Science LIVE

LESSON 5: Capturing Ecological Patterns - Scientific Inquiry Using Camera Trap Data

GRADES: 6-12

DESCRIPTION

In this open-ended, inquiry-based lesson, students use skills learned in earlier lessons on camera trap data to develop their own question about wildlife that can be answered with data from City of Boulder Open Space and Mountain Parks (OSMP). Students develop a question, hypothesis, and research plan, they then collect appropriate data from the OSMP to answer their question and draw conclusions from their results.

LEARNING GOALS:

After completing this activity, students will be able to:

- Conduct a camera trapping study, including developing a question, a hypothesis, methods, and drawing conclusions from their results
- Apply their experience analyzing others' data to design a new, hypothetical study on the research question of their choice

TIME: Two 50 minute class periods + a write-up for homework (given the open nature of this lesson, students may need more or less time, depending on the question they ask and their familiarity with spreadsheets)

PREREQUISITES:

- Lesson 1: The Science of Camera Trapping

MATERIALS:

- Student Worksheet: "Capturing Ecological Patterns"
- Access to the Boulder Open Space photos Google Drive folder

Throughout this lesson, items in **bold blue font** indicate that students should answer a question on their worksheets.

Adapted from curriculum developed by Okaloosa S.C.I.E.N.C.E. in Okaloosa, Florida.

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Next Generation Science Standards* Addressed:

*GSS Lead States. 2013. *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.

Exact standards will vary based on students' selected questions, but this lesson will likely address standards such as:

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

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.

Science and Engineering Practices:

Analyzing and Interpreting Data

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to provide evidence for phenomena. (MS-LS2-1)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict phenomena. (MS-LS2-2)

Engaging in Argument from Evidence

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

- Construct an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-LS2-4)

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

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

Science and EngineeringPractices:

Developing and Using Models

Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show how relationships among variables between systems and their components in the natural and designed worlds.

- Develop a model based on evidence to illustrate the relationships between systems or components of a system. (HS-LS2-5)

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.

- Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-LS2-3)

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THE LESSON:

BACKGROUND:
If your class has not yet completed Lesson 1 of the eMammal curriculum series (Virginia Lessons - Lesson 1: The Science of Camera Trapping), we highly recommend you do so with your class prior to this lesson. Lesson 1 introduces students to the nature of camera trap data and what can and cannot be concluded from these data sets. Completing that lesson prior to this inquiry-based lesson will save students and you from confusion as they develop and test hypotheses.

STEP 1: Identify a question

1. Have students work in small groups to think about what questions about wildlife they want to answer today. Of course there are limits to what can be answered with the data available, so this process should include some exploration of the data sets available and what they do and don't include.

2. The City of Boulder Open Space and Mountain Parks Department (OSMP) has shared images from several of their cameras along Boulder Creek and Canyon for students' use in this lesson*. The "Boulder Open Space photos" Google Drive folder contains all these photos – over 2,200 photos in all! These are organized as follows:
    - The photos are from two broad research areas. One of these is located in the forested foothills outside of Boulder in Boulder Canyon, while the other is located in the Boulder Creek riparian area running through the grasslands near Boulder.
        - The camera in the grasslands site was deployed for 7 months in 2013, from February through September, when it was flooded in the high water event that occurred that year. This camera was deployed quite close to the creek, and features wetland species such as beavers, mink, and even an otter (the first river otter seen in Boulder in over a century!).
        - The forested foothills site is split into four different camera locations, all different distances from a recreational trail that is used by hikers and mountain bikers. These cameras are:
            - Foothills 1 – 15 m off the trail
            - Foothills 2 – 65 m off the trail (near an intermittent stream)
            - Foothills 3 – 125 m off the trail (near an intermittent stream)
            - Foothills 4 – 365 m off the trail

3. Once students have thought about these data sets a bit, students should work in small groups to develop a testable question and **write it on their worksheet**.

   Please revisit Lesson 1 for the type of information that can be acquired from camera data. Also, as students develop their questions, you may want to keep the following in mind:
   - Some **independent variables** that are available include:
     - ***Location*** – forest vs. grassland, or distance from trail
     - ***Time of day***
     - ***Season*** (month)
   - **Dependent variables** that are easily measured include:
     - ***Species richness*** (number of species)
     - ***Species presence/absence*** (i.e. occupancy) – this is best measured as the percentage of sites (i.e. deployments) at which a certain species is found. *It is important to steer students toward measuring the percentage of deployments, rather than counting number of photos of a species (this is relative abundance) or total number of deployments detecting a species.* Calculating percentages (100 x number of deployments with the species divided by total number of deployments) will correct for sampling effort; e.g. if there were 100 deployments in the foothills and 50 in the grassland, finding raccoons at 10 sites each would represent 10% of sites in the foothills area and 20% in the grassland, indicating that raccoons are more prevalent in the grassland.
     - ***Relative abundance*** – number of photos of a species per deployment/site. The ***relative*** term is very important. Cameras often take multiple pictures of the same individual, so counting photos of a species does not mean you are counting individuals, but we can get a sense for a species' relative use of different areas.
   - The easiest questions to answer will be those that compare patterns in different areas/projects or compare different species in the same area.
     - **Examples of Different Areas:**
       - What is the effect of trails on species richness?
       - Are turkeys more common in grasslands or forests?
     - **Different Species Example:**
       - Are bobcats or coyotes more nocturnal?

