ready – Background Activities</u>

1. Assess your students' knowledge of extinction by asking questions such as:

What is an extinct species?
What are some reasons that animals and plants become extinct?
Is all extinction natural?
Do humans cause problems that can affect the survival of wildlife species?

2. Explain that although extinction is a natural process, human activities have greatly accelerated the rate of extinction in modern times. Human actions may have direct effects on species and ecosystems (directly taking an organism's life) or indirect effects (not directly taking an organism's life, but impacting the organism's ability to survive; e.g. reducing suitable habitat).

3. Ask students if they know of any species that have been federally listed as threatened or endangered under the Endangered Species Act.

Clarify the difference between an endangered and threatened species. An endangered species is a plant or animal that is in danger of becoming extinct in the very near future throughout all or a significant portion of its range. A "threatened species is a plant or animal that is likely to become endangered within the foreseeable future. All species of plants and animals, except pest insects, are eligible for listing as endangered or threatened. Discuss some of the listed species that students have heard of or that have been in the news.

4. Hand out the "Northern Long-Eared Bat Fact Sheet" and the "White-Nose Syndrome Fact Sheet." This background reading assignment can be done in class or may also be given as a homework assignment. Have the students highlight or underline sections of the fact sheets that may indicate items that could make the northern long-eared bat (or other bats) susceptible to becoming threatened or endangered.

5. Tell the students that they are going to learn more about the devastating disease that is killing bats in the United States and Canada as they hibernate in caves and mines. Play the short film (14.5 minutes), "Battle for Bats: Surviving White-Nose Syndrome" (available at http://vimeo.com/76705033). While watching the video, have students write-down additional items that make WNS so deadly to bats at the bottom of the "White-Nose Syndrome Fact Sheet."

6. Tell your students that they are now going to participate in a simplified simulation of how White-Nose Syndrome has contributed to the decline of the northern long-eared bat and its listing as threatened under the Endangered Species Act.

Get Set – Set Up Simulation

1. This activity can be done as one large group or students can be divided into smaller groups (each with at least five students). For each group, place 100 small counting chips (or paperclips, popsicle sticks, or other small items that can be easily spread out and collected) on a front table or central table. Place a container with an additional 40 chips near the table. Note, only five students will be "infecting" bats during their each simulation. Place a container with an additional 40 chips near the table. Note, only five students will be "infecting" bats during each simulation. However, you can change the students for each new round to increase participation.

2. Provide students with copies of the Student Worksheet – Part One (Pages 7-10).

GO! – Simulation Activity – Part One

1. Have the students write down their name at the top of the sheet and then work through the directions.

2. Review the "Things to think about while we do the simulation."

3. As a whole group or in small groups, complete the simulation activity.

4. Ask students to make notes about how the simulation does and does not reflect a real-life situation at the bottom of their worksheet.

5. Have students answer the discussion questions. Allow time for small groups and/or whole group discussion about their answers.

Go Even Further – Simulation Activity and Bat Research – Part Two

1. Divide students into small groups. Each group will choose a threatened or endangered bat species (preferably local) for research and model development. State departments of natural resources should have a list of all state-listed threatened and endangered species. Or, students could select a species from the list on pages 19-20 which includes all federally listed species in the United States. Please note, some basic background has been added to the table for your use and should not be shared with students.

2. Provide students with a copy of the "Bats at Risk" Worksheet (pages 14-18). Students will use the links included on the worksheet, as well as library and internet resources to research their bat species.

3. After completing their research, students will develop their own simulation/model to show how multiple factors are causing the decline of their selected bat species. Challenge the students to make their model more complex than the northern long-eared bat simulation. Remind students that

their models should include at least two factors that influence the bat population. They should also describe the model's limitations and accuracies.

4. Each group will present a brief overview of their species and model to the class based on the information they gathered during their research including the following:

- an argument for why the bat species is important,
- threats facing the bat species,
- imitations of their model, and
- conservation strategies that may increase the population of their selected bat species.

If students are having difficulty finding information on a lesser known species, they may wish to bolster their research by looking at other similar species.

Reflect – Student Evaluation – Part One

1. Complete the modeling section of the student worksheet. Provide correct and thoughtful answers to questions.

2. Complete the discussion section of the student worksheet. Provide correct and thoughtful answers to questions. Participate in small group/whole group discussions.

Reflect – Student Evaluation – Part Two

1. "Bat Species at Risk" Worksheet complete

2. Working model of bat population decline, including at least two factors contributing to the decline, and a discussion of the limitations and accuracies of the model.

