Lesson: Thinking Like a Scientist Series-How Scientists Use Natural History Collections Data to Answer Questions About Plants and Animals

Date:

Subject/grade level: Life Sciences/ Middle School and High School

Materials:
Computer connected to the internet, with speakers

NC SCOS Essential Standards and Clarifying Objectives
Bio.2.1: Analyze the interdependence of living organisms within their environments.
Bio.2.1.2: Analyze the survival and reproductive success of organisms in terms of behavioral, structural and reproductive adaptations.
Bio.2.1.3: Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within ecosystems.
Bio2.2: Summarize how humans modify ecosystems through population growth, technology, consumption of resources, and production of waste. Interpret data regarding the historical and predicted impact on ecosystems and global climate.
Bio.2.2.1: Infer how human activities (including population growth, pollution, global warming, burning of fossils fuels, habitat destruction, and introduction of nonnative species) may impact the environment.
Bio2.2.2: Explain how the use, protection, and conservation of natural resources by humans impact the environment from one generation to the next.

NGSS Objectives
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.
MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

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

Lesson objective(s):
Upon completion of this lesson, each student should be able to:
- Collect data from a digitized natural history collection.
- Analyze spatial occurrence data for Red-cockaded Woodpecker.
- Examine the natural history data of the Red-cockaded Woodpecker.

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Differentiation strategies to meet diverse learner needs:
English Language Learner students and students with learning disabilities should have multiple forms of instruction including visual and written instruction sheets as well as a verbal instruction and demonstration.

ENGAGEMENT

A. Describe Scenario: You're walking in the woods on a science field trip, and suddenly you hear a rapid tapping noise. Is someone doing construction out here in the woods? As you look around puzzled, your friend remarks that she hears a woodpecker, and suddenly, your confusion subsides. Your teacher thinks it's a Red-cockaded woodpecker, but anyone who can build a case for that identification will earn extra credit. You decide to make it your mission to think like a scientist and determine if the Red-cockaded woodpecker lives in these woods.
B. Have students read the iDigBio's Biodiversity Spotlight on Red-cockaded Woodpeckers (https://www.idigbio.org/content/march-2016-biodiversity-spotlight)

C. Have students listen to the Red-cockaded Woodpecker call and tree-drumming (http://www.xeno-canto.org/species/Picoides-borealis)

EXPLORATION

Hands on activities:

a. Open an internet browser (e.g., Chrome, Firefox, Safari).
b. To find the scientific or Latin name (the binomial name or the combination of the organism's genus and specific epithet) for the Red-cockaded Woodpecker, go to http://eol.org/ (Encyclopedia of Life).
c. Type in *Red-cockaded Woodpecker* into the search bar and click "Go."
d. Copy the scientific name (The Latin name displayed above the common name – it is in italics) here: _____
Answer: *Picoides borealis*. Students may discover there are two scientific names (called synonyms) on the EOL page. *Leuconotopicus borealis* is actually the correct name as of 2014. Scientific names are in constant flux due to ongoing research. In this exercise, we will use the name *Picoides borealis* because the museums are still using this name. One task for museum staff is to keep their taxonomic information up to date. This is a never-ending job!
e. Go to https://www.idigbio.org/portal.
f. Search for the records of the Red-cockaded Woodpecker by typing *Picoides borealis* into the search box **ScientificName** and hit enter**.**
g. Select the box "**Must have a map point**" so you will only look at records that have GPS coordinates (they are the points displayed on the map).
h. Open the first record from your search by scrolling down past the map and clicking on the

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blue **View** on the right side of the first row.

i. When you click on a specimen record a new window will open. The top of the window will contain a summary of the record. If you scroll down, you can find all of the data associated with this particular museum specimen.

j. Look at what kinds of data scientists regularly collect. Under "Data", there are five subheadings. What are they?_____,
_____, _____,
_____, and _____.
Answer: Taxonomy, Specimen, Collection Event, Locality, and Other.

