Ecosystem Dynamics: Bat Populations in a Changing Environment

Developed by Cynthia Hopkins – Corpus Christie, TX – 6th Grade Science (2023-2024)

Guiding Question

Why are bats essential to the environment?

Learning Objectives

Students will be able to:

- explain why bats are important to the environment.
- identify causes for declines in the bat populations.

Background Information

Bats are essential to the environment for several reasons:

1. **Pollination**: Many bat species are pollinators, especially in tropical and desert climates. They pollinate various plants, including fruits like bananas, mangoes, guavas, and agave plants.
2. **Seed Dispersal**: Bats help with seed dispersal, which is crucial for the regeneration and spread of various plant species. This helps maintain healthy forest ecosystems and promotes biodiversity.
3. **Pest Control**: Bats consume vast amounts of insects, including agricultural pests and mosquitoes. This natural pest control reduces the need for chemical pesticides, benefiting crops and human health.
4. **Nutrient Cycling**: Bat guano (feces) is a rich source of nutrients that enriches soil, promoting plant growth and aiding in ecosystem nutrient cycling.
5. **Indicator Species**: Bats are sensitive to environmental changes and can serve as indicators of ecosystem health. A decline in bat populations often signals broader ecological issues.

Standards Alignment

Performance Expectations:

- *MS-LS2-1:* Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- *MS-LS2-2:* Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.
- *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.
- *HS-LS4-5:* Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

Science & Engineering Practices:

- *Analyzing and Interpreting Data:* Using data to understand the role bats play in ecosystems, such as their impact on insect populations and plant pollination.
- *Engaging in Argument from Evidence:* Evaluating and arguing the importance of bat conservation based on scientific evidence.
- *Obtaining, Evaluating, and Communicating Information:* Gathering and disseminating information about bats and their ecological importance to various stakeholders.

Disciplinary Core Ideas:

- *LS2.A: Interdependent Relationships in Ecosystems:* Bats as pollinators, seed dispersers, and pest controllers show how organisms and their environments interact.
- *LS2.C: Ecosystem Dynamics, Functioning, and Resilience:* Understanding how bats contribute to ecosystem stability and how their decline can impact ecosystem health.
- *LS4.D: Biodiversity and Humans:* The impact of bats on biodiversity and the benefits to humans through ecosystem services.

Crosscutting Concepts

- *Cause and Effect:* Understanding the cause-effect relationships between bat activities (pollination, pest control) and ecosystem health.
- *Systems and System Models:* Viewing ecosystems as interconnected systems where bats play a crucial role.
- *Stability and Change:* Analyzing how changes in bat populations can affect ecosystem stability and lead to broader environmental changes.

This material is based upon work supported by National Science Foundation under Grant No. 2101310

Advice for Educators

Teaching this unit why bats are essential to the environment has been highly rewarding, with several noteworthy successes and challenges, and the most successful moments included the initial Observation & Discussion activity, where students demonstrated keen observational skills and engaged in thoughtful discussions about bat images. This exercise helped them build a solid foundation for understanding the importance of bats. Students were particularly captivated by the interactive and visual aspects of the unit, such as the fencepost activity and creating bat posters, which fostered creativity and collaboration.

I found that students needed more support during the research phase, specifically in navigating and synthesizing information from the provided websites. Some students struggled with identifying reliable sources and summarizing their findings effectively. Providing additional guidance on research skills and perhaps a structured template for the posters could alleviate these difficulties.

If I were to teach this unit again, I would integrate more structured scaffolding for the research activities and allocate more time to the map design and data interpretation sections. Incorporating a peer review process for the posters could also enhance the learning experience, allowing students to receive constructive feedback before the final presentation.

For educators interested in using this unit, I advise emphasizing the interactive and visual components, as they significantly enhance student engagement. Additionally, ensure that students have ample opportunities to discuss and reflect on their learning, as these moments are crucial for deepening their understanding of the material. Finally, be prepared to offer extra support during the research phase to help students navigate and synthesize information effectively.

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Materials

- Computer and LCD Projector to display artwork and dataset
- Observation & Discussion Slide Deck: PowerPoint; pdf
- Featured Artwork: *Filming swabbing bats, collecting air samples*
- Additional Artwork: *Biologists conduct modern bat surveys, Photo by Andrew King, USFWS*
- Featured Data: *Bat Diversity in U.S. National Parks*
- Sticky notes/easel/dry erase boards for recording questions
- Long strips of cardstock paper approximately 10 inches long by 2 inches across so you can have 5 squares of 2 in. x 2 in. (Template). Dimensions and shape can be changed based on your circumstances/resources/space.
- String and clothespins or tape
- Scissors, markers, colored pencils, erasers
- Rulers
- Paper clips
- Scratch paper
- 11" x 17" vellum tracing paper
- U.S. Base Map Template
- Handouts:
  - Fencepost Survey Questions
    Optional: Data Visualization Choices Worksheet
  - Design Tools Guide
  - Additional Mapped Datasets
    - Bats - Projected Spread of White Nose Syndrome
    - Population Density – U.S.
  - Data Sketches Student Worksheets
  - Optional: Bat Week Announcements (2023)

