Bats & White-Nose Syndrome: A Closer Look at This Parasitic Relationship Grades 9 – 12

Learning Objectives

1. Identify properties of a 'stable ecosystem.'
2. Define and identify examples of ecological relationships including predation, parasitism, commensalism, mutualism, and competition.
3. Explain how the disease white-nose syndrome is impacting bat populations in North America and infer how this disease could influence ecosystem stability in the future.

Essential Questions

1. What ecological relationship exists between the fungus that causes white-nose syndrome and bats?
2. How could white-nose syndrome impact ecosystem stability in North America?

Time Needed

• Engage: Picture an Ecosystem	5-15 minutes
• Explore 1: Describe a Stable Ecosystem	15-20 minutes
• Explore 2: Ecosystem Stability: A Closer Look	20-30 minutes
• Explore 3: Ecological Roles & Relationships	45-50 minutes
• Explore 4: Ecological Roles & Relationships of Bats	45-50 minutes
• Explore 5: Bats of Texas	35-45 minutes
• Explore 6: A Global View of Bats	15-20 minutes
• Explore 7: What is white-nose syndrome? How does it spread?	40-45 minutes
• Explain	20-30 minutes
• Elaborate: Curious to learn more?	15-?? minutes*
• Evaluate: Apply What You Learned	20-30 minutes

*Multiple resources are shared in this section. Students could look into one resource in about 15 minutes or spend as much time as they'd like (and is feasible) to explore additional resources further.

Texas Essential Knowledge & Skills (TEKS)

2017 Science TEKS	Science TEKS, Approved by SBOE 2020 *implementation begins fall 2024*
• BIO(12)(A) interpret relationships, including predation, parasitism, commensalism, mutualism, and competition, among organisms • BIO(12)(E) describe how environmental change can impact ecosystem stability	• BIO(13)(A) investigate and evaluate how ecological relationships, including predation, parasitism, commensalism, mutualism, and competition, influence ecosystem stability
Scientific and Engineering Practices Approved by SBOE 2020 *implementation begins fall 2024*	
• BIO(3)(A) develop explanations and propose solutions supported by data and models and consistent with scientific ideas, principles, and theories • BIO(3)(B) communicate explanations and solutions individually and collaboratively in a variety of settings and formats • BIO(3)(C) engage respectfully in scientific argumentation using applied scientific explanations and empirical evidence	
Recurring Themes and Concepts Approved by SBOE 2020 *implementation begins fall 2024*	
• BIO(6) Science consists of recurring themes and making connections between overarching concepts. Recurring themes include systems, models, and patterns. All systems have basic properties that can be described in space, time, energy, and matter. Change and constancy occur in systems as patterns and can be observed, measured, and modeled. These patterns help to make predictions that can be scientifically tested, while models allow for boundary specification and provide a tool for understanding the ideas presented. Students should analyze a system in terms of its components and how these components relate to each other, to the whole, and to the external environment.	

Next Generation Science Standards (NGSS)

HS-LS2-6. Evaluate 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.

The performance expectation listed above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science & Engineering Practices

Engaging in Argument from Evidence

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

Disciplinary Core Ideas

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.

Crosscutting Concepts

Stability & Change

- Much of science deals with constructing explanations of how things change and how they remain stable.

HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

The performance expectation listed above was developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science & Engineering Practices

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.

- Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Disciplinary Core Ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience

- 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.

LS4.D: Biodiversity and Humans

• Biodiversity is increased by the formation of new species (speciation) and decreased by the loss of species (extinction). (secondary) • Humans depend on the living world for the resources and other benefits provided by biodiversity. But human activity is also having adverse impacts on biodiversity through overpopulation, overexploitation, habitat destruction, pollution, introduction of invasive species, and climate change. Thus sustaining biodiversity so that ecosystem functioning and productivity are maintained is essential to supporting and enhancing life on Earth. Sustaining biodiversity also aids humanity by preserving landscapes of recreational or inspirational value. (secondary) (Note: This Disciplinary Core Idea is also addressed by HS-LS4-6.) ETS1.B: Developing Possible Solutions • When evaluating solutions it is important to take into account a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. (secondary)
Crosscutting Concepts Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable.

Academic Vocabulary

From: lead4ward Kinder-Grade 12 Academic Vocab https://lead4ward.com/resources/

Biology		
• adaptation • abiotic factor • biotic factor • carnivore • commensalism • competition for resources • consumer • decomposer • ecosystem	• ecosystem instability • ecosystem stability • environmental change • fungi • herbivore • impact • mutualism • omnivore • organism	• parasitism • population • predation • predator • producer • resistance • species • species diversity • symbiosis • symbiotic relationship

Background Information

Ecosystem Stability

'Ecosystem stability' is a term that is in the 2017 streamlined Biology TEKS BIO(12)(E) and also appears in the updated Biology TEKS, approved by the Texas State Board of Education in 2020 for implementation in fall 2024, BIO(13)(A-D):

- BIO(13)(A) investigate and evaluate how ecological relationships, including predation, parasitism, commensalism, mutualism, and competition, influence ecosystem stability
- BIO(13)(B) analyze how ecosystem stability is affected by disruptions to the cycling of matter and flow of energy through trophic levels using models
- BIO(13)(C) explain the significance of the carbon and nitrogen cycles to ecosystem stability and analyze the consequences of disrupting these cycles
- BIO(13)(D) explain how environmental change, including change due to human activity, affects biodiversity and analyze how changes in biodiversity impact ecosystem stability

In the middle school science TEKS, students describe how biodiversity contributes to the stability and sustainability of an ecosystem.

The term 'ecological stability' is also used in ecological work and research. However, the concept does not have a clear definition. Scientific publications have analyzed the many different ways the term is used and have proposed strategies to streamline the use of the term. The goal of these strategies is to ensure the term is used consistently and applies to the complex changes ecosystems face across the globe today. For more information on this discussion, read the abstracts of the following two articles:

- Grimm, V. & Wissel, C. (1997). Babel, or the ecological stability discussions: an inventory and analysis of terminology and a guide for avoiding confusion. *Oecologia,* 109, 323–334 https://doi.org/10.1007/s004420050090
- Kéfi, S., Domínguez-García, V., Donohue, I., Fontaine, C., Thébault, E. & Dakos, V. (2019). Advancing our understanding of ecological stability. *Ecology Letters*, 22, 1349-1356. https://doi.org/10.1111/ele.13340

To begin this lesson, students will work in groups to explore the concept of ecological stability from the perspectives of multiple publications. Then the class will work to create a definition of the term and identify properties of a stable ecosystem. Students' understanding of the term will evolve through this lesson.

Bats

Bats are unique and fascinating animals. They are the only mammals capable of true flight. They belong to the order Chiroptera which includes more than 1,400 bat species. Bats live on every continent, apart from Antarctica, and have survived on Earth for over 50 million years (BCI, 2023). Different bat species fill different ecological roles

and are part of different ecological relationships, making bats key members of the ecosystems they inhabit.

Threats to Bats Worldwide

Bat populations are declining worldwide. Some of the main reasons for their population declines include:

- Human activities are destroying bat habitats such as cutting down forests, mining guano, and thoughtless tourism into caves and abandoned mines.
- The impacts of climate change harm bat populations. Some examples include:
    - Increased extreme weather events increase bat mortality.
    - Increased aridity and drought make it difficult for some bat populations to survive and reproduce.
    - Changes in seasonal timing negatively impact bats that migrate.
- A disease called white-nose syndrome is currently spreading throughout bat populations in the United States and Canada.
- Bats are hunted for sport and meat.
- Dead bats are found under wind turbines worldwide. While wind turbines are a step toward reducing our reliance on fossil fuels, they are negatively affecting bats.
  (BCI, Bats 101, 2024)

White-Nose Syndrome

White-nose syndrome (WNS) is a disease that has killed millions of bats in North America since it was first identified in 2007. The disease is caused by the fungus *Pseudogymnoascus destructans* (Pd for short) which grows on the bare skin of hibernating bats. Sometimes the fungus looks like white fuzz on bats' faces, which is how the disease got its name.

Bats sick and dying from WNS were first observed in caves near Albany, New York in 2007. However, there are pictures of bats with white fuzz on their noses taken by cave explorers the year before, in 2006, so the fungus has been in North America at least since 2006.

Since then, the fungus has spread throughout the United States and Canada. The fungus mainly spreads by bat-to-bat contact. However, the fungus can live in areas without bats and can be carried to new environments on surfaces such as human clothing, shoes, and other outdoor gear. So bats are also infected when they come into

contact with an environment where the fungus is growing and when humans spread spores to new areas. The fungus thrives in cold, dark, and damp places.

Currently, 12 bat species (including three endangered and one threatened species) have been confirmed with white-nose syndrome in North America. Pd has been found on an additional eight species (including two endangered species) without confirmation of the disease. There is a distinction between which bat species have been detected with Pd and which species actually develop WNS. These numbers will change. Stay up-to-date here: Bats Affected by WNS*(WNS Response Team, n.d.).
*Full URL if needed: https://www.whitenosesyndrome.org/static-page/bats-affected-by-wns

Bats of Texas
44 bat species live in North America, and 32 of these species live in Texas. In this lesson, students will observe the Mexican free-tailed bats that live in Bracken Cave, near San Antonio, Texas while watching three video clips from the film, *Deep in the Heart: A Texas Wildlife Story*. In addition to Mexican free-tailed bats, students will also learn about 5 other species of bats that live in Texas.

The 6 bat species explored in this lesson include:

- *Corynorhinus townsendii townsendii* (Townsend's big-eared bat)
- *Eptesicus fuscus* (big brown bat)
- *Myotis austroriparius* (southeastern myotis)
- *Myotis velifer* (cave myotis)
- *Perimyotis subflavus* (tricolored bat)
- *Tadarida brasiliensis* (Mexican free-tailed bat)

The lesson plan below will give you the option to have students explore more than these 6 Texas bat species if you'd like.

Bracken Cave
Texas is home to the world's largest bat colony and one of the largest concentrations of mammals on Earth. Bracken Cave, located along the southeastern edge of the Hill Country near San Antonio, Texas, is home to approximately 20 million Mexican free-tailed bats. This population is a maternity colony, consisting of females and their pups. The emergence of these millions of bats as they leave the cave at dusk during the spring, summer, and fall for their nightly insect hunt, is an unforgettable sight. They fly out of the cave in a spiral that looks like a tornado, a tornado of bats, a batnado!

Congress Avenue Bridge in Austin, Texas
The largest urban colony of bats in the world is made up of an estimated 1.5 million Mexican free-tailed bats that live under the Congress Avenue Bridge in Austin during the summer. The emergence of this colony each night has become one of the city's most popular summer tourist attractions.

Tips for Addressing Concerns/Fears About Bats
Many people are afraid of bats. For some, this may stem from a personal experience. However, most people have never been close to a bat. They may have seen the silhouette of a bat flying at night but have never encountered a bat in close range. This means that a fear of bats often comes from social cues.

Some of the common myths listed below may teach people to fear bats. The way bats are depicted for Halloween could also make people leery of bats. These portrayals may come from the fact that bats are different than us. They are active at night and live in dark spaces like caves. A fear of bats may develop due to unfamiliarity.

Watch carefully for your students' reactions as you introduce bats in the Explore 4 section of this lesson. If you notice any fears or discomfort, gently address these concerns directly. Ask students to share what they know about bats and any previous experiences they've had with bats. Use the information below to speak to any misconceptions students have about bats. Encourage students to become curious about bats, learn more about bats through this lesson, and see if any of their ideas about bats change by the end of the lesson.

As students observe bats in pictures and videos throughout this lesson, they may develop the opinion that bats are cute! They are small, furry, and curious about what is going on around them.