Big Idea Conceptual Questions:

k. What data would you need if you were a scientist studying the geographic distribution of a species through time?
_____
_____
_____
Answer: the where (GPS coordinates), when (because distributions of species change over time).

l. Red-cockaded woodpeckers are listed as a vulnerable species. Why do you think it's important to record this data for a vulnerable or declining species?
_____
_____
_____
_____

EXPLANATION

-If students have not done web searches, teachers should provide instruction on how to do so properly.
-They should also provide instruction on how to vet sources
-Have a conversation about taxonomy

-Do you think the decline in Red-cockaded Woodpeckers could affect other organisms within the upland pine ecosystem? Name three organisms that could be potentially affected and explain whether you think their populations might increase or decrease.

-What is a genus? A species?
-What are other woodpeckers in the US? What do they need? Are they different? Similar? Different habitats?
-Based on the description on a keystone species in the Biodiversity Spotlight do you think Longleaf Pines are keystone species? What is your evidence to support your claim? QUESTION: Red-cockaded Woodpeckers are endangered species.

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-If you were to lose the long-leaf pine, who would be affected? Would they all be gone, or will some survive? Who do you think will survive? Why?
-Dive into the Data: What would be valuable about having a sample that you can examine over and over, compared to having an observation that may not be able to be reproduced, or has been incorrectly identified?
-Why is specimen data good for understanding this example? Why would you use museum-based data over observation-based data? What's important about museum-based data? Populations are declining, why is museum data important to look at to understand populations decline?

ELABORATION

Vocabulary:

1. Nape
2. Endemic
3. Cockade
4. Longleaf Pines
5. Forage
6. Keystone Species
7. Endangered Species
8. Deforestation
9. Co-occurrence of species

Relevance to daily lives

- Specialized ecosystems
- Understanding outliers
- Changes in distribution→chances of seeing the bird in the wild, if you see it (or any other animal) in your backyard, think about the needs of that organism

Understanding Concept:

Scientists use maps to visualize spatial data about organisms. They create distribution or range maps to understand where organisms occur in space and time. We will create our own range maps next.

a. Go back to the first portal tab that contains your search results for *Picoides borealis*.
b. The map displays individual locations where museum specimens were collected in the field. You can zoom into North America by using the **+** button at the top right of the map and by clicking on the map and moving the view to center North America.
c. Click on a point on the map. A pop-up will show the data associated with that map point (there might be more than one specimen for each point!). What state is the map point in? _____ What is the latitude and longitude of the map point? _____ Answers will vary.
d. Now look at how all of the points on the map are distributed. Identify the points that seem far away from the majority of the other points. Click on one point that seems far away from the other points. What country and state were the specimen found in?

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Why do you think this "outlier" point occurs such a distance from the others?

_____

_____

_____

Answers will vary and they will lead to different conversations. Within the USA, these points represent the extreme range of the species. If the students click on the outlier in the middle of the ocean next to Africa, they will see that the latitude and longitude were listed as zero. This is a great time to talk about outliers, errors, the importance of being careful when recording data, etc. If they click on the outlier in Texas, this one is less likely to be a mistake. If they were a scientist, they might want to contact the scientist listed in order to view the specimen.

e. Scientists use museum specimen data to create current maps of an organism's current and former distribution. Click on each of the outliers. Click on "view record" in the small box that appears when you click on the point and read the record. Are there any records you would not include in your range map? Why not?

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_____

Answers will vary. Students should not include the one in the middle of the ocean, which is due to missing latitude and longitude points in the data. The northernmost point in Ohio was collected in 1872. This may not be a good record to use to represent the *current* distribution of the species. The one on the Texas/Mexico border appears to be a true outlier in that it was an individual outside of the expected range of the species collected recently (1997). There is only one record near this location, so it could be an anomaly or a bird that was only there temporarily. The record contains a recording of the Red-cockaded Woodpecker's vocalizations that are stored at the museum. You can click directly on this link to play the vocalization: http://macaulaylibrary.org/audio/109271 Scientists can go back to this record at any time and validate if the species was correctly identified because they can reexamine the specimen (or in this case media specimen). They do not have to rely on the original determination from the record. That is the power of museum data.

f. Create an image of your map by clicking on the **Camera Icon** at the top right-hand side of the map.