3. Conservation factors and arguments complete; arguments are persuasive

4. Outline of presentation about conserving a bat species

5. Identification of feasible conservation strategies.

Further Reading and Resources – Discover More

About Bats:

BatsLIVE: A Distance Learning Adventure – http://batslive.pwnet.org

Bats in Your State - Species Profiles - http:/www.batcon.org/index.php/resources/media-education/species-profiles

Hanging Around with Bats - http://www.tpwd.state.tx.us/learning/resources/keeptexaswild/bats/

Northern Long-Eared Bat Fact Sheet - http://www.fws.gov/midwest/endangedred/mammals/nleb/nlebFactSheet.html

About Threatened and Endangered Species:

U.S. Fish and Wildlife Service – Endangered Species - http://www.fws.gov/endangered/

About the Sixth Mass Extinction/Extinction:

Science Advances - http://advances.sciencemag.org/content/1/5/e1400253.full

Standford News – http://news.stanford.edu/news/2015/june/mass-extinction-ehrlich-061915.html

About White-Nose Syndrome:

Battle for Bats: Surviving White-Nose Syndrome - http://vimeo.com/76705033

National White-Nose Syndrome (WNS) Website – http://whitenosesyndrome.org/

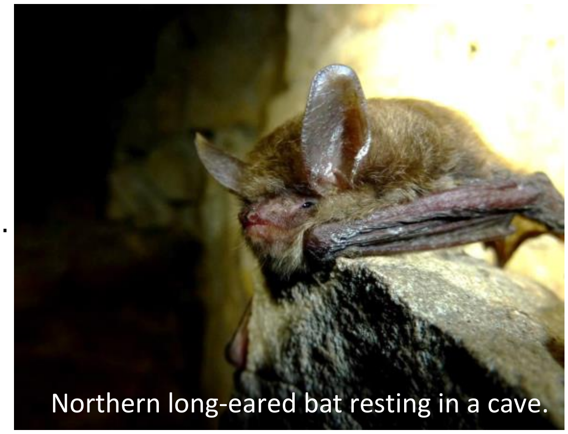
National Wildlife Health Center – http://www.nwhc.usgs/disease_information/white-nose_syndrome

Go Even Further – Additional Activities

Here is an additional activity that you can do with your students to make the first simulation more realistic. Start with 50 chips of one color to represent males and 50 chips of another color to represent females. Have students that are infecting bats pull out chips while wearing a blindfold (disease is random). When baby bats are added back in, selection of chips to be added back in are also random. See how changes in sex ratio affect the simulation. In a mammal population, reproductive potential is often determined by the number of females. Note that reproduction would stop if either the female or male population dropped to zero. There must be at least one male and one female. The simulation could continue, but extinction would be inevitable.

Northern Long-Eared Bat Fact Sheet

The Bat: The northern long-eared bat (*Myotis septentrionalis*) has a body length of 3 to 3.7 inches and a wingspan of 9 to 10 inches. This bat's fur can be medium to dark brown on the back and tawny to pale-brown on the underside. And, as its name suggests, this bat is distinguished by its long ears, particularly as compared to other bats in its genus, *Myotis*. The ears, when pushed forward, extend at least 4 mm past its nose. Northern long-eared bats feed in forests and tree-lined corridors, feeding on insects, which they catch while in flight. They also feed by gleaning motionless insects from vegetation and water surfaces.



Northern long-eared bat resting in a cave.

Photo by U.S. Fish and Wildlife Service

The Status: The northern long-eared bat is federally listed as threatened under the Endangered Species Act. Threatened species are animals and plants that are likely to become endangered in the foreseeable future.

Winter Habitat: Northern long-eared bats spend the winter hibernating in caves and mines, called hibernacula. They select various sized caves or mines with constant temperatures, high humidity, and no air currents. Within hibernacula, biologists find them hibernating most often in small crevices or cracks, often with only their nose and ears visible.

Summer Habitat: During the summer, northern long-eared bats roost singly or in colonies underneath bark, in cavities, or in crevices of both live and dead trees. Males and non-reproductive females may also roost in cooler places, like caves and mines. Northern long-eared bats seem to be flexible in selecting roosts, choosing roost trees based on the ability of the tree to retain its bark or to provide cavities or crevices. Northern long-eared bats rarely roost in human structures like barns and sheds.