There are legitimate reasons to steer clear of bats. Like all wild animals, bats should never be touched. If a bat is found on the ground and/or outside during the day, it may be sick. Give the bat plenty of room and contact a local rescue organization* to help. Like all mammals, bats can have rabies. This is one reason why one should never touch a bat or any other wild animal. *Full URL if needed: https://batworld.org/local-rescue/

The organization Bat Conservation International is leading the charge to ensure the worldwide survival of bats. Part of their conservation work includes teaching people

about specific bat species and the ecological and economic value of this extraordinary mammal. Learn more about their conservation work and bats in general here: https://www.batcon.org/our-work/inspire-through-experience/

Common Misconceptions about Bats

Myth	Facts
Bats are blind.	No. All bats are able to see. There is variation in eyesight from species to species. Some bat species have night vision which allows them to see in dimmer light, similar to the adaptation of a cat's eyes. Some species of bats can see ultraviolet light. Other bat species, like the Mexican free-tailed bat, rely on echolocation to navigate and hunt in the dark. While these species do not see well in the dark, they are still able to see. Their night vision is similar to that of a human's (BCI, FAQ, 2023).
All bats drink blood.	No! Of the 1,400+ species of bats on Earth, only three are vampire bats that feed on blood. These three species all live in the New World tropics (i.e., South America, Central America, and Mexico) (BCI, FAQ, 2023). Vampire bats do not actually suck blood. Instead, they use sharp, pointed front teeth to make small cuts in the skin of another animal and then lap up the blood. The saliva of these bats has proteins that prevent wounds from clotting. This anticoagulant has been developed into a medication that helps prevent strokes in humans (BCI, Common Vampire Bat, 2023).
Bats will fly into your hair.	No! Bats are not attracted to human hair. This is an old misconception. This idea could have evolved from humans seeing bats foraging for insects low, just above people's heads. Bats are able to catch small flying insects mid-flight and can definitely avoid a human head! (Virginia Department of Wildlife Resources, 2023). This myth may have been told as a way to deter young women from going out at night (Neighborhood Bat Watch, n.d.).
All bats have rabies.	Most bats do NOT have rabies. It is estimated that less than 0.005% of bats in wild populations contract the rabies virus (Idaho Fish and Game, 2005). Even among bats submitted for

	rabies testing in the US, only about 6 percent had rabies (Florida Fish and Wildlife Conservation Commission, 2024). All mammals can contract rabies. In 2021, 8,686 mammals (multiple species) in Texas were tested for rabies. Of those 8,686 animals, 455 (5%) were positive for rabies. In 2021, skunks were the primary source of positive rabies cases in Texas and bats had the second-highest number of confirmed rabies cases (Texas Department of State Health Services, 2021). It is very important to NEVER touch a wild animal, including a bat. If you find a bat on the ground or out during the daytime, there is a high chance that it is sick or injured. If you encounter a bat in a building or on the ground, contact a local rescue organization to help (BCI, FAQ, 2023). *Full URL if needed: https://batworld.org/local-rescue/
Bats are not that important. Bats are 'vermin' and should be exterminated.	Not true! All around the world, bats provide vital ecosystem services such as insect pest consumption, plant pollination, and seed dispersal. They are essential to the health of global ecosystems (BCI, Bats 101, 2023).
Bats are flying mice.	No! The most recent studies using gene comparisons suggest that bats are in the superorder Laurasiatheria. Bats' exact placement within the Laurasiatheria superorder is still uncertain, but they are thought to share a most recent common ancestor with hooved animals like horses and antelope as well as carnivores (Tsagkogeorga et al., 2013).
All bats are the same.	There are over 1,400 different bat species worldwide that vary in size, appearance, and characteristics. 44 of those species live in North America and 32 bat species live in Texas.

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Materials

Per Class

- *Deep in the Heart: A Texas Wildlife Story* Bats & White-Nose Syndrome: A Closer Look Grades 9-12 PowerPoint
  - English: https://docs.google.com/presentation/d/1nobNYx-8C-uF-ibw3HL560NJsj_OYLX3/edit?usp=drive_link&ouid=103309533954542071568&rtpof=true&sd=true
  - Spanish: https://docs.google.com/presentation/d/1RSfPYXPACeVtOPqAfHlDr3Ho9fgbUMov/edit?usp=drive_link&ouid=103309533954542071568&rtpof=true&sd=true
- Large piece of chart paper (or whiteboard or smartboard) and sticky notes (enough for each student to use multiple)
  Or: Digital sticky notes & shared online space where students can digitally post
- *Deep in the Heart* - Bat Edu Videos YouTube playlist https://www.youtube.com/playlist?list=PLZBxEBiVysUNqdGxmrv7THKArV6ZoeD_k
- *Survival of the Fattest* video https://vimeo.com/741467854
- 2 quarters or 1 AAA battery *to represent mass of a Mexican free-tailed bat ~12g*
- Answer Keys (pages 42-51)

Per Group

- 1 set of 'Ecosystem Stability' handouts (pages 23-25 for English/ 52-54 for Spanish)

Per Student

- Handouts (pages 26-41 for English/ 55-70 for Spanish)
- A device (laptop or tablet) that can access these sites:
  - Bat Conservation International Bat Profiles https://www.batcon.org/about-bats/bat-profiles/
  - Texas Parks & Wildlife Department https://tpwd.texas.gov/
  - Where is WNS Now? https://www.whitenosesyndrome.org/where-is-wns
  - *Survival of the Fattest* video https://vimeo.com/741467854

Prep

1. Consider downloading the PowerPoint files instead of viewing them in Google Drive so you have access to the correct formatting and embedded videos.
2. Preview the videos and websites to make sure they work with your and your students' technology. See the links in the Materials List above.

Engage – Picture an Ecosystem

1. Show students PowerPoint slide 3 which prompts students to:
    a. Picture an ecosystem in your mind.
    b. Imagine you are there. What do you see? hear? feel? smell?
    c. What things are found in your ecosystem?

    If students need support picturing an ecosystem, show the tips on PowerPoint slide 4:
    a. An ecosystem includes a community of organisms living together in the same area, the components of the physical environment, and the interactions between all components (both biotic and abiotic).
    b. Think of the last movie you watched. In what ecosystem did the movie take place?
    c. Or, picture the ecosystem your school or neighborhood is a part of.
2. Optional:
    a. Have students draw a quick sketch of the ecosystem they are picturing.
    b. Tell students to turn to a partner and describe the ecosystem they are picturing.

Explore 1 – Describe a Stable Ecosystem

3. Show the question on PowerPoint slide 5, 'What are features of a stable ecosystem?' (Or write this question on a piece of chart paper, a smartboard, or a whiteboard.) Tell students they will spend time investigating features of a stable ecosystem throughout this lesson.
4. To give everyone a chance to share their initial ideas, the class will use the Domino Share Routine. Show the image of dominos on PowerPoint slide 6 and explain the Domino Share Routine:
    a. Emphasize that this routine will gather information about what the students think *now*. Each student will share their initial ideas. The class will come back to these responses throughout the lesson and edit them based on what they learn. (So as the educator, you will not give feedback as students share their ideas during the Domino Share Routine.)
    b. The prompt is, "Share one feature of a stable ecosystem."
    c. Identify who the first student to respond to the prompt will be. Then identify the second and third. Explain that students will continue responding to the prompt in this order like a row of dominoes falling, until all students in the class have shared.

   d. Each person must reply quickly to keep the row of dominoes going, to not break the chain.
5. After all students have shared, tell students to record on a sticky note a response to the prompt, "Share one feature of a stable ecosystem." Use either paper sticky notes that can be posted in the classroom or digital sticky notes that can be shared virtually with the class. Each student can choose to record the comment they shared in the Domino Share Routine, or they can record a different idea they heard or thought of.
6. If using paper sticky notes, have students post the notes in a place where students will be able to see them throughout this lesson, such as on a piece of chart paper or whiteboard. If using digital sticky notes, have students share the notes virtually such as on a shared digital whiteboard. Title the chart, 'What are features of a stable ecosystem?'
7. Again, at this point in the lesson, you do not need to give feedback on students' responses. For now, have students record their ideas. The class will edit these replies throughout the lesson.

Explore 2 – Ecosystem Stability: A Closer Look

8. Draw students' attention to the sticky notes. With input from the class, organize the notes so similar ideas are posted together.
9. Divide the class into groups of 3. Assign each member of the group a letter: A, B, or C.
10. Tell students that 'ecosystem stability' is a term often used in ecology, but there is not one clear definition of the term. Inform students they will now read quotes from publications about ecosystem stability to learn more about the term. Each person in their group of 3 will read a different handout and then each group member will share what they learn with their group.
11. Give each partner one of the 'Ecosystem Stability' handouts. See pages 23-25 below for the English handouts and pages 52-54 for the Spanish handouts.
12. Provide time for each student to read their handout quietly to themselves.
13. When all group members have completed their reading, tell students to take turns sharing what they learned from their reading with their group members.
14. Then, tell each group to look over the ideas on the class sticky note chart. Ask, "Are there any ideas your group learned about ecosystem stability that are not on this chart?" Distribute additional sticky notes and provide time for each group to add any new ideas to the 'What are features of a stable ecosystem?' chart.

15. If students identify incorrect information on the chart, ask them to find specific text in the handouts they read that disproves the original idea.
16. Create a section on the 'What are features of a stable ecosystem?' chart titled, 'We used to think…' If the class comes to a consensus that one of the ideas on the sticky note chart is not correct, move the original sticky note to this section.

Explore 3 – Ecological Roles & Relationships

17. Tell students they will now look closer at roles and relationships in ecosystems.
18. Distribute an 'Ecological Roles & Relationships' handout. See pages 26-27 below for the English handout and pages 55-56 below for the Spanish handout. (Note: The Answer Key for this handout is on pages 42-43.)
19. Show PowerPoint slide 9 to review the directions. First, tell students to complete the 'Ecological Roles & Relationships' handout individually.
20. Then, tell students to return to their small group of 3 students and discuss their responses. Tell students to update their responses on their handouts if they learn anything new from talking with their group.
21. Next, tell students they will again use the Domino Share Routine. However, this time each group will assign one person to be the speaker. The speaker will be the person to share the group's responses. Provide time for each group to assign a speaker.
22. Then, explain how the Domino Share Routine will work for this part of the class. PowerPoint slide 9 has a summary of these directions.
    a. You, as the educator, will read prompt 1 on the 'Ecological Roles & Relationships' handout.
    b. The speaker from group 1 will share their group's response.
    c. All other students in the class will put a thumbs up if they agree and a thumbs down if they disagree.
    d. You (the educator) will mark down on your Answer Key for this handout if the class agreed or disagreed on the response. (See pages 42-43.)
    e. Then, move on to the next prompt. Read the 2nd prompt out loud and direct the speaker from group 2 to respond. Again, have all students put a thumbs up or thumbs down, to show if they agree or disagree with the speakers' response and mark down if the class agrees or disagrees. Repeat this process for all the prompts.
    f. Emphasize that this share-out routine should move quickly, like a row of dominos falling.

23. Once you have read all the prompts to the class and recorded their responses, use PowerPoint slides 10-18 to review the definitions of all the terms, taking more time to discuss any of the terms that were incorrectly defined by students on the 'Ecological Roles & Relationships' handout.
24. Challenge students to identify examples of symbiotic relationships by showing and discussing PowerPoint slides 19-21. Answer Key:
    a. PowerPoint slide 19 shows an example of commensalism (+/0). The bird benefits by having a place to build a nest, and the tree is generally not impacted.
    b. PowerPoint slide 20 shows an example of mutualism (+/+). The bee benefits in this relationship by gaining a food source. The flower also benefits by being able to reproduce.
    c. PowerPoint slide 21 shows an example of parasitism (+/-). The tick benefits in this relationship by gaining a food source. The host is harmed because the area where the tick attaches can become inflamed and swollen and the host can contract diseases from the tick.

