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Teaching animal habitat selection using wildlife tracking equipment

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ABSTRACT

We present a hands-on outdoor activity coupled with classroom discussion to teach students about wildlife habitat selection, the process by which animals choose where to live. By selecting locations or habitats with many benefits (e.g., food, shelter, mates) and few costs (e.g., predators), animals improve their ability to survive and reproduce. Biologists track animal movement using radio telemetry technology to study habitat selection so they can better provide species with habitats that promote population growth. We present a curriculum in which students locate "animals" (transmitters) using radio telemetry equipment and apply math skills (use of fractions and percentages) to assess their "animal's" habitat selection by comparing the availability of habitat types with the proportion of "animals" they find in each habitat type.

KEYWORDS

Ecology; mathematics; middle school; secondary; critical thinking

Introduction and background

To engage students, teachers need to pique their interest by providing opportunities for students to interact with scientific materials and data (Krajcik and Czerniak 2014). Moreover, active learning and problem solving help students to understand abstract scientific concepts (Laws et al. 1999). Our lesson teaches students (grades six through twelve) about wildlife habitat selection and conservation through a hands-on outdoor activity in which students collect their own data using wildlife tracking equipment. Through an interactive discussion, students analyze their data using mathematical skills and relate their findings to wildlife populations and conservation.

Animals depend on their environment (habitat) for the resources necessary to survive and reproduce. Unfortunately, habitat loss is a primary driver of wildlife declines. To conserve threatened wildlife species, biologists investigate which habitats promote population growth by observing where animals choose to live (habitat selection) (Browne and Paszkowski 2010). Animals select habitats that provide benefits such as food and mates, and they avoid habitats with high costs such as many predators. Maximizing benefits and minimizing costs facilitates survival and reproduction for each individual and collectively drives population growth and stability. One way biologists study wildlife habitat selection is by locating animals using radio telemetry, technology designed to track animal movement by securing a transmitter to an animal and using a receiver to determine the transmitter's approximate location.

Animals use some habitats more than others. Preferred habitats are areas that animals use more often than expected by the habitat's availability (the area(s) of habitat animals can access) (Table 1; Krausman 1999). Generally, preferred habitats have lower cost–benefit ratios than alternative available habitats. Conservation efforts create and restore preferred habitats for animals to provide individuals with resources that boost population growth. For example, conservation efforts in California helped declining populations of least terns (a small bird) by creating new artificial beaches closed to people so humans could not inadvertently step on and destroy nests. Terns nested on the new beaches and their chicks hatched successfully (Powell and Collier 2000).

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Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/vsca.

Table 1. Vocabulary.

Species: A category of similar plants or animals capable of reproducing with one another.
Population: A group of individuals of the same species living in close proximity.
Habitat Selection
Habitat: An environmental area where an animal resides (e.g., sleeps, eats, rests, mates). Habitat includes resources that animals need to survive and reproduce (e.g., food, shelter, mates).
Habitat Use: Occurs when an animal resides in and uses resources in an environmental area.
Habitat Selection: How and why animals choose where to live among various habitats (e.g., trees, grass, rocks, ocean, desert, tundra).
Habitat Preference: An animal uses a habitat more than expected by the habitat's availability.
Habitat Avoidance: An animal uses a habitat less than expected by the habitat's availability.
No Habitat Preference or Avoidance: An animal uses a habitat according to the habitat's availability.
Radio Telemetry
Wildlife Radio Telemetry: A transmitter (on an animal) sends information via radio waves to a receiver that can be used to locate the animal.
Radio Frequency: Radio waves carry radio signals. Frequency refers to the form of the radio wave. Different radio frequencies can carry different signals, just the way car radios play different stations. In wildlife radio telemetry, each transmitter has a unique frequency across which it sends a signal.
Yagi Antenna: An antenna composed of several short rods mounted across a support rod that can be used to locate radio transmitters.
Gain vs. Audio: Two available adjustments on radio telemetry receivers. Gain refers to signal strength and audio refers to volume.

Radio telemetry

How wildlife radio telemetry works

Animals are equipped with a transmitter secured as a necklace or backpack or inserted under the skin (Figure 1). Using a receiver with an antenna, biologists listen for a transmitter's unique radio frequency (Figure 2). When the receiver is tuned to the appropriate frequency, it emits a beep when it detects the transmitter. The beeps grow louder as the antenna on the receiver is pointed toward or gets closer to the transmitter, allowing the user to estimate the location of the transmitter by listening for changes in the volume of the beeps.

Figure 2. Telemetry demonstration.

Applications

The first large-scale radio telemetry project tracked grizzly bears in Yellowstone National Park. Biologists found that even though garbage dumps covered a small percentage of the park, bears spent a great deal of time at dumps, benefiting from easy access to large quantities of food (Figure 3). The project identified a major cause of human–bear conflicts and initiated efforts to increase safety in the park.