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STEP 1 – Observation and Discussion

Part 1 – Art

1. Share norms for the discussion and briefly introduce the process to the students.
2. Project the **Featured Artwork** so that it's visible to the entire class.
3. Invite students to observe the image silently for 1-2 min.
4. Have students journal or write down initial ideas during this time.
5. Tell students: "*Let's take a moment to look at this picture together*."
6. Invite as many students as possible to share their ideas about what the image shows, using the following prompts/facilitation sequence (10-15 minutes)
    a. Invite Student Ideas: *What's going on in this image*?
    b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the image that they are referencing so that the whole class can see.
    c. Paraphrase: Repeat the student's observations using different language, taking advantage of opportunities to introduce appropriate vocabulary and without validating/invalidating their ideas.
    d. Ask for Evidence: *What do you see that makes you say* _____ ?
    e. Invite More Ideas: *What more can we find*?
7. Thank the class for participating in the experience and for sharing their observations.
8. (Optional) Have students share in pairs any additional thoughts or observations (5 minutes): "*Now that we have all looked together, I know there are still more ideas. Turn to a person sitting next to you and share more or share something you didn't share with the larger group.*"

Part 2 – Data

1. Tell students that now you are going to use the same approach and observe a mapped dataset. **It is important you do these observation sessions back-to-back. The observation and discussion with the art image may be more accessible to many students and encourages those that do not usually speak up or that are uncomfortable with science/data to participate. The art image may be more engaging and personally relevant, getting the students primed in the approach of observing and talking.*
2. Optional: Share digital copies of the selected data-only visualization so that students can view on their own devices during the silent observation time. Have the students put these devices away and focus on the projected image after the observation time.
3. Project the **Featured Data** WITHOUT the legend. Ask for 1 minute of silent observation time and 2-3 minutes of journaling time. Use the map: ***Bat Diversity in U.S. National Parks - WITHOUT Legend***
4. (If this happens on the next day) Review the norms for discussion again.

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5. Invite as many students as possible to share their ideas about the visual patterns they see in the data visualization, using the following facilitation sequence and prompts (~5 minutes)
    a. Invite Student Ideas: *What's going on in this image*?
    b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the visualization that they are referencing so that the whole class can see.
    c. Paraphrase: Repeat the student's observations using different language, taking advantage of opportunities to introduce appropriate vocabulary related to the phenomenon, visualization, and/or data (e.g., scale, hemisphere, latitude/longitude, trend, variability) and without validating/invalidating their ideas.
    d. Ask for Evidence: *What do you see that makes you say _____* ?
    e. Invite More Ideas: *What more can we find*?
6. Project the **Featured Data** <u>WITH the title & legend now</u>, so that it's visible to the entire class.
7. Invite students to look again at the data visualization that now includes a legend, providing ~1 minute to silently and independently observe.
8. Invite as many students as possible to share their ideas about the visual patterns they see in the data visualization, using the following facilitation sequence and prompts (~5 minutes)
    a. Invite Student Ideas: *Now that you see this addition, how has your thinking changed?*
    b. Gesture: As each student is speaking, use your hand, mouse, or pointer to gesture to parts of the visualization that they are referencing so that the whole class can see.
    c. Paraphrase: Repeat the student's observations using different language, taking advantage of opportunities to introduce appropriate vocabulary related to the phenomenon, visualization, and/or data (e.g., scale, hemisphere, latitude/longitude, trend, variability) and without validating/invalidating their ideas.
    d. Ask for Evidence: *What do you see that makes you say _____ ?*
    e. Probe for more: *What do you think [visual feature you observed] might mean?*
    f. Invite More Ideas: *What more can we find?*
    g. If students are having difficulty providing new observations, try asking:
        i. *What do you wonder?*
        ii. *What jumps out at you? What do you see first?*
        iii. *Does anything in this visualization seem unusual or unexpected to you?*
        iv. *What's interesting to you? What is familiar to you?*
        v. *If you could talk to the scientists who made this, is there anything you'd want to ask them?*
9. Thank the class for participating in the experience and for sharing their observations.

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10. (Optional) Have students share in pairs any additional thoughts or observations. Ask them to think about additional questions they have which you will record in the next section (~5 minutes)
11. Tell students: "*Now that we have all looked together, I know there are still more ideas. Turn to a person sitting next to you and share more or share something you didn't share with the larger group. Think about additional questions you might have. We will discuss these questions next as a class.*"
12. Develop a list of questions that were generated and ask for more questions. It is at this point that you, the teacher, can interject questions that would facilitate the investigation/learning of content if the students have not yet brought it up. Ask: *What are you curious about? What questions do we have? I'm curious why the patterns are…?*
13. Create a digital (e.g., Google Docs) parking lot with a question list or use sticky notes and tell students you will revisit these questions later in the program. Another option is for the teacher to aggregate the questions into 5-10 questions for a Driving Question Board that can be displayed in the classroom during this unit.