Explore 4 - Ecological Roles & Relationships of Bats

25. Show students images of Mexican free-tailed bats on PowerPoint slides 23-27.
26. At first, provide time for students to make observations of the bats in the pictures quietly to themselves. Then ask a few students to share what they notice about Mexican free-tailed bats.
27. Here are some bat facts you can use to guide the discussion:
    a. The Mexican free-tailed bat is considered a medium-sized bat, although it is pretty small. On average, an adult Mexican free-tailed bat is about 12 grams. That's about the same mass as 2 quarters or 1 AAA battery. Show students 2 quarters or 1 AAA battery or something else that has a mass of about 12 grams. Pass the object you choose around the room so students can hold 12 grams in their hands and imagine what it might feel like to hold a Mexican free-tailed bat.
    b. Mexican free-tailed bats have short, dense fur, large, rounded ears, and wrinkly upper lips.
    c. They live in a variety of habitats, including caves, abandoned mines, bridges, culverts, and bat houses. The colonies of Mexican free-tailed bats tend to be large, including hundreds of thousands and sometimes millions of bats.

   d. In North America, most Mexican free-tailed bats are migratory, seasonally moving from the central and southern United States to Mexico.
   e. Mexican free-tailed bats are fast! They can reach average flying speeds of over 60 miles per hour. The fastest Mexican free-tailed bat flight recorded was just under 100 miles per hour.
28. Ask, "Why do you think these bats have 'free-tailed' in their name?" Give students a few moments to think and then have a few students share their initial ideas.
29. Show PowerPoint slide 28 and ask, "What do you notice about the bat tails in the illustrations?" Then, pose the question again, "Why do you think Mexican free-tailed bats have 'free-tailed' in their name?" In PowerPoint presentation mode, activate the animation feature so this question appears on the slide. Guide the discussion so that students identify:
   a. The tails of Mexican free-tailed bats extend beyond the tail membrane.
   b. The tails of most other bats are completely enclosed within the tail membrane. However, there are other free-tailed bats. Of the 1,400+ bat species worldwide, about 100 of them are classified in the family Molossidae, the 'free-tailed bat' family (NH PBS, 2023).
   c. The entire length of the tail of a Mexican free-tailed bat can be almost half its total body length.
30. Show the map on PowerPoint slide 29 that identifies where Mexican free-tailed bats live. Ask students, "Do Mexican free-tailed bats live in your area?" Guide students to use the map to answer this question.
31. Tell students they will learn more about the Mexican free-tailed bats that live in Bracken Cave. Bracken Cave, a cave in Texas, is home to approximately 20 million Mexican free-tailed bats during the summer months. This population is a maternity colony, consisting of females and their pups.
32. Show students the images on PowerPoint slides 30-31 to introduce them to Bracken Cave.
33. Show the Texas map on PowerPoint slide 32 that identifies where Bracken Cave is located. Ask the questions posted on the slide to help students make a connection to the location of Bracken Cave:
   a. What large city is closest to Bracken Cave?
   b. How long would it take you to get to Bracken Cave?
   c. Have you heard of Bracken Cave before?
   d. Have you visited the cave yet?

34. Distribute an 'Ecological Roles & Relationships of Mexican Free-Tailed Bats' handout to each student and review the directions. See page 28 below for English and page 57 for the Spanish version.
35. Provide time for students to read through all the prompts on the handout. Tell students they will reply to the prompts after watching three videos about Mexican free-tailed bats.
36. Show the videos in the *Deep in the Heart* - Bat Edu Videos YouTube playlist. This playlist includes three videos that are embedded in PowerPoint slides 33-35.
    a. PowerPoint slide 33: *Deep in the Heart: A Texas Wildlife Story Bats of Bracken Cave* (4 minutes) https://youtu.be/H-q58Jd50Lk?si=YPNKR-lAWvIN-7Nl
    b. PowerPoint slide 34: *Deep in the Heart: A Texas Wildlife Story Snakes Hunt Bats* (5 minutes) https://youtu.be/60Zf7-hLS4E?si=2PAJQFvBHva_yfMf
    c. PowerPoint slide 35: *Deep in the Heart: A Texas Wildlife Story Bats' Greatest Strength: Their Numbers* (4 minutes) https://youtu.be/Va7otBnHq_s?si=2n2v7ia1qvbgdjx4
37. After showing the videos, provide time for students to record their responses on the 'Ecological Roles & Relationships of Mexican Free-Tailed Bats' handout.
38. As a class review students' responses. See the 'Ecological Roles & Relationships of Mexican Free-Tailed Bats – Answer Key' on page 44 below and PowerPoint slides 36-38 to guide the discussion.
39. Show PowerPoint slide 39 and pose the following prompt to the class, "Did you notice any features of a stable ecosystem in the video? Explain your thinking."
40. Provide a few minutes for students to think about this prompt. Remind them to refer to the class sticky note chart to gain ideas.
41. Then ask students to share their responses to the prompt as a class. Tell students to use examples from the videos and text from the class chart to support their claims.

Explore 5 – Bats of Texas

42. Tell students that Mexican free-tailed bats are just one of many bat species that live in Texas. Of the 1,400+ bat species worldwide, over 30 of them live in Texas.
43. Distribute a 'Bats of Texas' handout to each student. See pages 29-30 below for English and pages 58-59 for Spanish. Review the directions on the handout and provide time for students to work. Optional: The handout guides students to learn about 1 of 6 listed species. As mentioned above, there are over 30 bat

species in Texas. If you'd like to expand this activity, challenge students to learn about other bat species that live in Texas.

44. When all students have completed their handout, facilitate a way for students to share what they learned about the bat species they chose so all students learn about all 6 bat species listed on the handout (and any other bat species they researched). Ideas include:
    a. Provide time for each student to share out one thing they learned about their bat species with the class. Challenge students to not repeat what has already been shared.
    b. Facilitate a gallery walk. Have each student put their completed handout on their desk and then provide time for students to walk around the room, reading other students' work.
    c. Facilitate sharing among partners in two parallel lines:
        i. Direct students to stand up with their completed handouts and form two parallel lines with each line facing the other. This means each student will have a partner across from them. If there is an odd number of students in the class, you (the educator) can join one of the lines.
        ii. Name one line 'Line A' and the other line 'Line B.'
        iii. Set a timer for 1 minute. Have each student in Line A share a bat fact from their completed handout with the student standing across from them in Line B.
        iv. When 1 minute is up, reset the timer and tell each student in Line B to share a bat fact with their partner in Line A.
        v. After each partner has shared, have everyone in Line A shift one person to the left. The person at the top of Line A will need to walk to the bottom of Line A so everyone has a partner.
        vi. Repeat multiple times.

Explore 6 – A Global View of Bats

45. So that students can further explore the ecological impacts of bats, direct them to read the text on the handout 'Bats: Essential to the Health of Our Ecosystems' and respond to the questions that follow. See pages 31-32 below for the English handout and pages 60-61 for the Spanish handout.

Explore 7 – What is white-nose syndrome? How does it spread?

46. Introduce students to white-nose syndrome by showing the 6-minute video embedded on PowerPoint slide 43. This video is also available at the following link: *Survival of the Fattest* https://vimeo.com/741467854
47. Distribute a 'What is white-nose syndrome?' handout to each student and provide time for them to complete it. See pages 33-34 below for English and page 62-63 for Spanish.
48. When all students are finished, review students' responses as a class. See the 'What is white-nose syndrome? Answer Key' on pages 46-47 to guide the discussion.
49. Next students will investigate the interactive spread map linked below by completing the 'Where is white-nose syndrome now?' part of the handout. See page 34 below for English and page 63 for Spanish. This handout provides students with the link to the map and prompts them to use the map to answer questions. Map link:
    Where is WNS Now? https://www.whitenosesyndrome.org/where-is-wns
50. Then have students learn more about WNS in Texas by reading the 'How is white-nose syndrome impacting bats in Texas?' handout. See pages 35-36 below for English and page 64-65 for Spanish.

Explain

51. Return to the question that was posed at the beginning of this lesson, "What are features of a stable ecosystem?" Ask students to add to the class chart based on what they learned. Prompt them to update any information on the chart that they now recognize as not accurate.
52. Support students to explain their learning by completing the Explain handout on page 37 for English and page 66 for Spanish. The handout will guide students to answer the following questions:
    a. What ecological relationship exists between the fungus that causes white-nose syndrome (WNS) and bats?
    b. Could white-nose syndrome (WNS) in North America impact ecosystem stability? Why or why not? Include at least one specific possible ecological consequence of WNS in your response.
    c. WNS is a big issue. Scientists across the globe are working to reduce the spread of Pd and the impact of WNS. Are there any small steps you can take to support the health of bats?

Elaborate – Curious to learn more?

53. Challenge students to learn more about what is being done to protect bats from white-nose syndrome and how the spread of Pd throughout North America is part of a larger extinction story. See the 'Curious to learn more?' handout below, pages 38-39 for English and pages 67-68 for Spanish.
54. Learning about and discussing the profound ways human actions have and continue to impact Earth's ecosystems, can bring up strong feelings, including overwhelm, powerlessness, sadness, anger, and anxiety, in all people – children, adolescents, teenagers, and adults. Read the following article to learn more about strategies that can guide students to feel hopeful and empowered, rather than hopeless when learning about global environmental topics:

    Christensen, A., Welton-Mitchell, C., Gold, A.U., James, L., & Zeitz, L. (2023). Beyond Doom and Gloom: Teaching Climate Change to Foster Empowerment. *Connected Science Learning,* 5(3). https://www.nsta.org/connected-science-learning/connected-science-learning-may-june-2023/beyond-doom-and-gloom-teaching

Evaluate – Apply What You Learned

55. Direct students to complete the 'Apply What You've Learned' handout. See pages 40-41 below for the English handout and pages 69-70 for the Spanish handout.

Ecosystem Stability – Partner A

"Ecosystem stability is an important corollary [consequence] of sustainability. Over time, the structure and function of a healthy ecosystem should remain relatively stable, even in the face of disturbance. If a stress or disturbance does alter the ecosystem it should be able to bounce back quickly" (Soil Quality for Environmental Health, 2011).

"Disturbances are events, like tornados, wildfires, or floods that cause marked changes to the impacted area… Disturbances often come in the form of short-term or temporary changes to the landscape but can have very significant ecosystem impacts" (USDA, Disturbances and Stressors, n.d.).

"Environmental or ecological stressors are thought of as pressures or dynamics that impact ecosystem components or processes caused by human and associated activities. Stressors, like pathogens or water stress, are dynamics that impair or comprise the function or productivity of the system" (USDA, Disturbances and Stressors, n.d.).

Sources

Soil Quality for Environmental Health. (2011). *Ecosystem Stability.* http://soilquality.org/basics/stability.html

U.S. Department of Agriculture (USDA). (n.d.). *Disturbances and Stressors.* Climate Hubs. https://www.climatehubs.usda.gov/disturbances-and-stressors

Ecosystem Stability – Partner B

"Our analysis shows that the general term 'stability' is so ambiguous as to be useless. It can be replaced by the stability properties 'staying essentially unchanged' (constancy), 'returning to the reference state (or dynamic) after a temporary disturbance' (resilience), and 'persistence through time of an ecological system' (persistence)" (Grimm & Wissel, 1997).

"To an ecologist, diversity is the number of different species in an area, also known as biodiversity or richness… Species diversity results in higher efficiency of resource capture among plants, especially sunlight, but also lowers nutrient losses from the soil and allows communities of plants to respond to varying annual conditions of drought. So, the jury is now in; conserving diversity ensures a more productive and stable set of ecosystems on which humans depend" (Schlesinger, 2017).

"It has long been assumed that diversity is a primary predictor of ecosystem stability; however, significant… inconsistencies in the diversity-stability relationship have led to debate about that assumption, particularly in the context of climate change" (USGS, 2024).

Sources

Grimm, V. & Wissel, C. (1997). Babel, or the ecological stability discussions: an inventory and analysis of terminology and a guide for avoiding confusion. *Oecologia* 109, 323–334 https://doi.org/10.1007/s004420050090

Schlesinger, W. (2017). *Why Species Matter*. Translational Ecology. https://blogs.nicholas.duke.edu/citizenscientist/why-species-matter/

USGS Science. (2024). *Quantifying the drivers of ecological stability in response to climate change across ecosystems*. John Wesley Powell Center for Analysis and Synthesis. https://www.usgs.gov/centers/john-wesley-powell-center-for-analysis-and-synthesis/science/quantifying-drivers-ecological

Ecosystem Stability – Partner C

"A dynamic [constantly changing] balance between plants, animals, and the surrounding environment comprises an ecosystem. The impact of humans, as an integral part of most ecosystems, must be taken into account when managing the system's health. For healthy functioning and sustainability, an ecosystem's living members must be in balance with the non-living elements" (USDA, Ecosystems, n.d.).

