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Saving Little Brown Bats: A Case Study of White-Nose Syndrome for Primary Grades

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Introduction

Figure 1 Little brown bats emerging from their roost on a warm, Connecticut summer evening.

On a warm summer evening in Connecticut, crickets and frogs chirp while fireflies flicker into the night. If you are lucky, you might hear an owl chatter in the distance. Unfortunately for people, the mosquitoes are also out in full force. Not only can mosquito bites be uncomfortable, mosquitos are also capable of spreading viral diseases that can infect humans and other animals. Fortunately, the bats are also out, fluttering and squeaking overhead as they feast on the abundant mosquito and midge population you were just swatting away.

Not long ago, the most abundant bat in the state was *Myotis lucifugus,* commonly known as the little brown bat. Its range in North America spans from Alaska and Newfoundland along the north, and as far south as Southern California, Northern Arizona, and New Mexico. There are no official population counts, but it is estimated that there were over 6 million individuals of just this one bat species prior to 2006.[1] Little brown bats flourished alongside people, often using human structures as roosting locations. In 2008, the species was listed as a conservation priority of least concern. By 2018, it was identified as an endangered species by the

International Union for Conservation of Nature (IUCN) as well as by several counties and states, including Connecticut.[2] Studies of hibernating bat colonies have revealed thousands of dead bats on the ground, in some cases as much as 95% of the colony was decimated. So, what happened to the bats? Why should we be concerned? How can people help the little brown bat species?

This unit examines the concept of species extinction and the impact it has on other plant and animal populations, with a focus on the little brown bat as a case study. A Yale unit differs from many commercially available educational units. You will not find pages to photocopy as worksheets alongside nifty activities. Instead, you will find detailed background information in conjunction with several effective and thoughtfully chosen teaching strategies and lesson suggestions. It is developed with knowledge gained through personal research while participating in the 2020 Yale National Initiative Caretakers versus Exploiters: Impacting Biodiversity in the Age of Humans seminar led by Dr. Paul Turner, Yale Professor of Ecology and Evolutionary Biology. It is a unit that I have researched, discussed, collaborated on, written, and will also teach. The background content should be a sufficient and significant starting place to help teach the five-unit lessons (approximately five, one-hour sessions).

My target audience for the unit is first grade. Six-year-olds! I teach STEM to K to 4th grade students at a magnet school in New Haven, CT. Students come to me once a week for an hour of hands-on science and engineering focused lessons and experiences based on the Next Generation Science Standards (NGSS). The educational standards I used as the basis of this unit fall under life science for first grade as well as K-2 engineering and design. An annotated list of the standards and how this unit addresses them is included in the appendix of this unit. Many elements of this unit can easily be adapted to any grade level despite it being written for primary grades.

The unit is divided into three sections. The first is a general overview of bat biodiversity with a focus on the role of bats in the ecosystem. The second section is an examination of the threats which bats are facing, such as loss of habitat, disease, climate change, and human-induced hazards. There will be a concentration on the plight of the little brown bat and the reason for the species decline in the Northeast United States. The third section highlights how and why several conservation efforts are being made, including how people can help in their neighborhoods. The unit culminates with the design and construction of a bat roosting box that can be used to promote local bat activity.

Bat Biodiversity

Figure 2 The little brown bat (Myotis lucifugus) is one of 8 bat species commonly found in Connecticut.

There are over 1,400 species of bats, making their order, *Chiroptera*, one of the most diverse order of mammals in the world second only to rodents. Bats are found on every continent except Antarctica, and their habitats vary from tropical, temperate, and boreal forests to deserts, grasslands, mountains, and caves. The greatest bat biodiversity occurs along equatorial regions, with countries such as Indonesia and Columbia hosting nearly a third of the world's bat species. [3] There are 8 species of bats in Connecticut, with the little brown bat (*Myotis lucifugus*) and the big brown bat (*Eptesicus fuscus*) being the most dominant. *In the winter, the northeastern bats hibernate in large colonies, which helps for warmth and reproduction, but can lead to rapid disease transmission. In the spring, summer, and fall, bats will roost in small groups or even alone under building eaves, bridges, trees, rock formations, caves, wood piles, human-made bat boxes, etc. but not necessarily in the same location where they hibernate.*