Reproduction: Breeding begins in late summer or early fall when males begin to group near hibernacula. After copulation, females store sperm during hibernation until spring when they emerge from their hibernacula. After emerging, they ovulate and the stored sperm fertilizes an egg. This strategy is called delayed fertilization. After fertilization, pregnant bats migrate to summer areas where they roost in small colonies (called maternity colonies) and give birth to only a single pup each year. Maternity colonies of females and young generally have 30 to 60 bats at the beginning of the summer, although larger maternity colonies have also been observed. Most bats within a maternity colony give birth around the same time, which may occur from late May to late July, depending on where the colony is located within the species' range. Pups are born hairless and unable to fly. The pup begins to fly about 18 to 21 days after birth. Young bats have a high rate of mortality, just after weaning, when they begin flying greater distances and spending more time away from their roosts each night. The maximum lifespan for the northern long-eared bat is estimated to be up to 18.5 years.

The Threat: No other threat is as severe and immediate as White-Nose Syndrome. If this disease had not emerged, it is unlikely that northern long-eared bat populations would be experiencing such dramatic declines. Since symptoms were first observed in New York in 2006, White-Nose Syndrome has spread rapidly across the core of the northern long-eared bat's

White-Nose Syndrome Bat Fact Sheet

A bat infected with White-Nose Syndrome

Photo by U.S. Fish and Wildlife Service

The Disease: White-Nose Syndrome (WNS) has killed over six million bats in just six years. The disease is killing bats as they hibernate in caves and mines. Named for a cold-loving, white fungus typically found on the faces and wings of infected bats, WNS causes bats to awaken more often during hibernation. As a result, they use up their stored fat reserves which are needed to get them through the winter when insects are not available. Affected bats often emerge too soon from hibernation and are seen flying around in winter. These bats usually freeze or starve to death. Scientists identified a previously unknown species of cold-loving fungus, *Pseudogymnoascus destructans*, as the cause of the skin infection. *Pseudogymnoascus destructans* thrives in low temperatures (40–55° F) and high humidity – conditions commonly found in caves and mines where bats hibernate.

Alarming Death Rate: The impact of WNS is frightening! Up to 99% of bats in some WNS-infected populations die within a few years. Little brown bats, once the most common bat in the northeastern United States, may be in danger of regional extinction within the next 15 years.

The fungus invades the surface of the bat's skin, causing damage to the underlying connective tissue, blood vessels, and muscles. Bats may be infected with the fungus for a period of time before they show visible signs of the disease. In severe cases, holes and tears can occur in the wing membrane due to extensive cellular damage. Bat wings comprise 85% of the bat's body surface and are important for controlling body temperature, blood circulation, water balance, and gas exchange. Damage to the wing membrane not only inhibits flight, but more importantly disrupts crucial physiological functions during hibernation. Disruption of these vital processes due to WNS leads to life-threatening dehydration, electrolyte imbalances, and acid-base disturbances. Bats are usually able to fight off infection during the summer when they are active, but their immune system is greatly reduced during hibernation.

The Spread: First detected in New York in the winter of 2006-2007, WNS has spread south through the Appalachian Mountains and into the Southeast, north through New England and into eastern Canada, and west into the Great Lakes region and the Midwest. There is great concern that WNS will continue to spread across North America. The effects of WNS on North American bat populations has led the U.S. Fish & Wildlife Service to consider listing several of the most affected bat species for either threatened or endangered species status.

Other Threats to Bats: White-Nose Syndrome is just one of many threats that face bat populations. Other threats include habitat loss, pesticide use, wind energy development, oil and gas exploration, residential and industrial development, disturbance of hibernating bats, and improper eviction of bats from buildings. There is an urgent need to protect our bats!

Other Items That Could Make Bats More Susceptible to WNS: ________________________

____

Student Investigation Worksheet – Part One
Simulation: Modeling Northern Long-Eared Bat Population Decline

Name ____

You will simulate how White-Nose Syndrome (WNS) contributed to the decrease in the northern long-eared bat population.

How to do the simulation:

- Each round begins with 100 northern long-eared bats (100 chips on our front table).
- Five students will be selected from each group to represent the fungus that causes WNS. These students will “infect” bats with the fungus that causes WNS as they hibernate in caves and mines at the noted infection rate. All infected bats will die and the student representing the fungus will remove these bats (chips) from the table.
- Each round will have a different infection rate (Round 1: 2 infections per student; Round 2: 5 infections per student; Round 3: 10 infections per student; and Round 4: 15 infections per student).
- The remaining bats (chips) at the end of the round will form breeding pairs (two bats).
- Each female will have one offspring (one chip). Add these bats (chips) to the table to find the ending population.