"The two key components of ecosystem stability are resilience and resistance. Resistance is an ecosystem's ability to remain stable when confronted with a disturbance. Resilience is the speed at which an ecosystem recovers from a disturbance. For example, resistance refers to a forest's ability to withstand a windstorm; resilience refers to how quickly felled trees would grow back" (Groffman, 2008).

"…what can we do to increase the resistance and resilience of ecosystems? This is an active topic of research at the Cary Institute [of Ecosystem Studies]; some ideas are emerging. First is to maintain a diversity of plants and animals in an ecosystem. Humans have a tendency to simplify ecosystems to maximize one particular output. But this makes them more vulnerable to collapse or sudden change and should be avoided. Second is to minimize multiple stresses… A diversity of flora and fauna is good. A diversity of environmental stressors is not" (Groffman, 2008).

Sources

Groffman, P.M. (2008). *Keeping balance in the environment*. Cary Institute of Ecosystem Studies. https://www.caryinstitute.org/news-insights/feature/keeping-balance-environment

U.S. Department of Agriculture (USDA). (n.d.). *Ecosystems*. National Institute of Food and Agriculture (NIFA). https://www.nifa.usda.gov/topics/ecosystems

Name _____

Ecological Roles & Relationships

Directions: Use the words in the word bank to complete each sentence below.
Tip: Each word will be used once.

Word Bank

carnivore	commensalism	competition for resources	consumer	decomposer
herbivore	insectivore	mutualism	omnivore	parasitism
predator	prey	producer	scavenger	symbiosis

Ecological Roles

A _____ is an organism that converts water, carbon dioxide, and sunlight into the energy it needs to survive.

A _____ is an organism that gets the energy it needs by eating other organisms.

- An _____ is an animal that eats plants.
- An _____ is an organism that eats insects.
- A _____ is an animal that eats animal tissue (usually muscle, fat, and other soft tissues) through hunting or scavenging.
- An _____ is an animal that eats both plants and other animals.

Feeding Relationships

- A _____ is an organism that gains energy from killing and then eating all or parts of another organism.
- _____ is an animal that is caught and killed by another organism for food.
- A _____ is an organism that consumes mostly carrion (the decaying flesh of dead animals) and/or rotting plant matter.
- A _____ is an organism that breaks down dead organisms into simpler inorganic materials, making nutrients available to primary producers.

Ecological Relationships

_____ occurs when two different organisms or species use the same limited resource which results in a negative impact on each other.

_____ is a close, prolonged (lengthy) association between two or more different species.

- _____ is a symbiotic relationship between two species in which both benefit. The relationship can be represented as: +/+
- _____ is a symbiotic relationship between two species in which one benefits and the other is unaffected. The relationship can be represented as: +/0
- _____ is a symbiotic relationship between two species in which one benefits and the other is harmed. The relationship can be represented as: +/-

Name _____

Ecological Roles & Relationships: Mexican Free-Tailed Bats

Directions:

- First, read all the questions below.
- Next, watch the 3 *Deep in the Heart Mexican Free-Tailed Bat* videos here.*
- Then, respond to the questions below.

Are Mexican free-tailed bats producers? YES NO

Are Mexican free-tailed bats consumers? YES NO

If yes, identify the type of consumer Mexican free-tailed bats are:

- ☐ herbivore
- ☐ insectivore
- ☐ omnivore
- ☐ carnivore

What role(s) do Mexican free-tailed bats play in feeding relationships? Check all that apply.

- ☐ predator
- ☐ prey
- ☐ scavenger
- ☐ decomposer

Did you observe Mexican free-tailed bats competing for resources? YES NO

Were the Mexican free-tailed bats in the videos a part of any of the following symbiotic relationships? Check all that apply.

- ☐ mutualism (+/+)
- ☐ commensalism (+/0)
- ☐ parasitism (+/-)

*Full URL if needed: *Deep in the Heart* - Bat Edu Videos
https://www.youtube.com/playlist?list=PLZBxEBiVysUNqdGxmrv7THKArV6ZoeD_k

Name _____

Bats of Texas

Of the 1,400+ bat species worldwide, over 30 of them live in Texas. In this activity, you will learn more about 1 bat species.

Directions:

- Select one bat species from the list below to learn more about.
- Look up this bat species using the two resources listed below.
- Reply to the prompts in this handout.

Bat Species:

Corynorhinus townsendii townsendii (Townsend's big-eared bat)	*Eptesicus fuscus* (big brown bat)	*Myotis austroriparius* (southeastern myotis)
Myotis velifer (cave myotis)	*Perimyotis subflavus* (tricolored bat)	*Tadarida brasiliensis* (Mexican free-tailed bat)

Resources:

- Bat Conservation International Bat Profiles https://www.batcon.org/about-bats/bat-profiles/
- Texas Parks & Wildlife Department (use the search bar) https://tpwd.texas.gov/

Scientific Name: _____

Common Name: _____

Distribution (Where in the world does this bat species live?):

_____

_____

Preferred habitat: _____

_____

_____

Global Conservation Status (IUCN) Circle one category below.

Not Evaluated Data Deficient Least Concern Near Threatened Vulnerable

Endangered Critically Endangered Extinct in the Wild Extinct

What type of consumer is this bat species?

- ☐ herbivore
- ☐ insectivore
- ☐ omnivore
- ☐ carnivore

What role(s) does this bat species play in feeding relationships?

- ☐ predator
- ☐ prey
- ☐ scavenger
- ☐ decomposer

Did you learn about any symbiotic relationships this species is a part of? YES NO
Reminder: Symbiotic relationships include mutualism, commensalism, & parasitism.
If yes, explain:

_____

_____

_____

_____

_____

List at least 2 other facts you learned about this bat species:

_____

_____

_____

_____

_____

Name _____

Directions:

- First, read the text below.
- Then, respond to the questions that follow.

Bats: Essential to the Health of Our Ecosystems

Bats are unique and fascinating animals. They are the only mammals capable of true flight. They belong to the order Chiroptera which includes more than 1,400 bat species. Bats live on every continent, apart from Antarctica, and have survived on Earth for over 50 million years (BCI, 2024). Different bat species fill different ecological roles and are part of different ecological relationships, making bats a key member of the ecosystems they inhabit.

Pest Eaters

Most of the 44 bat species that live in North America are insectivores. On average, an insectivorous bat can eat up to half its body weight in insects each night. A pregnant or nursing bat will consume up to 100% of its body weight on its nightly hunt. Scientists estimate that insect-eating bats may save US farmers roughly $23 billion each year by reducing crop damage and limiting the need for pesticides (BCI, 2024).

Pollinators

Most flowering plants rely on pollination to produce new seeds. Pollination is the process of moving pollen grains from the male part of the flower (the stamen) to the female part (the pistil) (BCI, 2024).

Some bats in tropical and subtropical parts of the world feed on nectar. As these bats drink the sweet nectar inside flowers, they pick up a dusting of pollen and move it to other flowers as they feed. The role of bats as a pollinator is critical for a wide variety of plants, including giant cacti and agave. Bat pollinations also play a vital role in the growth of plants that produce products such as balsa wood, carob, cloves, and durian fruit (BCI, 2024).

Seed Dispersers

Fruit eating bats often consume an entire fruit, including the seeds and then defecate the seeds, often in flight. This allows plants to grow in new areas. Fruit eating bats are found in tropical and subtropical areas of Africa, Asia, and Australia as well as some Pacific islands, Latin America, and the Caribbean (NPS, 2022).

1. Bats eat insects that would otherwise eat and damage farmers' crops. This is an example of:
   a. mutualism b. commensalism c. parasitism

   Explain why:

   _____

   _____

2. Bats eat fruit and then disperse the seeds as they fly. This is an example of:
   a. mutualism b. commensalism c. parasitism

   Explain why:

   _____

   _____

3. Bats pollinate plants as they move from flower to flower drinking nectar. This is an example of:
   a. mutualism b. commensalism c. parasitism

   Explain why:

   _____

   _____

4. What is one significant impact bats have on ecosystems in the United States?

   _____

   _____

   _____

Sources

Bat Conservation International (BCI). (2024). *An Unlikely Hero With Global Impact.* Bats 101. https://www.batcon.org/about-bats/bats-101/

National Park Service (NPS). (2022). *Made Possible by... Bats.* https://www.nps.gov/articles/000/made-possible-by-bats.htm

Name _____

What is white-nose syndrome?

Directions:

- First, watch this video: *Survival of the Fattest* https://vimeo.com/741467854
- Then, respond to the prompts below.

1. Where was white-nose syndrome (WNS) first identified in North America?

   a. Maine b. Florida c. Texas d. New York

2. What causes WNS?

   a. a fungus b. a virus c. a bacteria

3. The fungus grows on _____ bats.

   a. hibernating b. small c. large

4. What probably caused the fungus to spread from Eurasia to North America?

   _____

5. Why did the scientists in this video collect live bats?

   _____

   _____

   _____

6. How were the genes from the little brown bats that survived at least one winter hibernating in an area where the fungus was present different from the little brown bats that died from WNS?

   _____

   _____

   _____

   _____

7. The association between bats and Pd is an example of which type of ecological relationship?

   a. mutualism b. commensalism c. parasitism
   d. competition for resources e. predator/prey

8. What questions do you have about WNS and/or bats after watching this video? Write at least 2 questions below.

_____

_____

_____

Where is white-nose syndrome now?

Directions:

- First, explore this interactive white-nose syndrome spread map: Where is WNS Now? https://www.whitenosesyndrome.org/where-is-wns
- Then, respond to the prompts below.

1. After the first detection in New York in 2006, how many years did it take for WNS to spread to the West Coast? _____
2. In what year was the fungus (Pseudogymnoascus destructans, Pd for short) that causes WNS first confirmed in Texas? _____
3. According to the 'Where is WNS Now?' map, list the continental US states NOT yet impacted by WNS or the fungus that causes WNS (Pseudogymnoascus destructans, Pd for short): _____

_____

_____

How is WNS impacting bats in Texas?

Background: Pd & WNS in North America

Currently, 12 bat species have been confirmed with white-nose syndrome (WNS) in North America. The disease has caused severe and widespread mortality in three of these species. One species is now listed as endangered in the US because of WNS and two other species may also be added to the US endangered list soon. All three of these species are listed as endangered in Canada due to the impacts of WNS.

Pd, the fungus that causes WNS, has been found on an additional eight North American species (including two endangered species) without confirmation of the disease. Not all bats that are detected with Pd, develop WNS. These numbers will change as PD continues to spread west. Stay up to date here.*

Pd spreads when a bat touches another bat or a surface that has Pd on it. While Pd has NOT been known to make humans or other animals sick, humans can spread Pd to new areas. Pd spores can last a long time on clothes, shoes, and other equipment. So, a human can spread Pd by going to a place where the fungus is and then traveling to an area without it. The fungus thrives in cold, dark, and damp places, like caves.

Pd is not native to North America. It is thought to have been introduced to North America from Eurasia around 2006. Since bats in North America had not been exposed to Pd before, many North American species have little resistance to or tolerance of the fungus. Bats in Europe and Asia do not appear to become as sick from Pd. These bats seem to be more resistant to and tolerant of Pd infection.

Pd & WNS Detected in Texas

Pd was first detected in Texas over the winter of 2016-17. Two years later, over the winter of 2019-20, Texas's first instance of WNS was detected in *Myotis velifer* (cave myotis) bats. By the spring of 2020, hundreds of cave myotis bats in Texas were found dead. Pd continues to spread among this species, causing WNS in Texas and surrounding states.

During the winter of 2023-24, tricolored bats (*Perimyotis subflavus*) in Texas were identified with WNS. This species has suffered greater than 90% declines in other parts of its range (in the East Coast and Midwest) due to WNS so the detection of WNS in tricolored bats in Texas is a great concern.

The other bats in Texas that have been detected with Pd but have not yet developed WNS include:

- *Corynorhinus townsendii townsendii* (Townsend's big-eared bat)
- *Tadarida brasiliensis* (Mexican free-tailed bat)

Two other bat species hibernate in Texas but have not yet been detected with Pd in Texas:

- *Eptesicus fuscus* (big brown bat)
- *Myotis austroriparius* (southeastern myotis).