Bats are unique amongst mammals, as they are the only mammal capable of flight. Their forearms form wings with 25 moveable joints and are connected by a skin-like webbing with three extending fingers. They can achieve thrust, and are capable of sustained, self-propelled flight. Unlike feathered birds, bats have sensitive body hair that can detect small changes in air currents and breezes. Their unique wing and body structures enable acrobatic, short-term flight that makes them skilled predators. Bat species can vary significantly in size, from the 2-gram Kitti's hog-nosed bat from Thailand and Myanmar that is about the size of a bumblebee, to the Indian Flying Fox, a 1.6kg (3.5 pound) creature with up to a 1.7m (about 6 foot) wingspan! Bats can also live a long time compared to mammals of similar size, with an average lifespan ranging between 10 and 30 years depending on the species. A tiny male Brandt's myotis bat from Siberia is the oldest bat ever documented at 41 years old! When it was caught in 2005, it still bore a numbered band that had been attached by researchers who first captured the bat in 1964.[4]

Figure 3 Flying foxes, large fruit eating mega bats from Indonesia.

Bats play an important role in a variety of ecosystems throughout the world through insect control, plant pollination, and seed dispersion. Bat diets can be categorized into two main categories: insectivores and frugivores. About 70% of bat species are insectivores, often eating moths, midges, beetles, mosquitoes, and other small insects. The little brown bat can eat an estimated three times its body weight on a good night.

Most bats use echolocation to navigate and find insect prey. They emit ultrasonic sound waves at frequencies beyond human hearing. These sound waves bounce off objects in their environment and return to the bat's ears, who can then process the reflected sound to pinpoint even tiny insects in low light conditions. Sonar technology for navigating underwater and radar technology for using radio waves to navigate in open air are both technologies inspired by the bat's use of echolocation.

Some bats will eat small fish, amphibians, and other bats. There is only one species, the vampire bat from Central and South America, that feeds off the blood of small or grazing animals. Frugivores prefer fruit but may also feed on flowers, nectar, and pollen. Many of the large bat species are fruit eaters. They are also very messy eaters, which is excellent for seed dispersal. Bats that feed from nectar are excellent pollinators. Over 300 plant species across a variety of ecosystems depend on bats for pollination, including bananas, peaches, durian, cloves, carob, balsa wood, agave, and the Saguaro cactus.

Bat fecal matter, guano, is also a nutrient rich fertilizer that contains a concentration of 10 percent nitrogen (N), 3 percent phosphorus (P), and 1 percent potassium or potash (K). High nitrogen levels in the soil are responsible for fast, green growth, while phosphorus helps with root and flower development.

Bats in general do not have many natural predators. Occasionally weasels, raccoons, rats, owls, snakes, or other opportunistic predators (even other bats) might catch and eat one, but they are not a primary part of any predator's diet. Humans in certain regions eat bats as well, often marketed as bushmeat. Bats are also rather adaptable to coexisting alongside humans, even roosting in human structures. In many cases in the Northeast USA, bats were considered a nuisance and were reason to call an exterminator – especially if a colony decided to roost in your attic or barn. Today, due to the bat population decline, many extermination services offer removal and relocation as a preferred alternative. In states where bats have been listed as endangered, extermination is not an option.

Bats can host a variety of diseases, some of which are zoonotic, or able to be transmitted from bats to humans and other animals. This has, unfortunately, been a point of contention in the relationship between people and bats. The primary zoonotic diseases associated with North American bats are rabies, histoplasmosis, salmonellosis, yersiniosis and external parasites such as ticks, mites, and parasitic flies. Bats from other parts of the world can carry several zoonotic viruses including Nipah virus, Hendra virus, Ebola virus, SARS coronavirus and others which can cause severe and fatal illness in humans and other animals. Bats are often referred to as viral reservoirs because they can carry and quickly spread over 60 known viruses. Bats have an incredibly robust immune system and are not affected by most of the viruses they carry, where rabies virus is a notable exception. When bats fly, they release a great amount of energy, which increases their body temperature to 38° to 41° C (100° to 106° F). The pathogens that have evolved in bats are able to withstand these high temperatures. This presents a problem for humans because our immune system has evolved to use high temperatures, in the form of fever, to disable pathogens.[5] If these pathogens become resilient to higher temperatures, the resurgence of diseases and the human impact could be significant.

