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

GRADES: 9-12; prior experience with spreadsheets strongly encouraged

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 the eMammal data set. Students develop a question, hypothesis, and research plan, they then collect data from eMammal to answer the question and draw conclusions from their results.

LEARNING GOALS:
After completing this activity, students will be able to:

- Design 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 Patterns with Camera Traps"
- Access to http://emammal.si.edu, or another camera trap data set of your choice
- Access to and familiarity with MS Excel

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

STANDARDS:
Virginia State Science Standards Addressed:

(From "Science Standards of Learning for Virginia Public Schools – January 2010")

LS.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

f) dependent variables, independent variables, and constants are identified;
g) variables are controlled to test hypotheses, and trials are repeated;
h) data are organized, communicated through graphical representation, interpreted, and used to make predictions;
i) patterns are identified in data and are interpreted and evaluated; and
j) current applications are used to reinforce life science concepts.

BIO.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which:

a) observations of living organisms are recorded in the lab and in the field;
b) hypotheses are formulated based on direct observations and information from scientific literature;
c) variables are defined and investigations are designed to test hypotheses;
d) graphing and arithmetic calculations are used as tools in data analysis;
e) conclusions are formed based on recorded quantitative and qualitative data;
f) sources of error inherent in experimental design are identified and discussed;
g) validity of data is determined;
i) appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data, communicating results, modeling concepts, and simulating experimental conditions;

BIO.8 The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include

d) the effects of natural events and human activities on ecosystems; and
e) analysis of the flora, fauna, and microorganisms of Virginia ecosystems.

Depending on the questions asked by students, the following standards may also be addressed:

LS.8 The student will investigate and understand interactions among populations in a biological community. Key concepts include

a) the relationships among producers, consumers, and decomposers in food webs;
b) the relationship between predators and prey;
c) competition and cooperation;
d) symbiotic relationships; and
e) niches.

LS.11 The student will investigate and understand the relationships between ecosystem dynamics and human activity. Key concepts include

a) food production and harvest;
b) change in habitat size, quality, or structure;
c) change in species competition;
d) population disturbances and factors that threaten or enhance species survival; and
e) environmental issues.

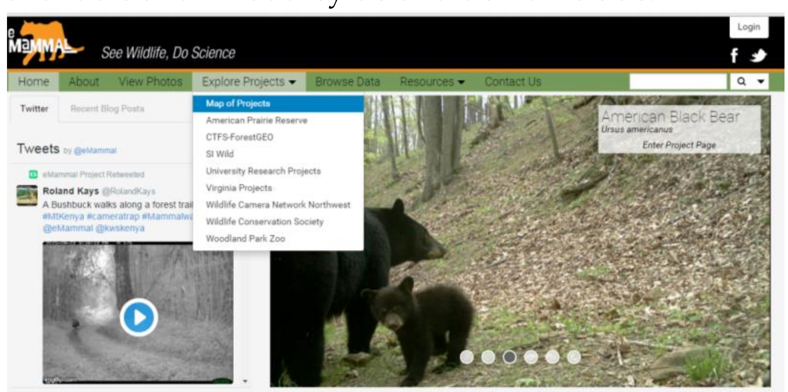
THE LESSON:

BACKGROUND:
If your class has not yet completed Lesson 1 of the Virginia eMammal curriculum series (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. In eMammal, students can learn more about projects by clicking on "Explore Projects" and selecting "Map of Projects" on the eMammal website.

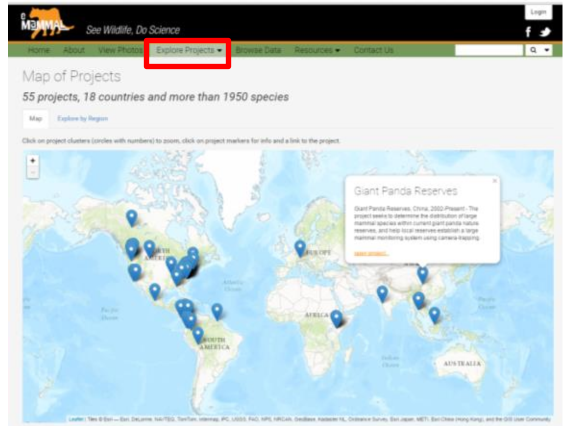


NOTE: Some projects listed on eMammal do not yet have downloadable data associated with them. As of September 2016, the following projects have available data:

Ecuador: Sumaco Cloud Forest Project
Kenya: Mount Kenya Survey
Thailand: Carnivores in Select Thailand Reserves
USA: Okaloosa S.C.I.E.N.C.E. (Florida)
APR Wildlife Survey Project (Montana)
Metropolitan Wildlife Network (New York)
Students Discover North Carolina (North Carolina)
Urban to Wild Project (Virginia/North Carolina)
Smithsonian BioAcoustic Monitoring Project (Virginia)

eMammal staff expect the following projects' data to be available in early 2017:

Canada: ForestGEO Scotty-Creek
China: Giant Panda Reserves
Panama: STRI-BCI
Thailand: Carnivores of Thailand
USA: Pace University (New York)



3. Provide students with the list of available projects and allow them to explore potential research areas on the map page of eMammal (Explore Projects → Map of Projects). They can click on any project to learn more about it, though only those listed on page 3 have data associated with them. Some regions have many projects, so they may want to use the zoom features to hone in on an area of interest.