However, big brown bats have been widely detected with Pd in the East and Midwest and are thought to be resistant to WNS. Pd has been detected and WNS has been confirmed in southeastern myotis bats in other parts of their range but this species is thought to be less susceptible to WNS.

*This information was written in April 2024 and is likely to change as Pd continues to spread. The following webpage includes current information about bat species detected with Pd and those that have been impacted by WNS: https://www.whitenosesyndrome.org/static-page/bats-affected-by-wns

Name _____

Explain Your Thinking

1. What ecological relationship exists between the fungus that causes white-nose syndrome (WNS) and bats?
   a. _____
   b. Explain your thinking. Why did you select the answer you wrote above?
   _____
   _____
   _____
   _____
   _____

2. Could white-nose syndrome (WNS) in North America impact ecosystem stability? Why or why not? Include at least one specific possible ecological consequence of WNS in your response.
   _____
   _____
   _____
   _____
   _____

3. White-nose syndrome (WNS) is a big issue. Scientists across the globe are working to reduce the spread of Pd and the impact of WNS. Are there any small steps you can take to support the health of bats?
   _____
   _____
   _____
   _____
   _____

Name _____

Curious to learn more about white-nose syndrome (WNS)?

What can be done to protect bats from the devastating impact of WNS?

Read the webpage linked below to learn how Bat Conservation International (BCI) supports the quest to find solutions that will protect bats from WNS and learn what you can do to prevent the spread of the fungus Pd.

- BCI Finding solutions to protect bats from a deadly disease
  https://www.batcon.org/our-work/research-and-scalable-solutions/white-nose-syndrome/

Scientists worldwide are working as quickly as they can to develop strategies to reduce the spread of Pd and the impact of WNS. There is currently a call out for creative thinkers to submit innovative solutions to eliminate the threat of WNS to North American bats.

Read this article to learn more about what is being done and what kind of ideas the scientific community is seeking:

- White-Nose Syndrome Challenge Background
  https://www.whitenosesyndrome.org/static-page/white-nose-syndrome-challenge-background

We need creative thinkers! What ideas do you have that could stop the spread of Pd and the impact of WNS in North American bats?

_____

_____

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_____

_____

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_____

The spread of WNS in North America is part of a larger story.

Many scientists have declared that we are in the midst of a 6th mass extinction. A mass extinction is a profound loss of biodiversity in a relatively short period of time.

While prior mass extinction events have been caused by extreme changes in climate that were the result of events such as huge volcanic eruptions, seafloor spreading, and asteroid impact, this 6th mass extinction is being caused by humans.

Human-initiated habitat destruction, illegal trade, overexploitation of species, the spread of invasive species, pollution, the spread of diseases as well as emerging diseases, and climate change are leading to a biodiversity crisis.

Pd was most likely introduced to North America by humans and is one example of how human action can negatively impact multiple species.

To learn more about this topic, here are some optional resources to read:

- 'Researchers Say We're in a Sixth Mass Extinction. This Time, Humans Are the Culprit' by Meara Isenberg (2022 May 28) CNET: https://www.cnet.com/science/features/researchers-say-were-in-the-sixth-mass-extinction-heres-why-it-matters/
- 'Are we in the midst of the sixth mass extinction? A view from the world of amphibians' by David B. Wake and Vance T. Vredenburg (2008) Proceedings of the National Academy of Sciences: https://sci-hub.st/https://www.pnas.org/doi/abs/10.1073/pnas.0801921105
- *The Sixth Extinction: An Unnatural History* by Elizabeth Kolbert (2015): https://bookshop.org/p/books/the-sixth-extinction-an-unnatural-history-elizabeth-kolbert/8424309

Learning about this issue can seem overwhelming. What are your initial thoughts and feelings about the topic of a 6th mass extinction?

_____

_____

While this mass extinction is a global issue, are there any small steps you can take to support the health of ecosystems near where you live?

_____

_____

_____

Name _____

Apply What You've Learned

Directions:

- First, read the text about chytrid disease below.
- Then, respond to the 3 questions that follow.

Chytrid Disease

Batrachochytrium dendrobatidis (Bd for short) is a fungus that infects amphibians worldwide. It causes the disease Chytridiomycosis (also called chytrid disease). Chytrid is known to affect over 350 species of amphibians and is impacting frog species most severely. (Although not all species of frogs are impacted.)

Bd invades the outer layer of a frog's skin, causing skin damage as the fungus multiplies, producing spores. The spores shed from the host frog, spreading out into the environment. An infected frog typically dies roughly 21 days after infection. Chytrid disease most commonly kills adult frogs. While frog eggs and tadpoles are susceptible to infection, the fungus does not typically kill eggs or tadpoles. However, infection in the egg and tadpole stages *is* likely to negatively affect the organism's long-term survival.

Bd infection causes a combination of physical (skin integrity) and physiological (osmoregulation, hydration, oxygen exchange) issues. The actual cause of death is thought to be cardiac arrest and abnormal cardiac electrical activity.

Bd is a waterborne fungus that disperses into the environment and travels through water to search for a new host. The fungal spores can live in water for weeks (depending on the water temperature) before finding a new host. When a host is found, the fungus enters through the skin.

The fungus Bd is easily spread by human activity. The fungus can attach to a person's boots, clothing, and equipment in one aquatic environment and then spread to another environment as the person moves locations. Also, the movement of wild amphibians to new environments by humans can cause Bd to spread. Once Bd is introduced to an environment, it quickly becomes widespread.

There is currently no vaccine for this disease, and it can be difficult to treat infected amphibians in the wild. The disease has had a role in the decline of 501 species over the past 50 years, including the presumed extinction of 90 species of frogs and other amphibians.

1. The relationship between Bd and frogs is an example of which type of ecological relationship?
   a. mutualism b. commensalism c. parasitism
   d. competition for resources e. predation

2. How might chytrid disease influence ecosystem stability?
   a. Populations of predators that eat frog species that are impacted by chytrid disease may decline.
   b. The insect population may increase.
   c. Other diseases spread by insects may increase in humans and livestock.
   d. All of the above.

3. Do you think humans should work to support the health of bats that are susceptible to white-nose syndrome and amphibians that are susceptible to chytrid disease? Why or why not?

_____

_____

_____

_____

_____

_____

Sources

Scheele, B.C., et al. (2019 Mar 29). Amphibian fungal panzootic causes catastrophic and ongoing loss of biodiversity. *Science*, 363(6434), 1459-1463. doi: 10.1126/science.aav0379

Cornell University College of Veterinary Medicine. (2023). *Chytridiomycosis.* Cornell Wildlife Health Lab. https://cwhl.vet.cornell.edu/disease/chytridiomycosis

Ohio Department of Natural Resources Division of Wildlife. (n.d.). *Chytridiomycosis (Amphibian Chytrid Fungus Disease).* https://ohiodnr.gov/static/documents/wildlife/wildlife-management/Chytridiomycosis%20Amphibians.pdf

Van Rooij, P., Martel, A., & Pasmans, F. (2015) Amphibian chytridiomycosis: a review with focus on fungus-host interactions. *Veterinary Research* 46. https://doi.org/10.1186/s13567-015-0266-0

Name _____

Ecological Roles & Relationships - ANSWER KEY

Directions: Use the words in the word bank to complete each sentence below.
Tip: Each word will be used once.

Word Bank

carnivore	commensalism	competition for resources	consumer	decomposer
herbivore	insectivore	mutualism	omnivore	parasitism
predator	prey	producer	scavenger	symbiosis

Ecological Roles

A **producer** is an organism that converts water, carbon dioxide, and sunlight into the energy it needs to survive.

A **consumer** is an organism that gets the energy it needs by eating other organisms.

- An **herbivore** is an animal that eats plants.
- An **insectivore** is an organism that eats insects.
- A **carnivore** is an animal that eats animal tissue (usually muscle, fat, and other soft tissues) through hunting or scavenging.
- An **omnivore** is an animal that eats both plants and other animals.

Feeding Relationships

- A **predator** is an organism that gains energy from killing and then eating all or parts of another organism.
- **Prey** is an animal that is caught and killed by another organism for food.
- A **scavenger** is an organism that consumes mostly carrion (the decaying flesh of dead animals) and/or rotting plant matter.
- A **decomposer** is an organism that breaks down dead organisms into simpler inorganic materials, making nutrients available to primary producers.

Ecological Relationships

Competition for resources occurs when two different organisms or species use the same limited resource which results in a negative impact on each other.

Symbiosis is a close, prolonged (lengthy) association between two or more different species

- **Mutualism** is a symbiotic relationship between two species in which both benefit. The relationship can be represented as: +/+
- **Commensalism** is a symbiotic relationship between two species in which one benefits and the other is unaffected. The relationship can be represented as: +/0
- **Parasitism** is a symbiotic relationship between two species in which one benefits and the other is harmed. The relationship can be represented as: +/-

Name _____

Ecological Roles & Relationships: Mexican Free-Tailed Bats
ANSWER KEY

Directions:

- First, read all the questions below.
- Next, watch the 3 *Deep in the Heart Mexican Free-Tailed Bat* videos here.*
- Then, respond to the prompts below.

Are Mexican free-tailed bats producers? YES (NO)

Are Mexican free-tailed bats consumers? (YES) NO

If yes, identify the type of consumer Mexican free-tailed bats are:

- ☐ herbivore
- ☒ insectivore **Mexican free-tailed (MFT) bats eat insects.**
- ☐ omnivore
- ☐ carnivore

What role(s) do Mexican free-tailed bats play in feeding relationships?

- ☒ predator **MFT bats hunt and eat insects.**
- ☒ prey **Birds of prey, snakes, & other predatros hunt & eat MFT bats.**
- ☐ scavenger
- ☐ decomposer

Did you observe Mexican free-tailed bats competing for resources? (YES) NO

The MFT bats that live in Bracken Cave compete with each other for roosting space in the cave and air space as they fly out of the cave.

Were the Mexican free-tailed bats in the videos a part of any of the following symbiotic relationships? Check all that apply.

- ☒ mutualism (+/+)
  - **Humans & Bats - Humans grow crops and MFT bats eat insects that are attracted to the crops. MFT bats gain a food source and humans' food source (the crops) is protected from pests.**
  - **Bats & Crops - The crops attract pests that MFT bats eat. MFT bats gain a food source & the crops are protected from agricultural pests.**
- ☒ commensalism (+/0)
  - **Snakes & Cacti - When MFT bats get caught in cacti, snakes benefit (their prey is easier to catch) and the cacti are generally not impacted.**
- ☐ parasitism (+/-)

*Full URL if needed: *Deep in the Heart* - Bat Edu Videos
https://www.youtube.com/playlist?list=PLZBxEBiVysUNqdGxmrv7THKArV6ZoeD_k

Name _____

Directions:

- First, read the text below.
- Then, respond to the questions that follow.

Bats: Essential to the Health of Our Ecosystems

See the student handout for the text on the ecological roles of bats.

1. Bats eat insects that would otherwise eat and damage farmers' crops.
   This is an example of:
   a. mutualism b. commensalism c. parasitism
   Explain why:
   Humans & bats & crops benefit from this relationship. Humans grow crops and MFT bats eat pests that are attracted to the crops. MFT bats gain a food source and humans' food sources (crops) are protected from pests.

2. Bats eat fruit and then disperse the seeds as they fly. This is an example of:
   a. mutualism b. commensalism c. parasitism
   Explain why:
   Both bats & fruit-bearing plants benefit from this relationship. Plants produce fruits that contain seeds. Plants need their seeds to spread so new plants can grow. The fruit provides a food source for some bats. When the bats eat and then defecate the seeds, new plants grow in new areas.

3. Bats pollinate plants as they move from flower to flower drinking nectar.
   This is an example of:
   a. mutualism b. commensalism c. parasitism
   Explain why:
   Both bats & flowering plants benefit from this relationship. Plants produce flowers that contain nectar. The nectar is a food source for some bats. As bats drink the nectar inside flowers, pollen sticks to their bodies and they move this pollen to other flowers as they feed. This allows the flowers to reproduce by moving the pollen from the male to the female parts of plants.