Fortunately, the cases of bats infecting humans is extremely rare. Bats almost always avoid human contact as much as possible. According to the CDC, "rabies in humans is rare in the United States. There are usually only one or two human cases per year. But the most common source of human rabies in the United States is from bats. For example, among the 19 naturally acquired cases of rabies in humans in the United States from 1997-2006, 17 were associated with bats. Among these, 14 patients had known encounters with bats. Four people awoke because a bat landed on them and one person awoke because a bat bit him. In these cases, the bat was inside the home."[6]

Another disease that is affecting bats and leading to a drastic decline in some bat populations, is a fungal pathogen called *Pseudogymnoascus destructans*, which produces a disease known as White Nose Syndrome (WNS). The most dominate bat species in North America, *Myotis lucifugus,* commonly known as the little brown bat, has been facing an extinction level crisis due to WNS and will be the subject of the next section of this unit.

The Plight of the Little Brown Bat (a Case Study)

Unfortunately for the approximately 1,300 bat species around the world, there are a growing number of bat species that are in a state of decline for various reasons, primarily habitat loss, changing climate, or the emergence of WNS in North America. "The International Union for the Conservation of Nature (IUCN) currently lists 24 bat species as Critically Endangered, meaning they face an imminent risk of extinction. Fifty-three

others are Endangered, and 104 bat species are considered Vulnerable. Bats also are among the most under-studied of mammals. The IUCN lists 226 bat species as "Data Deficient"– there is simply too little information available to determine their conservation status. Of the 1,296 bat species that have been assessed by the IUCN almost a third are considered either threatened (vulnerable, endangered, or critically endangered) or data deficient, indicating the need for more conservation attention to these species."[7] "Scientists predict that the once common little brown bat (*Myotis lucifugus*), will be reduced to just 1% of its pre-WNS population numbers by 2030."[8] Events that kill large portions of populations, including natural or human induced disasters, increasingly threaten biodiversity. Assuming that biodiversity is a good thing and we want to 1) do no harm to an animal species or its habitat and 2) repair and restore the natural state of a species, then we first need to examine the threats that many of these endangered bats have in common.

Habitat Loss

Habitat loss and destruction caused by human activity has had adverse effects on many of the endangered bat species. Forests around the world have been reduced to make room for farms and cities, the timber harvested for wood. Mining operations have disturbed bat hibernation zones. Unlike the little brown bat, some species of bats have very small geographic ranges – some even limited to unique islands. These species are even more susceptible to habitat loss due to human encroachment. Not all human and bat interactions are harmful, and much like coyotes and raccoons in the Northeast United States, some animals tend to live side by side with humans quite well. The big and little brown bats of Connecticut once had a thriving population despite living near humans.

Climate Change

Bats are sensitive to temperature and any change in climate will undoubtfully result in a shift in the geographic ranges of some bat species. A study of vampire bats in Latin America has shown that these bats are highly sensitive to low temperatures and as overall temperatures increase, their range will continue to move northward. The movement of common vampire bats into the United States would present ecological, commercial, medical, and educational challenges, including probable impacts on other bat species, the livestock industry and public health concerns. Perhaps the most important impact might be increasingly negative views among the public about all bats; countless beneficial bats are killed throughout their range in mistaken efforts to eliminate vampire bats.