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STEP 2 – Bridging Approach: Fencepost Activity

1. Give each student the **Design Tools Guide** handout.
2. Provide context about data collection/sources and symbology. Tell students: "*Data like we just saw in the Mapped Data exercise comes from a variety of sources – individuals can collect data at a local level or one point in time and then combine those observations/data to show data over time or over a larger spatial area. We can also collect data with satellites which provide large areas of remotely sensed observations and can even provide global pictures of data/science phenomena. People use symbols to convey information in a simple and effective way. Symbols are an important part of maps and can represent a range of different types of data. Symbols are described in a legend – a box or other place on the map where there is a key that says what each color of symbol means. Let's look at different ways we can represent data.*"
3. Review the **Design Tools Guide** with students - ask the students to reflect on the previous activity comparing maps about which design tools were used/chosen and why.
4. Give each student a strip of paper that is divided into 5 numbered squares (You can use the **Template** provided).
5. Hand out the **Fencepost Survey Questions**.
6. Read through each question and discuss with the class which design tool would be best, and then determine which color, symbol, shading, etc. would work for that question. This could also be done initially in pairs and then discussed/decided on as a whole class. Tell the students that they can't use each design tool more than once in the survey. **Note: This can be a little time-consuming, but it's a great way to give students a chance to think carefully about design tools, and to take ownership over the data.**
7. Have the students answer the questions on their strip using the colors/symbols that correspond to their answer choice. Instruct the students to work their way through the questionnaire and respond to the first question in the first block and so on. For some questions, students can color, draw or collage with images from the magazines. For other questions, a written word or phrase is ideal.
8. After all students have finished their responses, line all the students' work side by side as a "fence post" (tape them on a wall or attach to a string) so that you can see trends across the class. Alternatively, you can spread them out onto a table so the strips can be moved around.
9. Invite the students to silently observe the 'fence posts' for 1 minute.
10. Invite discussion or written responses on the following:
    a. What patterns do you notice?
    b. What do the patterns tell us about our collected data?
    c. Do you think the patterns would be different in other locations/with other ages/more people?
11. Optional: Have students complete the **Data Visualization Choices Worksheet** in class or as homework.

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Optional Extension: Research

1. Refer students to the **Bat Week Announcements (2023)** document and the Bat Week Website to learn some quick facts about bats and start their research about the importance of bats to ecosystems around the world.
2. Working in pairs, have students do a web search of bat species by state and select one local species to investigate.
3. Have each pair create a poster on their bat species (either using Canva, Google Slides, or paper/color pencils). The poster should explain:
    a. Name & appearance of bat
    b. Bat habitat
    c. Diet
    d. Conservation Concerns
    e. Picture of the bat
4. Have students present their posters to their classmates.

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STEP 3 – Data Sketches: Making Data Visual

Have students sit in groups of three or four.

Part 1 – Plan & Sketch

1. Give each student a printed copy of the original mapped data (with legend) from the Observation and Discussion with Data session along with the **Design Tools Guide** handout.
   Note: By now the students should be familiar with both the original map and the design tools. It is important to keep referring to the design tools so students become familiar with using them.

2. Explain: "*Remember how we looked at the different mapped data representations and how we used the Design Tools to come up with our own symbols to answer the questions in the Fencepost Activity? Today we are going to discuss mapped data further and practice using these tools ourselves by creating our very own map legends with symbols, colors, marks…"*

3. First, let's remind ourselves about our map from earlier in this lesson. Invite discussion about the following questions regarding the printed map you have handed out (10 minutes)*:*

   - What design tools were used to draw the data on this map?
   - What is included in the legend?
   - Why do you think they chose this particular design tool for this set of data?
   - While some tools are better for representing sets of data, there is no right or wrong tool. Are there different design tools we could use to represent this data? *Look through the handout and discuss what some good choices might be for this topic.*

4. Give each group 2-3 **Additional Mapped Datasets** related to the topic so that each student has a different map to work with. You can have students choose or you can assign datasets to different students based on ability or interest. If your groups are smaller than 4, not every group will have every map represented, which is fine. Just make sure that someone from each group is assigned to the original **Featured Data**.

5. Invite students to silently observe their maps for a few minutes and have them spend a little time making sure they understand what the data is trying to show. (5 min.)