4. What is one significant impact bats have on ecosystems in the United States?
   Insectivorous bats eat A LOT of insects and help control the insect population.

   Scientists estimate that insect-eating bats may save US farmers roughly $23 billion each year by reducing crop damage and limiting the need for pesticides.

Name _____

What is white-nose syndrome? - ANSWER KEY

Directions:

- First, watch this video: *Survival of the Fattest* https://vimeo.com/741467854
- Then, respond to the prompts below.

1. Where was white-nose syndrome (WNS) first identified in North America?

   a. Maine b. Florida c. Texas d. New York

2. What causes WNS?

   a. a fungus b. a virus c. a bacteria

3. The fungus grows on _____ bats.

   a. hibernating b. small c. large

4. What probably caused the fungus to spread from Eurasia to North America?

   humans

5. Why did the scientists in this video collect live bats?

   Live bats were collected to compare the DNA of bats who had survived at least 1 winter hibernating in an area where the fungus Pd was present with the DNA of bats that died due to WNS.

6. How were the genes from the little brown bats that survived at least one winter hibernating in an area where the fungus was present different from the little brown bats that died from WNS? _____

   Little brown bats that survived have different versions of some genes compared to the ones that died. These are the genes that have to do with fat metabolism and waking up from hibernation. The bats that survived have adaptations that help them survive WNS.

7. The association between bats and Pd is an example of which type of ecological relationship?

   a. mutualism b. commensalism c. parasitism
   d. competition for resources e. predator/prey

8. What questions do you have about WNS and/or bats after watching this video? Write at least 2 questions below.

Answers will vary.

Where is white-nose syndrome now?

Directions:

- First, explore this interactive white-nose syndrome spread map: 'Where is WNS Now?' https://www.whitenosesyndrome.org/where-is-wns
- Then, respond to the prompts below.

1. After the first detection in New York in 2006, how many years did it take for WNS to spread to the West Coast? **about 10 years**
2. In what year was the fungus (*Pseudogymnoascus destructans*, Pd for short) that causes WNS first confirmed in Texas? **2016-17**
3. According to the 'Where is WNS Now?' map, list the continental US states NOT yet impacted by WNS or the fungus that causes WNS (*Pseudogymnoascus destructans*, Pd for short): **Utah, Florida, Nevada, Oregon, Arizona, South Dakota**

Pd is presumed to be California but has not yet been confirmed. (Note this is subject to change. Double check the 'Where is WNS Now?' map to make sure WNS has not been detected in the states listed above at some point after this lesson was written in early 2024.)

Name _____ **- ANSWER KEY**

Explain Your Thinking

Note: Other than 1.a., answers will vary. Below is a sample of how students might respond.

1. What ecological relationship exists between the fungus that causes white-nose syndrome (WNS) and bats?
   a. The ecological relationship between Pd and bats is parasitic.
   b. Explain your thinking. Why did you select the answer you wrote above?
   In the interaction between the fungus Pd and bats, the fungus benefits by having a host to grow on and by successfully spreading across North America. Bats are harmed. The fungus makes them sick and often causes bats to die.
2. Could white-nose syndrome (WNS) in North America impact ecosystem stability? Why or why not? Include at least one specific possible ecological consequence of WNS in your response.
   Yes, since bats are a critical component of ecosystems, the decline in bat populations across North America due to WNS could cause ecosystems to become less stable by reducing biodiversity and disrupting the food webs bats are a part of. Specifically in the United States, most bat species eat insects. They help control the insect population and protect our crops from pests that damage and destroy crops. Without bats, we (humans) may not be able to grow crops as effectively.
3. White-nose syndrome (WNS) is a big issue. Scientists across the globe are working to reduce the spread of Pd and the impact of WNS. Are there any small steps you can take to support the health of bats?
   Ideas include: Not going into places where bats hibernate, continuing to learn more about bats, telling others about the importance of bats and how WNS impacts bats, and donating money to organizations that support bats.

Educators: Use this chart to guide students if needed as they respond to question #1 on the Explain handout.

Question 1: What ecological relationship exists between the fungus that causes white-nose syndrome (WNS) and bats?

Evidence What measurements, observations, & information can help you answer the question?	**Science Concepts** What science concepts, connected to the evidence can help you answer the question?	**Reasoning** How do the evidence & science concepts support your claim?
Pseudogymnoascus destructans (Pd for short) is a fungus that grows on hibernating bats. The fungus causes some species of bats to develop white-nose syndrome, a disease that often kills bats. It is known that the fungus has been in North America since 2006. Pictures show Pd growing on bats in New York state in that year. Since then, Pd has spread to almost all US continental states.	A parasitic relationship is a symbiotic relationship between two species in which one benefits, and the other is harmed. It can be represented as: +/-	In the interaction between the fungus Pd and bats, the fungus benefits by having a host to grow on and by successfully spreading across North America. Bats are harmed in this relationship. The fungus makes them sick and often causes bats to die.

Claim Your answer to the question, based on the evidence & reasoning.
The ecological relationship between the fungus that causes white-nose syndrome (*Pseudogymnoascus destructans*, Pd for short) and bats is parasitic.

Educators: Use this chart to guide students as they respond to question #2 on the Explain handout.

Question 2: Could white-nose syndrome (WNS) in North America impact ecosystem stability? Why or why not?

Evidence What measurements, observations, & information can help you answer the question?	**Science Concepts** What science concepts, connected to the evidence can help you answer the question?	**Reasoning** How do the evidence & science concepts support your claim?
WNS syndrome often causes bats to die. It is negatively impacting bat species across North America. Currently, 12 North American bat species have been confirmed with WNS. Bats play important roles in ecosystems. They are prey to other predators. Many bat species are predators that prey on other species. Many bats species eat insects which helps control the insect population and protects crops from pests.	There is not one clear definition of a stable ecosystem. However, properties of ecosystems that are labeled as 'stable' include: - consistent (ability to maintain balance despite constant change), - ability to return to its original state after a temporary disturbance (resilience), and - persistence through time. Biodiversity in an ecosystem has been shown to make it more stable in the past. However, scientists are now debating if biodiversity is a good predictor of stability as ecosystems face multiple disturbances and stressors as a result of climate change.	Without bats: - predators may not have the prey they depend on, - bats' prey could become overpopulated, and - crops that humans depend on may not be protected from pests. These changes could prevent ecosystems from returning to their original state after WNS kills a significant number of bats in a specific area.

Claim Your answer to the question, based on the evidence & reasoning.
Yes, since bats are critical components of ecosystems, the decline in bat populations across North America due to WNS could cause ecosystems to become less stable by reducing biodiversity and disrupting the food webs bats are a part of.

Name _____

Apply What You've Learned - ANSWER KEY

Directions:

- First, read the text about chytrid disease below.
- Then, respond to the 3 questions that follow.

Chytrid Disease

See the student handout for the text on chytrid disease.

1. The relationship between Bd and frogs is an example of which type of ecological relationship?
   a. mutualism b. commensalism c. parasitism
   d. competition for resources e. predation

2. How might chytrid disease influence ecosystem stability?
   a. Populations of predators that eat frog species that are impacted by chytrid disease may decline.
   b. The insect population may increase.
   c. Other diseases spread by insects may increase in humans and livestock.
   d. All of the above.

3. Do you think humans should work to support the health of bats that are susceptible to white-nose syndrome and amphibians that are susceptible to chytrid disease? Why or why not?

Answers will vary.

La estabilidad de un ecosistema – Compañero A

"La estabilidad de un ecosistema es un importante corolario [consecuencia] de la sostenibilidad. A lo largo del tiempo, la estructura y la función de un ecosistema saludable debería mantenerse relativamente estable, incluso en caso de alguna perturbación. Si un factor estresante o una perturbación logra alterar el ecosistema, debería poder recuperarse con bastante rapidez" (Soil Quality for Environmental Health, 2011).

"Las perturbaciones incluyen eventos como los tornados, incendios forestales, o inundaciones que provocan cambios notables en la zona afectada… Las perturbaciones suelen consistir en cambios a corto plazo o temporales del paisaje, pero pueden tener repercusiones muy importantes en los ecosistemas" (USDA, Disturbances and Stressors, n.d.).

"Los factores estresantes ambientales o ecológicos se consideran presiones o dinámicas que impactan los componentes o procesos del ecosistema, causados por las actividades humanas y otras asociadas. Los factores estresantes, como los patógenos o el estrés hídrico, son dinámicas que perjudican o afectan la función o productividad del sistema" (USDA, Disturbances and Stressors, n.d.).

Fuentes

Soil Quality for Environmental Health. (2011). *Ecosystem Stability.* http://soilquality.org/basics/stability.html

U.S. Department of Agriculture (USDA). (n.d.). *Disturbances and Stressors.* Climate Hubs. https://www.climatehubs.usda.gov/disturbances-and-stressors

La estabilidad de un ecosistema – Compañero B

"Nuestro análisis muestra que el término general 'estabilidad' es tan ambiguo que resulta casi inútil. Puede ser reemplazado por las propiedades de la estabilidad 'permaneciendo esencialmente sin cambios' (constancia), 'volviendo al estado de referencia (o dinámico) después de una perturbación temporal' (resiliencia), y 'la persistencia de un sistema ecológica a lo largo del tiempo' (persistencia)" (Grimm & Wissel, 1997).

"Para un ecólogo, la diversidad es el número de especies diferentes en un área, también conocida como biodiversidad o riqueza… La diversidad de especies da como resultado una mayor eficiencia de las plantas en la captura de recursos, especialmente la luz solar, pero también reduce las pérdidas de nutrientes del suelo y permite que las comunidades de plantas respondan a las diferentes condiciones anuales de sequía. Entonces, el jurado está reunido; conservar la diversidad garantiza un conjunto más productivo y estable de ecosistemas de los que depende el ser humano" (Schlesinger, 2017).

"Durante mucho tiempo se ha asumido que la diversidad es un predictor primario de la estabilidad de un ecosistema; sin embargo… unas inconsistencias significantes en la relación diversidad-estabilidad han llevado a un debate sobre ese supuesto, particularmente en el contexto del cambio climático" (USGS, 2024).

Fuentes

Grimm, V. & Wissel, C. (1997). Babel, or the ecological stability discussions: an inventory and analysis of terminology and a guide for avoiding confusion. *Oecologia* 109, 323–334 https://doi.org/10.1007/s004420050090

Schlesinger, W. (2017). *Why Species Matter*. Translational Ecology. https://blogs.nicholas.duke.edu/citizenscientist/why-species-matter/

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La estabilidad de un ecosistema – Compañero C

"Un ecosistema se compone de un balance dinámico [cambiando constantemente] entre las plantas, los animales, y el medio ambiente circundante. El impacto de los seres humanos, como parte integral de la mayoría de los ecosistemas, debe tenerse en cuenta al gestionar la salud del sistema. Para un funcionamiento saludable y sostenible, los miembros vivos de un ecosistema deben estar en equilibrio con los elementos no vivos" (USDA, Ecosystems, n.d.).

"Los dos componentes clave de la estabilidad de un ecosistema son la resiliencia y la resistencia. La resistencia es la habilidad de un ecosistema permanecerse estable cuando se enfrenta a una perturbación. La resiliencia es la velocidad a la que un ecosistema se recupera de una perturbación. Por ejemplo, la resistencia hace referencia a la habilidad del bosque resistir una tormenta de viento; la resiliencia hace referencia a qué tan rápido volverían a crecer los árboles talados" (Groffman, 2008).

"¿…qué podemos hacer para aumentar la resistencia y la resiliencia de los ecosistemas? Este es un tema activo de investigación en el Instituto Cary [del Estudios de ecosistemas]; van surgiendo unas ideas. La primera es mantener una diversidad de plantas y animales en un ecosistema. Los seres humanos tenemos tendencia de simplificar los ecosistemas para maximizar un resultado determinado. Pero esto los hace más vulnerables al colapso o al cambio repentino y deberían evitarse. La segunda es minimizar las tensiones múltiples … Una diversidad de flora y fauna es buena. Una diversidad de factores estresantes ambientales no es" (Groffman, 2008).