Understanding how and when these bats might expand into the United States should give us time to prepare and educate before problems arrive.[9] The vampire bats' response to the changing climate should also give us hints about how the ranges of some other bats might be altered. We expect to see changes in the range and migration timing of some bat species and fear that some species may be lost. The next few decades will be extremely challenging for scientists trying to discern critical impacts of climate change and the rapid alterations in species distributions and interactions that it will cause.[10]

In 2002, "overheated flying foxes, panting and frantically fanning themselves with their wings, fell from the trees in New South Wales, Australia. Up to 3,500 black and grey-headed flying foxes died on the ground beneath their roosts, victims, researchers believe, of heat waves that pushed temperatures to 108 degrees F (42º C). In this era of looming climate change, such scorching temperatures are occurring more often. Tragically so: since 1994, more than 30,000 flying foxes have died in New South Wales, apparently because of at least 19 episodes of extreme heat."[11] Another consideration due to climate change is the impact it has on microbes that exist around bats. As temperatures change, so can the resistances of potential microbial

pathogens.

Invasive species can be a major contributor to population declines, including invasive pathogens, against which native species can experience high mortality due to a lack of evolved immunity and other defenses. Introduced fungal pathogens can be particularly dangerous as they can frequently survive in the environment for extended periods, affect a relatively broad range of hosts, and can be highly virulent, thereby driving mass-mortalities of native species of plants and animals.[12]

White-Nose Syndrome

Figure 4 Little brown bats with visible white fungus syndrome on their noses.

Herein lies the problem for the little brown bat. They are not endangered necessarily due to habitat destruction, predation, or climate change (although these issues do play a role in species survival). Despite living in close conditions where the spread of disease is likely, bats have incredibly robust immune systems. The reason for their drastic decline is due to a fungal disease that has been contact sourced to a cave outside of Albany, NY in 2006 and is spreading across the continent, largely via infected bats. *Pseudogymnoascus destructans* (abbreviated *P. destructans*) is a highly destructive fungal pathogen that has decimated populations of bats, with twelve out of 49 known North American bat species currently affected, and some populations, such as the little brown bat, experiencing observed losses of 90–100% in places where colonies hibernate. The fungal infection is commonly known as white-nose syndrome (WNS) due to the small, white fungal spots that appear around the nose, muzzle, and wings of the bat's body.[13] *P. destructans* is a cold loving fungus that grows within the temperature range 10°C to 20°C (50°F to 68°F), and little brown bats hibernate in caves and structures in that same temperature range. The exact mechanism of death is still being studied, but bats apparently die from secondary physiological complications, mainly depleted fat reserves, associated with too frequent disturbances in their hibernation. In other words, they wake up more frequently due to irritations caused by the fungus, which in turn depletes their stored energy and they basically starve to death. Bats affected by WNS register a slightly higher body temperature, indicating an energy depleting fever response. The fungus also depletes collagen in the bat's skin and as the fungus grows it replaces the living skin underneath.

The *P. destructans* fungus is nothing new. Evidence from researchers of the *P. destructans* genome have found different fungal variants in Europe and Asia; however, the variant found in North America seems to have originated in Europe. So why don't bats in Europe suffer the same fate with WNS as in North America? A study published in March 2020 suggests that differences in environmental reservoir dynamics play an important role in population growth rates of bats in both North America and Eurasia. "Data from both native regions where bat populations have coexisted with P. destructans for thousands of years reveal that a crucial difference between stable and declining bat populations is the extent of the environmental reservoir in early winter. The seasonal decay of *P. destructans* in the environment over the summer in Eurasia leads to a reduced reservoir of *P. destructans* in early winter, delayed infection, a shorter period of pathogen growth on bats, and lower fungal loads at the end of winter. This means that while most bats eventually become infected by the end of winter across Eurasia, they survive until spring, when they can emerge from hibernation and clear infection. In contrast, bats in WNS-established areas of North America become rapidly infected when they return to an extensive and heavily contaminated environmental reservoir in early winter and, given these longer periods of infection, have higher fungal burdens (and greatly increased mortality)."[14]

Why Should We Care?