6. Ask the students to decide within their group how they might represent the data in each of the three maps in a different way than it is currently while using three distinct design tools (i.e., color, symbols, scale) from their **Design Tools Guide** for the three maps. Have students work on developing new legends for each map using scrap paper, pencils, and markers (10 minutes)

7. Ask each student to choose one of the maps. Hand out the **Data Sketches Student Worksheet 1** and the **U.S. Base Map Template**.

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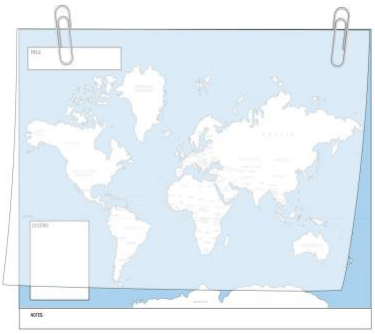
8. Have students paperclip a sheet of tracing paper over the map template and follow the prompts on Worksheet 1 (*please show an example of what they are being asked to do*). This worksheet will guide them through beginning their map. *The map template provided to be used as a guide under the tracing paper is important because it forces each student to create a map that is on the same scale as the others so that these maps can be easily layered together in the second part of this exercise. The order of steps on the worksheet is important to follow because it allows the student to create the legend prior to getting involved in the task of drawing. You, as the teacher, can walk through each step one at a time, if needed, or have the students follow the instructions independently. (10 minutes)*



9. "Sketch" - the final task of this worksheet asks for the student to use their new legend as a guide to sketching out their mapped data in a new way. Students are also asked to note important features. *Students may begin by tracing the outline of the countries and, although it is not necessary and sometimes time-consuming, it is a way that they can begin to process the map spatially. For that reason, the timing of this component is variable and left up to the teacher. Students should have a minimum of 20 minutes to respond or the teacher may choose to break here and allow the students to complete their mapped "work of art" at home overnight and wrap up the next day with Part 2. (20 minutes – 2 hours)*

Part 2 – Analyze & Discuss

1. Looking at the maps they have sketched, ask students to write a one or two sentence summary of what their sketched data represents and then complete the **Data Sketches Reflection Worksheet**.
2. Have the students share their answers with their group. (5 min.)
3. Group work Round 1 - Patterns, Correlations, Hypotheses: The group works together to layer two maps at a time and look carefully at the paired maps, noting any patterns and correlations they can find and hypothesizing about what the correlations mean and giving each other feedback. (15 minutes)

   Suggested sentence starters:

   - *We notice that there is a correlation between ___ and ____ …*
   - *There seems to be a pattern in…*
   - *One possible hypothesis that could explain this correlation / pattern is… This makes sense because…*
   - *This could tell us about… by…*
4. Have students report out as a group to the rest of the class about possible patterns, correlations, hypotheses. (10 minutes)

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Wrap Up/Synthesis

1. Group work Round 2 - Evaluating Design Choices. Students discuss the design tools they used and evaluate how well those choices worked in terms of helping their analysis of the data.

   Suggested sentence starters:

   - *One design tool we used was… It helped us notice…*
   - *When we used…. as a design tool, it made it more difficult to notice…*
   - *Using …. as a design tool was interesting because…*
   - *If we could do it again, we would do… differently. This is because…*

   Have students use a dry erase board to write down their ideas for evaluating their design choices. (10 minutes)

2. Have students report out as a group to the rest of the class about their design choices. (5 minutes)

STEP 4 – Guided Discussion

1. Revisit the questions generated (parking lot/sticky notes) in Step 1.
2. Review if the answers were found during the rest of the activities or if more sleuthing and research needs to be done. This can also be a great jumping off point for other related lessons and activities related to your content.
3. Discuss with the class the following questions:
   a. What questions did we answer?
   b. What questions remain?
   c. How can we find the answers to the remaining questions?
   d. What skills/tools have we learned that can help us answer them?
   e. What research can we do? What additional data do we need?

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Assessment (Optional)

Have students write a claim, evidence, and reasoning in response to the guiding question: Why are bats essential to the environment?

	0	1	2	3
Claim	Nothing turned in / Blank	Claim is scientifically correct and complete or Correct multiple choice option chosen		
Evidence		Does not provide evidence, or only provides inappropriate evidence (evidence that does not support claim).	Provides appropriate but insufficient evidence to support claim or also includes some inappropriate evidence.	Provides appropriate and sufficient evidence to support claim.
Reasoning: Completeness		Does not provide reasoning, or only provides reasoning that does not link evidence to claim.	Some attempt is made to relate evidence to underlying principles, but there are missing pieces.	All of the ideas necessary to link the evidence to the claim are included.
Reasoning: Accuracy		The links between the evidence and the claim are based on incorrect ideas.	The evidence is tied to the claim by scientific principles established in the class, but there are also "extra" ideas that are incorrect.	The evidence is tied to the claim by scientific principles established in the class, AND there are NO "extra" ideas that are incorrect.

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