Figure 1. Pheasant equipped with a necklace radio transmitter.

Figure 3. The Craighead brothers collaring a grizzly bear while working on the first large-scale wildlife radio-telemetry study. Photograph courtesy of the Craighead Institute.

Biologists Track Grizzly Bears in Yellowstone National Park

In 1959 Frank and John Craighead (biologists and brothers) began tracking grizzly bears usig radio telemetry in Yellowstone National Park. At the time, extremely close and dangerous human-bear encounters unnerved both managers and park visitors. The Craigheads developed methods to immobilize bears in order to equip them with radio transmitters. They applied sedative to a dart and used a dart-gun to render bears unconscious from a safe distance. The Craigheads discovered that grizzlies regularly visited the park's open-pit garbage dumps to feed and consequently habituated to humans and relied on dumps as a critical food source. The Craigheads worked with the park to slowly close open-pit garbage dumps in order to ensure bears found alternative food sources and moved away from campsites and developed areas. Today there are considerably fewer human-bear encounters in Yellowstone (McCullough 1986).

Activity

Our lesson teaches students about habitat selection through a hands-on outdoor activity in which students use radio telemetry equipment to locate "animals" and assess habitat preference using mathematical skills. Teaching habitat selection meets many teaching standard requirements (Table 2). The activity is suitable for students in grades 6 through 12) (see Modifications and Extensions for more challenging additions that incorporate computer technology and trigonometry). The activity does not require teachers or students to have previous knowledge of wildlife habitat selection or wildlife tracking equipment (see Additional Resources and citations for suitable background information). The activities require 45 to 60 min outdoors with an additional 45 to 60 min of discussion. Groups may need up to 2 hr outside depending on group size, students' abilities, and transmitter placement.

Table 2. Application of Education Standards.

Next Generation Science Standards (NGSS 2013) Grades 6–8:
MS-LS-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
MS-LS-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
Common Core State Standards (CCSS and NGA 2010) *Standards apply to activity modification, "Teach trigonometry through telemetry triangulation."*
High School Geometry:
Define trigonometric ratios and solve problems involving right triangles.
HSG.SRT.C.7: Understand that by similarity, side ratios in right triangles are properties of the angles in the triangle, leading to definitions of trigonometric ratios for acute angles
HSG.SRT.C.7: Explain and use the relationship between the sine and cosine of complementary angles.
HSG.SRT.C.8: Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.

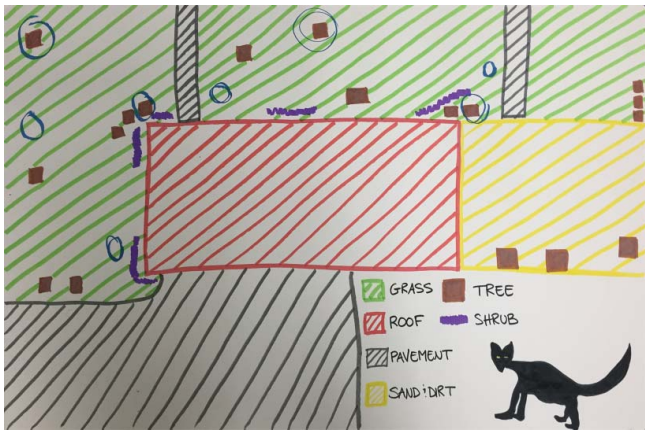

Figure 4. The outdoor classroom: Map of habitat availability and transmitter locaitons. Students drew blue circles to indicate where they found transmitters. In this example, the fictitious black tiger cat preferred trees.

Materials

1. Telemetry equipment:
   a. Receivers
   b. Handheld Yagi antennas
   c. Cords (to connect each antenna to a receiver)
   d. Transmitters
   State wildlife agencies (see Additional Resources) as well as many universities and colleges have telemetry equipment, which is often readily available for educational purposes. We recommend asking for a brief tutorial similar to the demonstration described below before borrowing equipment.
2. Two decks of playing cards

Activity preparation

Choose an animal, real or fictional.

Create a map of the habitats in the outdoor classroom (Fig. 4) and record for your own notes their approximate proportions.

Select the number of transmitters to hide in each habitat in order to exemplify habitat preference, avoidance, and no preference/avoidance (Table 3).

- Preference: The percentage of transmitters in this habitat should be *greater than* the percentage of the classroom this habitat covers.

- Avoidance: The percentage of transmitters in these habitats should be *less than* the percentage of the classroom these habitats cover.
- No Preference/Avoidance: The percentage of transmitters in these habitats should be *equal to* the percentage of the classroom these habitats cover.