It is important to realize how much of a role bats in North America play in insect control. This is difficult to estimate or place a value on, but current estimates are at about $23 billion annually in the United States alone.[15] Thomas Kunz, a renowned bat researcher at Boston University, calculated how more farmers in different regions would spend on pesticides if bats were not present. The value varied per each region in various studies. One such study occurred in the Winter Garden agricultural region in southern Texas. The researchers estimated that at least 1.5 million bats feed nightly over the agricultural fields each summer night and the researchers calculated that the annual value of insect suppression by bats in the region approached $1.7 million. What they discovered was that the consumption of moths by Brazilian free-tailed bats reduces crop damage, eliminates one application of pesticide, and possibly delays the time when pesticides are first used. Each of these findings has important positive economic and environmental benefits.[16]

In addition to insect control for agricultural purposes, bats also reduce the insects responsible for the transmission of some infectious diseases. According to the CDC, "West Nile virus is the most common virus spread by mosquitoes in the continental United States. People can also get sick from less common viruses spread by mosquitoes, like La Crosse encephalitis or St. Louis encephalitis. In rare cases, these can cause severe disease or even be deadly. Most people infected with these viruses do not have symptoms, or have only mild symptoms like fever, headache, nausea, and vomiting."[17] Other mosquito-borne illnesses include viruses like dengue, Zika, and chikungunya and are well-known to people living in US territories like Puerto Rico and the US Virgin Islands. Many people infected with these viruses can have symptoms that include fever, headache, rash, muscle pain, and joint pain.[18] Zika virus can also affect the development of unborn children, causing a birth defect called microcephaly, a condition where a baby's head is much smaller than expected because a baby's brain has not developed properly during pregnancy or has stopped growing after birth.[19]

How Are Humans Already Helping the Little Brown Bat?

Measures are being taken to place the little brown bat on the federal Endangered Species list. The Endangered Species Act (ESA) of 1973 provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found. Congress recognized that our rich natural heritage is of "esthetic, ecological, educational, recreational, and scientific value to our Nation and its people." It further expressed concern that many of our nation's native plants and animals were in danger of becoming extinct. The law requires federal agencies to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction of critical habitats. The law also prohibits any action that causes a removal of any listed species of endangered fish or wildlife.[20] Under the ESA, species may be listed as either endangered or threatened. "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.[21]

Placing little brown bats on the federal endangered species list would accomplish five things. First, the federal government is required to take conservation measures to prevent harm and support recovery. Laws can be put into place to prevent further damage or exploitation of the species. Second, the government must be held accountable to show what it is doing to protect the species and devote adequate resources to the conservation effort. Third, critical habitats for the species are usually designated and protected. In the case of the little brown bat, this means they need safe places to hibernate. Designation of critical habitat for the little brown bat would protect crucial sites for its survival and recovery. Fourth, listing of a species is often followed by the development of a recovery plan to ensure best efforts will be made to protect and nurture a healthy population recovery. Finally, adding a species to the endangered list promotes public awareness and education.

There are over one hundred reputable non-profit bat conservation groups worldwide. In the United States, Bat Conservation International (www.batcon.org), North American Symposium for Bat Research (www.nasbr.org), and Merlin Tuttle's Bat Conservation (www.merlintuttle.org) are three of the largest bat conservation agencies. They all promote scientific research, including bat monitoring, as well as educational resources that are available to the public. Each of these organizations has also dedicated substantial resources and funding into WNS research.

How Can We Help Our Local Bats?

The best way we can help local bats is to leave them alone (unless you are a WNS researcher, but even then, they know it is best not to disturb hibernating bats). That means avoiding caves and other areas that are hibernation sites. As part of the endangered species plan for little brown bats, known hibernation locations are often covered with a "bat gate" to prevent human entry. Disturbing hibernation, especially in a colony infected with WNS, can lead to even more bat deaths. If bats are discovered roosting in a building and need to be removed, they should be relocated rather than killed (which in some states is illegal as bats may be a protected species).