Fuentes

Groffman, P.M. (2008). *Keeping balance in the environment*. Cary Institute of Ecosystem Studies. https://www.caryinstitute.org/news-insights/feature/keeping-balance-environment

U.S. Department of Agriculture (USDA). (n.d.). *Ecosystems*. National Institute of Food and Agriculture (NIFA). https://www.nifa.usda.gov/topics/ecosystems

Nombre _____

Funciones y relaciones ecológicas

Instrucciones: Usa las palabras en el banco de palabras para completar cada oración abajo. Consejo: Cada palabra se usará solamente una vez.

Banco de palabras

carnívoro	comensalismo	competición por recursos	consumidor	descomponedor
herbívoro	insectívoro	mutualismo	omnívoro	parasitismo
depredador	presa	productor	carroñero	simbiosis

Funciones ecológicas

Un _____ es un organismo que convierte el agua, el dióxido de carbono, y la luz solar en la energía que necesita para sobrevivir.

Un _____ es un organismo que obtiene la energía que necesita comiendo otros organismos.

- Un _____ es un animal que come plantas.
- Un _____ es un organismo que come insectos.
- Un _____ es un animal que come tejido animal (usualmente tejido muscular, graso, y otros tejidos suaves) por medio de cazar o buscar carroña.
- Un _____ es un animal que come ambas plantas y otros animales.

Relaciones alimenticias

- Un _____ es un organismo que obtiene energía matando y luego comiendo todo o unas partes de otro organismo.
- Un _____ es un animal que es capturado y matado por otro organismo para alimentarse.
- Un _____ es un organismo que mayormente consume la carroña (la carne en descomposición de animales muertos) y/o la materia vegetal en descomposición.
- Un _____ es un organismo que descompone los organismos muertos en materiales inorgánicos más simples, lo que permite que los nutrientes estén disponibles para los productores primarios.

Relaciones Ecológicas

_____ ocurre cuando dos diferentes organismos o especies usan el mismo recurso escaso, causando un impacto negativo entre sí.

_____ es una estrecha y prolongada (larga) asociación entre dos o más diferentes especies.

- _____ es una relación simbiótica entre dos especies en la que ambas se benefician. La relación puede ser representada como: +/+
- _____ es una relación simbiótica entre dos especies en la que una se beneficia y la otra no se afecta. La relación puede ser representada como: +/0
- _____ es una relación simbiótica entre dos especies en la que una se beneficia y la otra sale perjudicada. La relación puede ser representada como: +/-

Nombre _____

Funciones y relaciones ecológicas: Murciélagos mexicanos de cola libre

Instrucciones:

- Primero, lee todas las preguntas abajo.
- Luego, mira los 3 videos "*Deep in the Heart Mexican Free-Tailed Bat*" aquí.*
- Después, responde las preguntas.

¿Son productores los murciélagos mexicanos de cola libre? SÍ NO

¿Son consumidores los murciélagos mexicanos de cola libre? SÍ NO

Si es así, identifica qué tipo de consumidor son los murciélagos mexicanos de cola libre:

- ☐ herbívoro
- ☐ insectívoro
- ☐ omnívoro
- ☐ carnívoro

¿Qué papel(es) desempeñan los murciélagos mexicanos de cola libre en las relaciones alimentarias? Marca todo lo que corresponda.

- ☐ depredador
- ☐ presa
- ☐ carroñero
- ☐ descomponedor

¿Observaste los murciélagos mexicanos de cola libre compitiendo por recursos?

SÍ NO

¿Los murciélagos mexicanos de cola libre en los videos formaban parte de alguna de las siguientes relaciones simbióticas? Marca todo lo que corresponda.

- ☐ mutualismo (+/+)
- ☐ comensalismo (+/0)
- ☐ parasitismo (+/-)

*Full URL if needed: *Deep in the Heart* - Bat Edu Videos
https://www.youtube.com/playlist?list=PLZBxEBiVysUNqdGxmrv7THKArV6ZoeD_k

Nombre _____

Los murciélagos de Texas

De las 1,400+ especies de murciélagos en todo el mundo, más de 30 de ellas viven en Texas. Durante esta actividad, aprenderás sobre 1 especie más de murciélago.

Instrucciones:

- Elige una especie de murciélagos de la lista abajo para obtener más información.
- Busca información sobre esta especie de murciélagos usando los dos recursos enumerados abajo.
- Responde las preguntas en este folleto.

Especies de murciélagos:

Corynorhinus townsendii townsendii (murciélago orejón de Townsend)	*Eptesicus fuscus* (murciélago moreno)	*Myotis austroriparius* (miotis del sureste)
Myotis velifer (miotis mexicano)	*Perimyotis subflavus* (pipistrelo del este americano)	*Tadarida brasiliensis* (murciélago mexicano de cola libre)

Recursos:

- Bat Conservation International Bat Profiles https://www.batcon.org/about-bats/bat-profiles/
- Texas Parks & Wildlife Department (use the search bar) https://tpwd.texas.gov/

Nombre científico: _____

Nombre común: _____

Distribución (¿Dónde vive esta especie de murciélago?):

_____

_____

Hábitat preferido: _____

_____

_____

Estado de conservación mundial (IUCN) Encierra en un círculo una categoría abajo.

No evaluado | Datos deficientes | De menor preocupación | Casi amenazado | Vulnerable

En peligro | En peligro crítico | Extinto en estado salvaje | Extinto

¿Qué tipo de consumidor es esta especie de murciélago?

- herbívoro
- insectívoro
- omnívoro
- carnívoro

¿Qué papel(es) desempeña esta especie de murciélagos en las relaciones alimentarias?

- depredador
- presa
- carroñero
- descomponedor

¿Aprendiste sobre alguna relación simbiótica de la que forma parte esta especie?

SÍ NO

Recordatorio: Las relaciones simbióticas incluyen el mutualismo, comensalismo, & parasitismo.

Si es así, explica:

_____

_____

_____

_____

_____

Enumera al menos 2 otros hechos que aprendiste sobre esta especie de murciélago:

_____

_____

_____

_____

_____

Nombre _____

Instrucciones:

- Primero, lee el texto a continuación.
- Luego, responde las preguntas que siguen.

Murciélagos: Esenciales para la salud de nuestros ecosistemas

Los murciélagos son animales únicos y fascinantes. Son los únicos mamíferos capaces de vuelo real. Pertenecen al orden Chiroptera que incluye más de 1,400 especies de murciélagos. Los murciélagos viven en todos los continentes, menos la Antártida, y han sobrevivido en la Tierra por más de 50 millones de años (BCI, 2024). Diferentes especies de murciélagos desempeñan diferentes papeles ecológicos y forman parte de diferentes relaciones ecológicas, haciéndolos miembros clave de los ecosistemas en los que habitan.

Comedores de plagas

La mayoría de las 44 especies de murciélagos que viven en Norteamérica son insectívoros. De media, un murciélago insectívoro puede comer hasta la mitad de su peso corporal en insectos cada noche. Un murciélago preñado o lactante consumirá hasta 100% de su peso corporal durante su caza nocturna. Los científicos estiman que los murciélagos que comen insectos pueden ahorrar a los granjeros de los Estados Unidos aproximadamente 23 mil millones de dólares cada año reduciendo el daño a los cultivos y limitando la necesidad de pesticida (BCI, 2024).

Polinizadores

La mayoría de las plantas con flores dependen de la polinización para poder producir nuevas semillas. La polinización es el proceso de traslado de los granos de polen de la parte masculina de la flor (el estambre) a la parte femenina (el pistilo) (BCI, 2024).

Algunos murciélagos en las zonas tropicales y subtropicales del mundo se alimentan de néctar. Cuando estos murciélagos toman el dulce néctar dentro de las flores, recogen una capa de polen y lo llevan a otras flores mientras sigan alimentándose. La función de los murciélagos como polinizadores es crítica para una gran variedad de plantas, incluso los cactus gigantes y el agave. La polinización por los murciélagos también juega un papel vital en el crecimiento de las plantas que producen productos como la madera de balsa, algarroba, clavos de olor, y el fruto durián (BCI, 2024).

Dispersores de semillas

Los murciélagos frugívoros a menudo consumen una fruta entera, incluso las semillas, y luego defecan las semillas, muchas veces en vuelo. Esto permite que crezcan las

plantas en nuevas zonas. Los murciélagos frugívoros se encuentran en las zonas tropicales y subtropicales de África, Asia, y Australia y también en algunas islas del Pacífico, en Latinoamérica, y en el Caribe (NPS, 2022).

1. Los murciélagos comen insectos que de otro modo comerían y dañarían los cultivos de los granjeros. Esto es un ejemplo de:
   a. mutualismo b. comensalismo c. parasitismo

   Explica por qué: _____

   _____

2. Los murciélagos comen frutas y luego dispersan las semillas mientras vuelan. Esto es un ejemplo de:
   a. mutualismo b. comensalismo c. parasitismo

   Explica por qué: _____

   _____

3. Los murciélagos polinizan las plantas mientras pasan de una flor a otra tomando el néctar. Esto es un ejemplo de:
   a. mutualismo b. comensalismo c. parasitismo

   Explica por qué: _____

   _____

4. ¿Cuál es un efecto significante que tienen los murciélagos sobre los ecosistemas en Estados Unidos?

   _____

   _____

   _____

Fuentes

Bat Conservation International (BCI). (2024). *An Unlikely Hero With Global Impact.* Bats 101. https://www.caryinstitute.org/news-insights/feature/keeping-balance-environment

National Park Service (NPS). (2022). *Made Possible by... Bats.* https://www.nps.gov/articles/000/made-possible-by-bats.htm

Nombre _____

¿Qué es el síndrome de la nariz blanca (WNS)?

Instrucciones:

- Primero, mira este video: *Survival of the Fattest* https://vimeo.com/741467854
- Luego, responde las preguntas a continuación.

1. ¿En qué parte de Norteamérica se identificó la enfermedad WNS por primera vez?

   a. Maine b. Florida c. Texas d. New York

2. ¿Qué causa el WNS?

   a. un hongo b. un virus c. una bacteria

3. El hongo crece en los murciélagos _____ .

   a. en hibernación b. pequeños c. grandes

4. ¿Qué probablemente causó que el hongo se propagara desde Eurasia a Norteamérica? _____

5. ¿Por qué los científicos en este video recogieron murciélagos en vivo?

   _____

   _____

   _____

6. ¿En qué se diferenciaban los genes de los pequeños murciélagos marrones que sobrevivieron al menos un invierno hibernando en un área donde el hongo estaba presente de los pequeños murciélagos marrones que murieron a causa del WNS?

   _____

   _____

   _____

   _____

7. ¿La asociación entre los murciélagos y Pd es un ejemplo de cuál tipo de relación ecológica?
   a. mutualismo b. comensalismo c. parasitismo
   d. competición por recursos e. depredador/presa

8. ¿Qué preguntas tienes sobre el WNS y/o los murciélagos después de ver este video? Escribe al menos 2 preguntas abajo.

_____

_____

_____

¿Dónde está el síndrome de la nariz blanca ahora?

Instrucciones:

- Primero, explora este mapa interactivo sobre la propagación del síndrome de la nariz blanca: ¿Dónde está el WNS ahora? https://www.whitenosesyndrome.org/where-is-wns
- Luego, responde las preguntas a continuación.

1. Después de la primera detección en Nueva York en 2006, ¿cuántos años tardó el WNS en extenderse hasta la costa oeste? _____
2. ¿En qué año se confirmó por primera vez en Texas el hongo (Pseudogymnoascus destructans Pd para abreviar) que causa WNS? _____
3. De acuerdo con el mapa, enumera los estados continentales de EE.UU. que aún NO están afectados por el WNS ni por el hongo que causa el WNS (Pseudogymnoascus destructans, Pd para abreviar):

_____

_____

_____

¿Cómo está afectando el WNS a los murciélagos en Texas?