Things to think about while we do the simulation:
Each round of the simulation will begin with 100 bats (chips), NOT with the number of bats left at the end of the previous round. The four rounds, then, are a comparison of four different WNS infection rates at four different hibernacula. They are NOT chronological increases in WNS infections. Please be thinking about how this setup impacts the accuracy or limitations of the model. Record your ideas below and be prepared to discuss these impacts during our follow-up discussions.

My ideas about the setup: ____

____

How does this simulation reflect a real-life situation?

____

____

How does this simulation NOT reflect a real-life situation?

____

____

____

Student Investigation Worksheet – Part One
Simulation: Modeling Northern Long-Eared Bat Population Decline

Round 1 - Infection Rate: 2 bats per student

Starting population	Number of bats killed	Number of bats born	Ending population
100			

Question for discussion: Assuming no other factors act on the ecosystem, over time will the overall bat population decrease at this rate of WNS infection? Explain your logic.

Round 2 - Infection Rate: 5 bats per student

Starting Population	Number of bats killed	Number of bats born	Ending Population
100			

Question for discussion: Assuming no other factors act on the ecosystem, over time will the overall bat population decrease at this rate of WNS infection? Explain your logic.

Round 3 - Infection Rate: 10 bats per student

Starting population	Number of bats killed	Number of bats born	Ending Population
100			

Question for discussion: Assuming no other factors act on the ecosystem, over time will the overall bat population decrease at this rate of WNS infection? Explain your logic.

Round 4 - Infection Rate: 15 bats per student

Starting population	Number of bats killed	Number of bats born	Ending Population
100			

Question for discussion: Assuming no other factors act on the ecosystem, over time will the overall bat population decrease at this rate of WNS infection? Explain your logic.

Student Investigation Worksheet – Part One
Discussion Questions

1. What are the limitations of this simulation (model)? In particular, how do the reduced population sizes (looking at only 100 bats instead of one million or more bats) and the predictable/standardized WNS infection rates and birth rates used here compare to what happened in the wild during the northern long-eared bat population decline? For instance, is it likely that all males and females that survive are able to reproduce?

2. Keeping these limitations in mind, which infection rate of the four simulated here seems to be the best illustration of how northern long-eared bat levels were impacted by WNS infection? Explain your reasoning.

3. If you were going to develop a complex model to illustrate the factors that contributed to the decline of the northern long-eared bat, would you include the 2 bats per infection and 5 bats per infection rates in your simulation? Why or why not?

Student Investigation Worksheet – Part One
Discussion Questions (continued)

4. This simulation did not include an infection rate at which the ending population was the same as the starting population. How would you figure out what that infection rate would be?

5. Clearly, new diseases can have negative impacts on a population, especially if the disease is not native to an area. However, disease often plays a role in population control. In this simulation, in which WNS is the only factor reducing population size, how would the population change over time with no or very limited disease? What could be some implications of skyrocketing populations of a single species?

6. What other factors may have impacted bat population declines? Were those factors incorporated into the simulation (model) in any way? Discuss how focusing on only a single factor limits the accuracy of the simulation. How could the simulation be improved to incorporate multiple factors?

Teacher Answer Pages

Round 1 - Infection Rate: 2 bats per student

Starting population	Number of bats killed	Number of bats born	Ending population
100	10	45	135

Question for discussion: No. The ending population number is larger than the starting population number.

Round 2 - Infection Rate: 5 bats per student

Starting population	Number of bats killed	Number of bats born	Ending Population
100	25	37	112

Question for discussion: No. The ending population number is larger than the starting population number.

Round 3 - Infection Rate: 10 bats per student

Starting population	Number of bats killed	Number of bats born	Ending population
100	50	25	75

Question for discussion: Yes. The ending population number is less than the starting population number. The population will not be able to sustain itself at this rate of infection.

Round 4 - Infection Rate: 15 bats per student

Starting population	Number of bats killed	Number of bats born	Ending population
100	75	12	37

Question for discussion: Yes. The ending population number is less than the starting population number. The population will not be able to sustain itself at this rate of infection. Due to the high rate of infection and mortality this species could be in serious trouble.

Discussion Questions and Answers

1. What are the limitations of this simulation (model)? In particular, how do the reduced population sizes (looking at only 100 bats instead of one million or more bats) and the predictable/standardized WNS infection rates and birth rates used here compare to what happened in the wild during the northern long-eared bat population decline? For instance, is it likely that all males and females that survive are able to reproduce?