Bat Roosting Box Construction

Many people build or purchase bat roosting boxes to attract local bats. These can be purchased in various sizes for round $30-$100. Alternatively, one could also construct a bat roosting box for much less money. In one of the unit lessons, students will construct a bat roosting box of their own, either with the teacher to be installed on the school property, or each student can construct their own if you have access to enough materials. There are several videos and online articles that provide blueprints and tips for bat roosting box construction. Ideally you want to replicate a design that is like where bats would normally roost and raise their young in nature – between the bark and the trunk of a tree. There are a few essential components of a bat roosting box that must be included for bats to even consider moving in. Bat boxes must be sealed to retain heat and prevent moisture. The inside wall should not be smooth since bats will need a ledge or ridge to grasp. While some online plans for bat houses use screen stapled to the inner walls but this is not recommended because over time it could rust or tear, therefore making the bat house uninhabitable. A dark color is also preferred to retain more heat. Cedar is an ideal wood since it is naturally rot resistant. The proper placement location is also critical. It should be placed about 15 feet off the ground to help bats avoid predators. A separate pole or installation on the side of a building is ideal. It should be somewhere that receives heat most of the day. If it is too shady, as putting it on a tree trunk might be, then it will not be warm enough to attract bats, tree branches might be a deterrent obstacle, and predators are more likely to find them. Keep in mind that these are spring and summer homes for bats – not the same as the hibernation areas where local bats gather for the winter. A home or school bat roosting box provides a warm, dry, dark shelter for bats to rest during the day and night when they are not out hunting insects.

Figure 5 A bat box similar to the one I purchased on Amazon for about $30.00

Here are two good resources for bat box construction:

www.nwf.org/Garden-for-Wildlife/Cover/Build-a-Bat-House.[22]

https://www.batcon.org/about-bats/bat-houses.[23]

In my class, I intend to bring in a purchased bat box and have students analyze and replicate its construction. We will take it apart to see how it is made and use what we learn to design our own.

Teaching Strategies

We will examine the role of humans as caretakers, including conservation efforts by people and the impact government statuses such as “extinct”, “endangered”, “threatened”, etc. have on those national or state led conservation efforts. Students will observe and monitor bat activity in their neighborhoods and nearby locations. Students will apply their observations, research on bat physiology, and understanding of the role of being a human caretaker by designing and constructing a bat roosting box to encourage bat activity in their area.

The teaching section of this unit will include a sequence of lessons and activities that will amount to at least five, one-hour long class sessions. The unit will begin with an introduction to bats through literature (the book *Stellaluna* by Janell Cannon immediately comes to mind) and media. Students will discuss and record what they already know about bats, including stories of their own bat experiences and feelings, and compare them to birds. This will be followed by several lessons on bat physiology and behaviors, as well as their role in the ecosystem. I will attempt to build a local connection to any current museum, zoo, Audubon, or other scientific research and conservation agencies working with bats in our area. This would be an excellent time to have students visit, or be visited by, a presenter with live specimens of bats. It would also be a good opportunity to look at the works of engineers who have used the study of bats, such as their use of echolocation, as the basis for some human technologies and inventions.

Once students have a foundational understanding and appreciation of bats, we will examine reasons for their decline. Students will learn about the research into the main disease, white-nose syndrome, that is killing bats by the millions each year, and what is being done to help them (which at this point, isn’t much beyond understanding the disease). Per the USDA, “At least 5.5 million bats have died from WNS since 2006, but it is difficult to document the extent of these declines and their impacts on agriculture, forests, and other ecosystems because there is no coordinated program to monitor bat populations in North America.”[24] In response to this need, scientists and statisticians from several federal agencies and universities, including representatives from Canada and Mexico, developed the North American Bat Monitoring Program (NABat), which can be used to monitor trends in bat populations on state, federal, provincial, tribal, and private lands. Students will evaluate data and consider the impacts that an environment without bats might look like, including the human costs such as the impact on food production and the increased use of pesticides, or the uptake in the spread of diseases through insects that bats would have eaten. I will also consider having the class contribute to national monitoring efforts like NABat. Students will have a take-home field journal to document and record bat activity and return that information to class to compile the data.

As caretakers, we will try to promote a healthy population and attract bats to our area by designing and building bat roosting boxes. To make these, students will need to research and design bat boxes that will be appealing, attractive, and functional. We may construct one out of wood and other materials as a class to be placed on the school grounds (part of our building includes an outdoor classroom), and I may have students build their own smaller versions to take home (depending on time, materials, etc.…). Either way, successful construction and usage by local bats will be based on student research, including bat physiology and behavior,

local bat activity observations, and careful material selection, roosting box design, and construction. Students have access to woodworking tools and materials and have been trained to use them in my STEM lab.