De fondo: Pd & WNS en Norteamérica

En la actualidad, se ha confirmado que 12 especies de murciélagos en Norteamérica tienen el síndrome de la nariz blanca (WNS). Esta enfermedad ha causado una mortalidad grave y generalizada en tres de estas especies. Una especie ahora está catalogada como en peligro de extinción en los Estados Unidos debido al WNS y dos otras especies puede que pronto se añadan a la lista de especies en peligro de extinción en Estados Unidos. Todas las tres especies están catalogadas como en peligro de extinción en Canadá debido a los efectos del WNS.

Pd, el hongo que causa el WNS, se ha encontrado en otras ocho especies norteamericanas (incluso dos especies en peligro de extinción) sin confirmación de la enfermedad. No todos los murciélagos que se detectan con Pd, desarrollan el WNS. Estos números cambiarán mientras Pd continúa extendiéndose hacia el oeste. Mantente al día aquí.*

Pd se propaga cuando un murciélago toca a otro murciélago o una superficie en que hay Pd. Aunque Pd NO se sabe que enferme a los humanos ni a otros animales, los humanos pueden propagar Pd a nuevas áreas. Las esporas de Pd pueden durar mucho tiempo en la ropa, los zapatos, y otro equipo. Entonces, un humano puede propagar Pd yendo a un lugar donde está el hongo y luego viajando a una zona en que no existe. El hongo prospera en lugares fríos, oscuros, y húmedos, como las cuevas.

Pd no es nativo de Norteamérica. Se cree que fue introducido a Norteamérica desde Eurasia cerca de 2006. Ya que los murciélagos en Norteamérica no han estado expuesto Pd antes, muchas especies norteamericanas tienen poca resistencia o tolerancia al hongo. Los murciélagos en Europa y Asia no parecen ponerse tan enfermos de Pd. Estos murciélagos parecen ser más resistentes y tolerantes a la infección del Pd.

Pd & WNS detectados en Texas

Pd se detectó por primera vez en Texas durante el invierno de 2016-17. Dos años después, durante el invierno de 2019-20, se detectó el primer caso del WNS en Texas en los murciélagos de la especie *Myotis velifer* (miotis cavernícola). Para la primavera de 2020, cientos de miotis cavernícola en Texas se encontraron muertos. Pd continúa

propagándose en esta especie, causando el WNS en Texas y en los estados circundantes.

En el invierno de 2023-24, el pipistrelo del este americano (*Perimyotis subflavus*) en Texas fue identificado con el WNS. Esta especie ha sufrido descensos de más que 90% en otras partes de su área de distribución (en la costa este y el medio oeste) debido al WNS así que la detección del WNS en el pipistrelo del este americano en Texas es una gran preocupación.

Los otros murciélagos en Texas que han sido detectados con Pd sin haber desarrollado el WNS incluyen:

- *Corynorhinus townsendii townsendii* (murciélago orejón de Townsend)
- *Tadarida brasiliensis* (murciélago mexicano de cola libre)

Dos otras especies de murciélago hibernan en Texas, pero no han sido detectados con Pd:

- *Eptesicus fuscus* (murciélago moreno)
- *Myotis austroriparius*

Los murciélagos morenos se han detectado ampliamente con Pd en el este y el medio oeste, y se cree que son resistentes al WNS. Pd se ha detectado y el WNS se ha confirmado en los murciélagos de la especie Myotis austroriparius en otras partes de su área de distribución, pero se cree que esta especie es menos susceptible al WNS.

*Esta información fue escrita en April 2024 y es probable que cambie mientras Pd continúa propagándose. La siguiente página web incluye información actual sobre las especies de murciélagos que se han detectado con Pd y las que han estado afectado por el WNS: https://www.whitenosesyndrome.org/static-page/bats-affected-by-wns

Nombre _____

Explica tu pensamiento

1. ¿Cuál relación ecológica existe entre el hongo que causa el síndrome de la nariz blanca (WNS) y los murciélagos?
   a. _____
   b. Explica tu pensamiento. ¿Por qué elegiste la respuesta que escribiste arriba?
   _____
   _____
   _____
   _____
   _____

2. ¿Podría el síndrome de la nariz blanca (WNS) en Norteamérica impactar la estabilidad del ecosistema? ¿Por qué o por qué no? Incluye al menos una consecuencia ecológica específica posible del WNS en tu respuesta.
   _____
   _____
   _____
   _____
   _____

3. El WNS es un gran problema. Los científicos por todo el mundo están trabajando para reducir la propagación de Pd y los efectos del WNS. ¿Hay algún pequeño paso que puedas tomar para apoyar la salud de los murciélagos?
   _____
   _____
   _____
   _____
   _____

Nombre _____

¿Tienes curiosidad por saber más sobre el síndrome de la nariz blanca?

¿Qué se puede hacer para proteger a los murciélagos de los efectos devastadores del WNS?

Lee la página web vinculada abajo para aprender cómo la organización "Bat Conservation International" (BCI) apoya la búsqueda de soluciones para proteger a los murciélagos del síndrome de la nariz blanca e informarte sobre lo que puedes hacer tú para prevenir la propagación del hongo Pd.

- BCI Encontrando soluciones para proteger a los murciélagos de una enfermedad mortal
  https://www.batcon.org/our-work/research-and-scalable-solutions/white-nose-syndrome/

Los científicos por todo el mundo están trabajando tan rápido como puedan para desarrollar estrategias para reducir la propagación de Pd y el impacto del WNS. Actualmente se hace un llamamiento a los pensadores creativos para que presenten soluciones innovadoras para eliminar la amenaza del síndrome de la nariz blanca a los murciélagos norteamericanos.

Lee este artículo para aprender más sobre lo que se está haciendo y que tipos de ideas la comunidad científica está buscando:

- Contexto del Desafío del síndrome de la nariz blanca
  https://www.whitenosesyndrome.org/static-page/white-nose-syndrome-challenge-background

¡Necesitamos a pensadores creativos! ¿Qué ideas tienes que podrían eliminar la propagación de Pd y el impacto del WNS en los murciélagos norteamericanos?

_____

_____

_____

_____

_____

_____

La propagación del WNS en Norteamérica forma parte de una historia más amplia.
Muchos científicos han declarado que estamos en medio de una 6ta extinción masiva. Una extinción masiva es una pérdida profunda de biodiversidad en un periodo de tiempo relativamente corto.

Mientras que las instancias de extinción masiva anteriores han sido causadas por cambios extremos en el clima que resultan de eventos como enormes erupciones volcánicas, expansión del fondo marino, y el impacto de asteroides, esta 6ta extinción masiva está siendo causada por los seres humanos.

La destrucción de hábitats provocada por el hombre, el comercio ilegal, la sobreexplotación de especies, la propagación de especies invasoras, la contaminación, la propagación de enfermedades, así como de enfermedades emergentes, y el cambio climático están provocando una crisis de la biodiversidad.

Lo más probable es que Pd fue introducido a Norteamérica por los humanos y es un ejemplo de cómo las acciones humanas pueden afectar negativamente a múltiples especies.

Para aprender más sobre este tema, aquí se presentan unos recursos opcionales para leer:

- "Researchers Say We're in a Sixth Mass Extinction. This Time, Humans Are the Culprit" by Meara Isenberg (2022 May 28) CNET: https://www.cnet.com/science/features/researchers-say-were-in-the-sixth-mass-extinction-heres-why-it-matters/
- "Are we in the midst of the sixth mass extinction? A view from the world of amphibians" by David B. Wake and Vance T. Vredenburg (2008) Proceedings of the National Academy of Sciences: https://sci-hub.st/https://www.pnas.org/doi/abs/10.1073/pnas.0801921105
- *The Sixth Extinction: An Unnatural History* by Elizabeth Kolbert (2015): https://bookshop.org/p/books/the-sixth-extinction-an-unnatural-history-elizabeth-kolbert/8424309

Aprender sobre este tema puede parecer abrumador. ¿Cuáles son sus pensamientos y sentimientos iniciales sobre el tema de una 6ta extinción masiva? _____

_____

_____

Aunque esta extinción masiva es un problema mundial, ¿hay alguna pequeña medida que puedas tomar para contribuir a la salud de los ecosistemas cercanos a tu lugar de residencia? _____

_____

Nombre _____

Aplica lo que has aprendido

Instrucciones:

- Primero, lee el siguiente texto sobre la enfermedad quítrida.
- Luego, responde las 3 preguntas a continuación.

La enfermedad quítrida

Batrachochytrium dendrobatidis (Bd para abreviar) es un hongo que infecta a los anfibios por todo el mundo. Causa la enfermedad Quitridiomicosis (también llamada la enfermedad quítrida). Se sabe que la enfermedad quítrida afecta más de 350 especies de anfibios y se está impactando a las especies de rana más severamente. (Pero no todas las especies de ranas son afectadas.)

Bd invade la capa externa de la piel de la rana, causando daño a la piel mientras el hongo se multiplica, produciendo esporas. Las esporas se desprenden de la rana huésped y se extienden por el medio ambiente. Una rana típicamente se muere 21 días después de ser infectada. La enfermedad quítrida más comúnmente mata las ranas adultas. Aunque los huevos de rana y los renacuajos son susceptibles a la infección, el hongo normalmente no mata los huevos ni los renacuajos. Sin embargo, es probable que una infección durante la etapa de huevo o renacuajo *sí* podrá afectar negativamente la supervivencia del organismo a largo plazo.

La infección con Bd causa una combinación de problemas físicas (la integridad de la piel) y psicológicas (osmorregulación, hidratación, intercambio de oxígeno). Se cree que la causa real de la muerte es un paro cardíaco y actividad eléctrica cardíaca anormal.

Bd es un hongo transmitido por el agua que se dispersa en el medio ambiente y viaja a través del agua en busca de un nuevo huésped. Las esporas fúngicas pueden vivir en el agua por semanas (dependiendo en la temperatura del agua) antes de encontrar un huésped nuevo. Cuando se encuentra un huésped, el hongo entra a través de su piel.

El hongo Bd se propaga muy fácilmente a través de la actividad humana. El hongo puede adherirse a las botas, la ropa y el equipo de una persona en un ambiente acuático y luego extenderse a otro medio ambiente mientras la persona se mude de un lugar a otro. También, la reubicación de los anfibios salvajes a nuevos entornos por los humanos puede causar que Bd se propague. Una vez que Bd se introduce a un medio ambiente, muy pronto se generaliza.

Actualmente no existe vacuna para esta enfermedad, y puede ser difícil tratar a los anfibios infectados en la naturaleza. La enfermedad ha contribuido a la disminución de 501 especies en los últimos 50 años, incluida la presunta extinción de 90 especies de ranas y otros anfibios.

1. ¿La relación entre Bd y las ranas es un ejemplo de cuál tipo de relación ecológica?
   a. mutualismo b. comensalismo c. parasitismo
   d. competición por recursos e. depredación

2. ¿Cómo pudiera la enfermedad quítrida influir la estabilidad de un ecosistema?
   a. Las poblaciones de depredadores que comen las especies de ranas afectadas por la enfermedad quítrida pueden disminuirse.
   b. La población de insectos puede aumentarse.
   c. Otras enfermedades propagadas por los insectos pueden aumentar en los seres humanos y el ganado.
   d. Todo lo anterior.
   e. ¿Crees que la gente debe trabajar para apoyar la salud de los murciélagos susceptibles al síndrome de la nariz blanca y de los anfibios que son susceptibles a la enfermedad quítrida? ¿Por qué o por qué no?

_____

_____

_____

_____

_____

Fuentes

Scheele, B.C., et al. (2019 Mar 29). Amphibian fungal panzootic causes catastrophic and ongoing loss of biodiversity. *Science*, 363(6434), 1459-1463. doi: 10.1126/science.aav0379

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Ohio Department of Natural Resources Division of Wildlife. (n.d.). *Chytridiomycosis (Amphibian Chytrid Fungus Disease)*. https://ohiodnr.gov/static/documents/wildlife/wildlife-management/Chytridiomycosis%20Amphibians.pdf

Van Rooij, P., Martel, A., & Pasmans, F. (2015) Amphibian chytridiomycosis: a review with focus on fungus-host interactions. *Veterinary Research* 46. https://doi.org/10.1186/s13567-015-0266-0