Take a look at the distribution map at Cornell University's Red-cockaded Woodpecker website: https://www.allaboutbirds.org/guide/Red-cockaded_Woodpecker/id by going to the website, clicking on "maps", and then "range map". Look at the map you generated using specimen data and the map that was created by the Cornell scientists using specimen and observational data.

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What are the differences and why are they different?

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You can also show students this map: http://maps.iucnredlist.org/map.html?id=22681158 which shows where Red-cockaded Woodpeckers occur and what areas they have most likely been eradicated from.

EVALUATION

- How will students demonstrate that they have achieved the lesson objective?
- This should be embedded throughout the lesson as well as at the end of the lesson

Final Activity:

One biotic factor that limits the distribution of Red-cockaded Woodpeckers is their reliance on old- growth pine forests. Research has shown that they prefer the Longleaf Pine over other species for foraging and nesting. We will now conduct an additional search in the iDigBio Portal for Longleaf Pine (*Pinus palustris*) to show the relationship between these two species.

a. Hit **Reset** above the search record box. Search for records of the Longleaf Pine by hitting **Enter** after *Picoides borealis* and typing *Pinus palustris* in the line below in the field **ScientificName.**
b. Click on the button "**add EOL Synonyms**". This will add records that have slight variations in the name (such as a subspecies), or are still referenced under outdated taxonomy. Note the birds are in green and the plants are in other colors on the map.
c. Examine the map. How does the distribution of the Longleaf Pine relate to the distribution of the Red-cockaded Woodpecker?

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_____

Answer: The Pinus species occur in most of the areas in which the woodpecker is found (=co-occurrence). During this section, it would be a good time to talk about how Red-cockaded Woodpeckers have been declining and considered Near Threatened by the IUCN Red List (http://www.iucnredlist.org/details/22681158/0). One reason for the decline is thought to be habitat loss because of the destruction of old growth pine forests.

d. Remove the Red-cockaded Woodpecker from your search hitting **Clear**, re-entering *Pinus palustris* into the **ScientificName** field, and clicking **Add EOL Synonyms**.

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e. Create a map by zooming into the Southeastern United States and clicking the camera button.
f. Compare the map you made with a range map created previously by scientists. http://www.pollenlibrary.com/map.aspx?map=Pinus-palustris.png How does your map compare to the scientists' map?

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Assessment:

1. Based on what you have observed how could people increase the number of Red-cockaded Woodpeckers?

_____
_____

Answer: Plant Longleaf Pine. Protect mature southern Pine forests.

2. The Biodiversity Spotlight mentions that Red-cockaded Woodpeckers are a keystone species. Would a decline in Red-cockaded Woodpeckers affect other species in the ecosystem? How so?

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_____
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Answers will vary and could include less competition with other woodpeckers for nesting and food, decrease in animals that depend on their cavities through loss of roosting and nesting habitat, increase in insects associated with pine trees.

3. Search for *Campephilus principalis* (Ivory-Billed Woodpecker) in the database. In what year was the most recent specimen collected? (You can find this information by clicking on the **Date Collected** column to organize it from most recent to oldest. The arrow should point down.) Ivory-Billed Woodpeckers are extinct due to loss of habitat. How does this relate to Red-cockaded Woodpeckers and Longleaf pine?

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_____

Answers will vary. Scientists could use information about the Ivory-Billed Woodpecker to demonstrate that harvesting forests can lead to the extinction of species. If lands such as the Longleaf Pine forests are altered or destroyed that could mean we lose animals that rely on Longleaf Pine forests for survival.

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4. Design two other research questions that could be answered in part with data from iDigBio.

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Answers will vary. One example might be, “what is the predator of the Red-Cockaded Woodpecker?” or “what type of woodpecker lives in my region?”

5. To earn your extra credit, does the Red-cockaded Woodpecker live in the forests near your school?

_____
_____
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