Finally, students will observe their bat roosting boxes for signs of bat activity and evaluate the effectiveness of their design, construction, and placement of the box.

In summary, students will learn about a variety of bats and their roles as either pollinators or insect control. Then they will focus on the little brown bats and the reasons for little brown bat population decline due to a human introduced fungal infection and other reasons. They will examine the multiple ripple effects of a healthy little brown bat population as well as a decimated or extinct little brown bat population.

Lesson 1: (1 hour) Introduce students to the terms “extinct” and “endangered species” and engage in discussion of what it means for something to be extinct or endangered. Continue by introducing students to bats as an example of a creature that we see in Connecticut that is facing possible extinction. Read *Stellaluna* by Janell Cannon and/or *Bat Count* by Anna Forrester. Follow these literature resources with some short bat documentaries designed for kids on YouTube. https://youtu.be/9FVoTMOorXA and https://youtu.be/z4fexFb9cco are two that I found at the time of this writing. If you read the book *Bat Count*, it works as a great introduction to observing bats from home in the evening. Each evening around dusk, students will be encouraged to look for bats in the sky near their homes and count them. The count can then be kept as a class tally. Encourage students to “hunt for bats” using a camera if they have one available.

Lesson 2: (1 hour) Bat physiology. In this lesson, have students create a model of a bat body. This can be through sculpture, drawing, or other types of craft media. Key components of a bat body should be labeled or somehow identified. They are wing, thumb, elbow, forearm, claw, feet, tail, eye, nose, and mouth.

Lesson 3: (1 hour) Discuss White Nose Syndrome, what it is, what it looks like, and the impact it has on little brown bats. A good YouTube video to show students is done by Parks Canada and is called “Bats and white-nose syndrome” located at https://youtu.be/MQtrDxJRhOU. Then, teach students how to play the online White Nose Syndrome game located at https://www.whitenosesyndrome.org/mmedia-education/game-on-the-white-nose-syndrome-video-game. The goal of the game is to keep bats alive as long as possible while balancing funding through ecotourism, conservation, and research. The game is a bit difficult at first but give students some time to explore and see which variables lead to the healthiest bat population over time.

Lesson 4: (1 hour) Introduce a pre-built bat box. We will use our maker space materials and supplemental cedar planks and wood glue to construct a bat box, but first we should do some research by examining the features of the commercial box. Design on paper before getting materials and constructing. The teacher will need to decide if you are making one as a class, several in groups, or individual ones. I am sure cost and access to resources will influence this decision. Refer to the above section on Bat Roosting Box Construction for links to plans.

Lesson 5: (1 hour) Continue bat box construction and discuss placement. Building bat boxes may take some additional time beyond this hour, depending on the size of your class and how many bay boxes you are making.

Appendix of Annotated Educational Standards

Life Science:

1-LS1-1 *Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.* The bat physiology lesson and constructing a bat box lessons address this standard. Students will study bat bodies and their needs, then design and construct a bat roosting box tailored to meet the needs of a bat family.

1-LS1-2 *Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.* Lesson 1 addresses this standard by using literature and video clips to examine behavior patterns of bats and their offspring.

Engineering and Design:

K-2-ETS1-1. *Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.* Students will observe bat box construction and gather information about bats to design a bat box in lessons 4 and 5. Questioning, making observations, and gathering information is essential to these lessons.

K-2-ETS1-2. *Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.* Students will create a physical bat box designed to accommodate bats and evaluate how its shape and design meets suitable criteria for housing bats.

In addition to teaching the science content behind the standards, two secondary goals are to foster an appreciation for the role of bats in their environment as well as inspire students to take on a caretaker role for whatever it is they are passionate about.

Bibliography

[1] "Tracking the Decline of Bats in North America – Research Highlights - US Forest Service Research & Development," accessed June 22, 2020, https://www.fs.fed.us/research/highlights/highlights_display.php?in_high_id=712.