- We are only considering one factor that reduces the bat population.
- The starting population is only 100.
- The WNS infection rates and the birth rates are standardized.
- In the ecosystem there would be a lot more variability in each of these parameters.
- The model does not consider that the most vulnerable time for bats is when they are young and learning to fly. Mortality rates are very high in the first year.
- The model does not take into account that not all males and females would breed successfully and not all young would survive.
- Combining these variables with the large (actual) population size would make it much more difficult to create an accurate simulation or model.

2. Keeping these limitations in mind, which infection rates of the four simulated in this activity seem to be the best illustration of how northern long-eared bat levels were impacted by WNS infection? Explain your reasoning.

- 10 bats and 15 bats per student are the only rates tested that shows a decline in the overall bat population over time. An infection rate of 10/15 bats per student were chosen for illustrative purposes, but they are not necessarily representative of infection patterns of WNS since 2006. However, the infection rate of 15 does represent a very quick reduction in the population. Likewise, WNS killed hundreds of thousands of northern long-eared bats in less than ten years.

3. If you were going to develop a complex model to illustrate the factors that contributed to the decline of the northern long-eared bat, would you include the 2 bats per infection and 5 bats per infection rates in your simulation? Why or why not?

- Answers will vary, but the students should provide clear statements to support their answer.
- Low infection rates allow people viewing the model to more clearly see the low impact on the population. The modeler could include comments suggesting that the low rates are not representative of what really happens in the ecosystem.
- High infection rates allow people viewing the model to see the impact on populations and to see when the population will no longer sustain itself.

- Showing a range of infection rates could allow the modeler to gauge how serious the threat might be and could be used to help consider whether the species should be listed as threatened or endangered under the Endangered Species Act

4. This simulation did not include an infection rate at which the ending population was the same as the starting population. How would you figure out what that infection rate would be?

- x = number of bats killed
- 100 = [(100-x) + ½(100-x)]/5 (This assumes there are 5 students to infect bats.) = 6.67 bats per student (The infection rate is approximately 6 or 7 bats per student.)
- In order for a population to decline, the birth rate must be lower than the death rate (as seen in Round 3).

5. Clearly, new diseases can have negative impacts on a population, especially if the disease is not native to an area. However, disease often plays a role in population control. In this simulation, in which WNS is the only factor reducing population size, how would the population change over time with no or very limited disease? What could be some implications of skyrocketing populations of a single species?

- The population could rise at a high rate if there was only limited disease.
- Overpopulation problems could include lack of food, competition for limited habitat, degradation of habitat, and the potential to spread disease more quickly (within the bat population and potentially to other animals).

6. What other factors may have impacted bat population declines? Were those factors incorporated into the simulation (model) in any way? Discuss how focusing on only a single factor limits the accuracy of the simulation. How could the simulation be improved to incorporate multiple factors?

- Other factors that commonly impact bat populations include: human development (leading to food and habitat loss), intentionally killing of bats by humans, fragmentation of habitat, human disturbance of hibernating and/or maternity colonies, wind farm development (loss of habitat and collisions/death with turbines), physically closing caves or mine entrances, and loss of genetic diversity when population numbers become very low. Including some of these factors would likely result in a more accurate estimate of overall population declines.

Resources for Researching Bat Species

Bats in Your State - Species Profiles - http://www.batcon.org/index.php/resources/media-education/species-profiles

U.S. Fish and Wildlife Service – Endangered Species - http://www.fws.gov/endangered/

Your Bat Species – Research Notes

Scientific name: _____________________ **Common name:** _____________________

Conservation status (threatened/endangered/other): __________________________

- "Endangered" means a species is in danger of extinction throughout all or a significant portion of its range.
- "Threatened" means a species is likely to become endangered within the foreseeable future.

Appearance (note size, color, and any defining characteristics):

Geographic Distribution – Range:

Population (number of individuals – rough estimates are OK! Just be sure to document your rationale):

Part Two – Bats at Risk
Student Worksheet

Winter Habitat:

Summer Habitat:

Reproduction:

Feeding Habits:

Threats to Species:

Conservation strategies and prospects for species' survival:

If implemented, would these strategies affect your model? How?:

Additional Notes:

Develop a model to illustrate the decline of your bat species

Kinds of models your group can develop:

- game
- diagram
- simulation
- mathematical model

1. Describe your model and how it works

2. Include at least two factors in your model that influence the bat population.

Factor One:

Factor Two:

Factor Three: (optional)

3. List the limitations and the accuracies of your model.

4. Develop an argument for conserving your bat species – be persuasive!

5. Prepare to present your bat species and model to the class. Be sure to develop an outline to help organize your presentation. Your outline should include the following:

Present your model to the class.