4. Once students have explored data sets of interest, they 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 in all eMammal projects include:
     - ***Location*** – latitude or region (e.g. Virginia vs. Montana or China)
     - ***Time of day***
     - ***Season*** (month)
     - Additional **independent variables** may be available, depending on the nature of the project. For example, the Urban to Wild project has subprojects for different levels of human development (urban, suburban, exurban, etc.), while the Carnivore Intraguild Interactions project in Thailand surveyed in four different protected areas, each of which is labeled as a subproject. In both cases, students could compare patterns in one subproject to another for this exercise.
   - **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[1]) at which a certain species is found.

[1] When looking at summaries of camera trap projects on eMammal, you may wonder about the words "deployments" and "sequences." We categorize camera-trap data as hierarchical and in four levels (**Project**, **Deployment**, Image **Sequence**, and **Image**). The terms used in the standard are: (1) A ***Project*** is a scientific study that has a certain objective, defined methods, and a defined boundary in space and time. (2) A camera ***Deployment*** is a unique placement of a camera trap in space and time. (3) An image ***Sequence*** is a group of images that are all captured by a single detection event, defined as all pictures taken within 60 seconds of the previous picture or another time period defined by the Project. A sequence can either be a burst of photographs or a video clip. (4) A camera-trap ***Image*** is an individual image captured by a camera trap, which may be part of a multi-image sequence.

It is important to steer students toward measuring the percentage of deployments, rather than counting number of photos/sequences[1] of a species or total number of deployments detecting a species. Calculating percentages ($100 \times \left(\frac{\#\ Deployments\ Detecting\ the\ Species}{Total\ \#\ of\ Deployments}\right)$) will correct for sampling effort; e.g. if there were 100 deployments in a rural area and 50 in the city, finding raccoons at 10 sites each would represent 10% of sites in the rural area and 20% in the city, indicating that raccoons are more prevalent in the city.

- ***Relative abundance*** – the number of photos (or preferably sequences) of a species per deployment/site. The ***relative*** term is very important. Cameras often take multiple sequences 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 latitude on opossums?
        - Are wild cats in the United States and Kenya active at the same time of day?
        - Is there greater mammal diversity in Virginia or Ecuador?
    - **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[2], 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 on the next page. Please note that all justification examples are not necessarily correct scientifically, they are just examples of what a student justification might look like.

[2]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. If you choose to add a research component, students investigating Virginia species can use the eMammal Virginia Camera Trapping Guide (https://www.inaturalist.org/guides/3098) for species information. For species outside of Virginia, we encourage use of the Encyclopedia of Life (www.eol.org).

Q: What is the effect of latitude on opossums?
H: Opossums are more common at lower latitudes.
Justification Examples:
Opossums originally colonized North America from South America.
Opossums are omnivores that rely heavily on insects for food, and there are more insects in the South.

Q: Are wild cats in the United States and Kenya active at the same time of day?
H: Yes, cats in both areas will be primarily nocturnal or crepuscular.
Justification Example: All large cats use stealth to catch prey, and partial or total darkness would contribute to this stealth.

Q: Is there greater mammal diversity in Ecuador or Virginia?
H: There is higher diversity of large mammals in Ecuador.
Justification Examples:
Tropical rainforests house more species.

STEP 3: Downloading and Organizing Data

Once students have selected specific projects in eMammal to use, they will need to download the data. We have created a PowerPoint presentation with step-by-step instructions ("DownloadingData.ppt" or "DownloadingData.pdf") and have provided a sample dataset for your use in guiding students through this process.

For directions on how to analyze eMammal data once you have downloaded the Excel spreadsheet, please see the eMammal Academy YouTube channel. On this channel, you'll find specific videos for different analyses, including:

- Detection Rate in Different Habitats (e.g. opossums at different latitudes): https://www.youtube.com/watch?v=A85zmpPCaIo
- Detection Rate in the Presence/Absence of Another Species: https://www.youtube.com/watch?v=hb7Tt0S6PCU
- Daily Activity Patterns (e.g. wild cats in US and Kenya): https://www.youtube.com/watch?v=IU1BwEZ1QJ4
- Species Richness in Different Habitats (e.g. Ecuador vs. Kenya): https://www.youtube.com/watch?v=79AAlfWwZ8U