[2] "IUCN Red List of Threatened Species," accessed July 14, 2020, https://www.iucnredlist.org/.

[3] "Everywhere," accessed July 14, 2020, http://www.batcon.org/why-bats/bats-are/bats-are-everywhere.

[4] "BATS Magazine Article: The Oldest Bat," accessed July 15, 2020, http://www.batcon.org/resources/media-education/bats-magazine/bat_article/152.

[5] "Bats Host More Than 60 Human-Infecting Viruses | Live Science," accessed July 15, 2020, https://www.livescience.com/26898-bats-host-human-infecting-viruses.html.

[6] “Prevent Mosquito Bites | Division of Vector-Borne Diseases | NCEZID | CDC,” accessed August 16, 2020, https://www.cdc.gov/ncezid/dvbd/media/stopmosquitoes.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Ffeatures%2Fstopmosquitoes%2Findex.html.

[7] “Threatened,” accessed July 15, 2020, http://www.batcon.org/why-bats/bats-are/bats-are-threatened.

[8] “Threatened,” accessed July 14, 2020, http://www.batcon.org/why-bats/bats-are/bats-are-threatened.

[9] Giorgia G. Auteri and L. Lacey Knowles, “Decimated Little Brown Bats Show Potential for Adaptive Change,” *Scientific Reports* 10, no. 1 (December 1, 2020), https://doi.org/10.1038/s41598-020-59797-4.

[10] Auteri and Knowles.

[11] Giorgia G. Auteri and L. Lacey Knowles, “Decimated Little Brown Bats Show Potential for Adaptive Change,” *Scientific Reports* 10, no. 1 (December 1, 2020): 3023, https://doi.org/10.1038/s41598-020-59797-4.

[12] Auteri and Knowles, “Decimated Little Brown Bats Show Potential for Adaptive Change,” December 1, 2020.

[13] Winifred F. Frick et al., “An Emerging Disease Causes Regional Population Collapse of a Common North American Bat Species,” *Science* 329, no. 5992 (August 6, 2010): 679–82, https://doi.org/10.1126/science.1188594.

[14] Joseph R. Hoyt et al., “Environmental Reservoir Dynamics Predict Global Infection Patterns and Population Impacts for the Fungal Disease White-Nose Syndrome,” *Proceedings of the National Academy of Sciences of the United States of America* 117, no. 13 (March 31, 2020): 7255–62, https://doi.org/10.1073/pnas.1914794117.

[15] “Prevent Mosquito Bites | Division of Vector-Borne Diseases | NCEZID | CDC.”

[16] “Bats Are Worth at Least $3 Billion per Year | Ars Technica,” accessed August 1, 2020, https://arstechnica.com/science/2011/04/bats-are-worth-at-least-3-billion-per-year/?comments=1&post=21497290.

[17] “Prevent Mosquito Bites | Division of Vector-Borne Diseases | NCEZID | CDC,” accessed August 16, 2020, https://www.cdc.gov/ncezid/dvbd/media/stopmosquitoes.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Ffeatures%2Fstopmosquitoes%2Findex.html.

[18] “Prevent Mosquito Bites | Division of Vector-Borne Diseases | NCEZID | CDC.”

[19] “Prevent Mosquito Bites | Division of Vector-Borne Diseases | NCEZID | CDC.”

[20] “Prevent Mosquito Bites | Division of Vector-Borne Diseases | NCEZID | CDC.”

[21] “Prevent Mosquito Bites | Division of Vector-Borne Diseases | NCEZID | CDC.”

[22] “Prevent Mosquito Bites | Division of Vector-Borne Diseases | NCEZID | CDC.”

[23] “Build a Bat House,” accessed August 17, 2020,

https://www.nwf.org/Garden-for-Wildlife/Cover/Build-a-Bat-House.

[24] "Tracking the Decline of Bats in North America – Research Highlights - US Forest Service Research & Development," accessed June 23, 2020, https://www.fs.fed.us/research/highlights/highlights_display.php?in_high_id=712.

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