- Introduce your bat species
- Describe your model
- Discuss your model's limitations and accuracies

Your presentation should include the following:

A. Thorough description of your bat species (using the information you gathered during your research)

B. The reason(s) your bat species is important and why it should be conserved. Provide clear reasoning and document relevant evidence. Be persuasive!

C. Threats to your bat species

D. Description of your model

E. Discussion of your model's limitations and accuracies

F. Conservation strategies that may increase your bat species population and rationale to support your claims.

Part Two – Threatened and Endangered Bats of the United States

Scientific Name	Common Name	Conservation status	Geographic Range	Known Threats
Coryorhinus townsendii ingens	Townsend's big-eared bat	Endangered	Western US; British Columbia to Central Mexico; some isolated populations in Southeast US	- Human disturbance to roost sites (e.g. caving and mining)
Coryorhinus townsendii virginianus	Virginia big-eared bat	Endangered	eastern Kentucky, eastern West Virginia, southwestern Virginia, and northwestern North Carolina	- Human disturbance -White-Nose Syndrome
Eurnops floridanus	Florida bonneted bat	Endangered	Handful of counties in Southern Florida	- Human disturbance to roost sites - Hurricanes - Pesticide use - Diminishing food source
Lasiurus cinereus semotus	Hawaiian Hoary bat	Endangered	Hawaii	- Habitat destruction - Pesticide use - Introduced insects and disease
Leptnoycteris nivalis	Mexican long-nosed bat	Endangered	W Texas, New Mexico, SE Arizona, Mexico, Honduras, Guatemala	- Loss of roost sites - Harvesting of Agave plants - Killed for being mistaken as vampire bats
Leptonycteris yerbabuenae	Lesser long-nosed bat	Endangered	SE Arizona to SW New Mexico; Mexico for winter months	-Roost disturbance - Habitat loss

Scientific Name	Common Name	Conservation status	Geographic Range	Known Threats
Myotis grisescens	Gray bat	Endangered	AL, AR, MO, KT, TN, FL, OK, GA, NC, IL, IN, KS, MS, VA	- Disturbance of hibernating bats and maternity colonies - Cave flooding - Cave commercialization - Water pollution
Myotis septentrionalis	Northern long-eared bat	Threatened	Most of US and District of Columbia	- White-Nose Syndrome - Wind Turbines - Forest loss -Pesticides
Myotis sodalis	Indiana bat	Endangered	Southern and Midwestern States	- Disturbance of hibernating bats - White-Nose Syndrome - Human development - Wind turbines - Climate change

Curriculum/Standards Connections

Next Generation Science Standards

Middle School Life Science

Students who demonstrate understanding can:
MS-LS2-4. Ecosystems: Interactions, Energy, and Dynamics: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

High School Life Science

Students who demonstrate understanding can:
HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

HS-LS2.C: Ecosystem Dynamics, Functioning, and Resilience
A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. (HS-LS2-2),(HS-LS2-6)

Moreover, anthropogenic changes (induced by human activity) in the environment—including habitat destruction, pollution, introduction of invasive species, overexploitation, and climate change—can disrupt an ecosystem and threaten the survival of some species. (HS-LS2-7)

Common Core State Standards Connections:

Middle School Writing

ELA/Literacy -
RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4)
RI.8.8. Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS2-4)
WHST.6-8.1. Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4)
WHST.6-8.9. Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4)

High School Writing

CCSS.ELA-LITERACY.W.9-10.1
Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.
CCSS.ELA-LITERACY.W.9-10.1.A
Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among claim(s), counterclaims, reasons, and evidence.
CCSS.ELA-LITERACY.W.9-10.1.B
Develop claim(s) and counterclaims fairly, supplying evidence for each while pointing out the strengths and limitations of both in a manner that anticipates the audience's knowledge level and concerns.

A Special Thanks! The simulation for this activity is an adaptation of “Modeling Population Decline” from The Chicago Academy of Sciences and the Peggy Notebaert Nature Museum and has been used with their permission. For more information about this important partner, please visit http:www.naturemuseum.org/teacheresources.

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