STEP 2: Develop a Hypothesis

A hypothesis is a potential answer to a scientific question. This should be an educated guess, based on students' knowledge of the study system. In this case, students may not have much prior knowledge on the subject*, but should be able to make an intelligent guess and **list their hypothesis on their worksheet**. They can follow this guess with some justification regarding why they came to this hypothesis.

Some examples of hypotheses for the sample questions above are listed below. Please note that all justification examples are not necessarily correct scientifically, they are just examples of what a justification might look like.

Q: What is the effect of trails on species richness?
H: Trails have a negative effect on species richness. Sites closer to the trail will have fewer species.
Justification Examples:
Many species are scared of humans, so we are likely to see lower diversity at camera locations close to the trail. Only species comfortable with humans will be present close to the trail, while all our native species are likely to be at sites farther away.

Q: Are turkeys more common in grasslands or forests?
H: Turkeys are more common in forests.
Justification Example: Turkeys are probably more common in forests because they roost at night in trees and can take shelter in trees.

Q: Are bobcats or coyotes more nocturnal?
H: Bobcats are more nocturnal.
Justification Example: Coyotes are very adaptable and are often seen hunting during the day.

*We encourage additional literature research on students' topics, if there is sufficient class time. Adding a literature or web search component will likely add another class period to the exercise, however, so if there is insufficient time for this, it will be important to impress upon students that their hypothesis will be more based in their opinion than scientific fact.

STEP 3: Organizing and collecting data
Though OSMP has already collected the raw data by setting up cameras and downloading the photos, students will need to somehow organize and quantify data to answer their question. What this will look like will vary by question and group, but will no doubt involve students choosing a subset of the data to analyze. They should **develop a research plan and write this on their worksheets**, so this plan can be verified by a teacher before it is enacted. We have provided suggested data analysis methods for the three sample questions below.

Q: What is the effect of trails on species richness?
Possible methods: Students could select two or more of the camera sites from the Foothills location to analyze. If limited by time, they could select the site closest to the trail and the site farthest away. Students would look through photos from both sites and identify animals in each of them, creating a species list for each site as they proceed. We will assume that each camera was deployed for a similar number of weeks, but to control for possible confounding variables, they may want to select a time frame for which there is data for both locations (e.g. April-December 2013).

Q: Are turkeys more common in grasslands or forests?
Possible methods: Students could answer this question by searching photos for turkeys in both the grassland and forest sites, tallying the number of turkey photos in each area. Again, it would be best for students to pick a similar time frame and just one of the four foothills sites, to make the data comparable.

Q: Are bobcats or coyotes more nocturnal?
Possible methods: Students can answer this question by searching for photos of bobcats and coyotes and recording the time of day in the timestamp for each photo. They would make a spreadsheet of times for bobcats and times for coyotes, and, to keep things simple, we would recommend them classing each photo as either night or day. If they want to take this question further, they can also class times as dusk or dawn, but this becomes difficult given seasonal differences in sunrise and sunset. Day/night classification can also be done by simply looking at whether the photo is dark or light as well.

STEP 4: Making conclusions

1. Once their data has been collected, students should be able to say **if their data supported or did not support their hypothesis** on their worksheets, along with **how they can tell**. Given the limited data in this lesson, students probably cannot run statistics to verify their findings, but they can determine if they found a trend. A professional scientist would replicate their data collection by deploying cameras in multiple sites with similar characteristics, e.g. three foothills sites vs. three grassland sites, instead of just one, to allow for statistical analysis of their data, and the limitations of only one replicate for a study should be discussed with the class.
2. **The final question on students' worksheets asks them to design their own study as a follow up to the study they conducted with OSMP data.**

Capturing Patterns with Camera Traps

Name(s): ______________________________

1. What question would you like to answer about Boulder wildlife today?

2. A hypothesis is an educated guess that answers your research question. What is your hypothesis?

3. Explain the hypothesis you listed above. What made you guess what you did?

4. How will you answer your research question using OSMP data today? Outline your research plan below. What data will you use and how will you analyze them?

5. Analyze your data and summarize your findings below.

6. Did your data support or not support your hypothesis? How can you tell?

7. If you could design your own follow-up study to the research you did today, including setting your own cameras wherever you would like, how would you design your research? What would your new question and hypothesis be, and how would you design your study?