Write transmitter frequencies on papers that students can carry during the activity.

Remove magnets attached to transmitters to activate them and then hide transmitters in designated habitats. Place transmitters within 200 m of where students will begin to ensure students can recover them. Conceal transmitters so students must use telemetry equipment to locate them.

Assemble telemetry equipment by unfolding antennas to resemble the photograph (Figure 2), tightening screws to secure them, and connecting one end of the cord to the receiver and the other end to the antenna. On the receivers, there are additional dials and switches that are not necessary for this activity. Marking the ones the students will use (on/off, frequency, volume, and gain or signal strength) will reduced the need to assist students while they locate transmitters.

Procedure for student engagement

Step 1: What is habitat?

Encourage students to brainstorm the definition of habitat. Ask them for examples of their habitat (e.g., town, school, house, room). Ask students what habitats are available to wild animals (e.g., trees, grass, rocks, rainforest, mountains, ocean).

Step 2: What is habitat availability?

Ask students what habitats are available in the outdoor classroom.

Step 3: Telemetry introduction

Provide a brief introduction about how wildlife biologists track animal movement and determine where animals live using radio telemetry (refer to Introduction to Radio Telemetry and Additional Resources).

Step 4: Telemetry equipment demonstration

Outside, place a transmitter 30 to 100 m away and tune the receiver to the transmitter's frequency. Demonstrate how to determine the direction of the transmitter by pointing the antenna in one direction for 1 to 3 s and listening to the beeps (Figure 2). Keep the volume set to medium/medium-high, and adjust the gain (signal strength) so that you can clearly hear the beeps while the receiver rests at waist height. Turn about 90 degrees and listen again. Repeat until you have turned a full circle, paying attention to which direction the beeps are the loudest. If you can barely detect a signal, increase the gain. If the signal is very loud in every direction, reduce the gain and try again. Walk toward the transmitter, stopping to reduce the gain as you get closer. As you approach, point the antenna toward the ground and then to the sky to determine the specific location of the transmitter.

Step 5: Students practice locating transmitters

Provide each group of two to three students with a receiver, an antenna, and a cord connecting them. Allow students to practice with an example transmitter to reduce the need for one-on-one assistance during the activity.

Step 6: Students locate hidden transmitters

Provide each group of students with a list of the frequencies of the one or two transmitters they will locate. Ask students to remember the habitats where they find each transmitter. After the students find all transmitters, gather inside.

Step 7: Introduce playing cards for prizes (a metaphor to help clarify the definition of preference)

Spread out a deck of cards, face up, on the table around which students are seated. Explain that attempts to answer questions correctly will be rewarded with the opportunity to choose a card (aces and face cards = ten points, numbered cards = five points). At the end of the activity, cards will be traded for prizes. Students will choose more face cards than numbered cards even though fewer face cards are

Table 3A. Habitat Availability, Use, and Selection Answers from students in activity steps 8 and 9.

Habitat Type	Availability (%)	Use (# trans)	Use (%)	Habitat Selection
Tree	5%	7	70%	Prefer
Pavement	10%	1	10%	Neither Avoid/Prefer
Dirt	10%	1	10%	Neither Avoid/Prefer
Grass	50%	0	0%	Avoid
Roof	25%	1	10%	Avoid

available, just as their animal chose its preferred habitat more than expected by habitat availability. Students choose face cards because more points provide more rewards, just as animals prefer habitats that provide food, mates, and protection from weather and predators. This analogy helps to clarify the meaning of habitat preference in step 10.

Step 8: Calculate available habitat

Present the map and ask students to identify the different habitat types and estimate their percent availability to complete the first two columns of Table 3A. Questions to facilitate discussion include:

- Is there more of one habitat than another?
- Which habitat covers the most area?
- Does a certain habitat cover more or less than half of the area?
- Work with students so that percentages of habitats add up to 100%.

Step 9: What is habitat use?

Invite students to share (and/or mark on the map) how many transmitters they found in each habitat and complete the third column of Table 3A. Ask students what percentage of transmitters they found in each habitat type to complete the fourth column of Table 3A. This is an opportunity for students to convert fractions to percentages. Questions to stimulate discussion include:

- Did your animal use all available habitats?
- What habitat did your animal use the most?

Step 10: What is habitat preference?

Ask students how they can distinguish habitat preference from habitat use. Encourage students to brainstorm the definition of preference. Refer to the card game and ask students to complete Table 3B to clarify what preference means. Discuss what habitat(s) your animal prefers, avoids, and neither prefers nor avoids.

Table 3B. Students Prefer Face Cards The distribution of cards picked by students. This can help to clarify the definition of preference in activity step 10.

Card Type	# in Deck	# Picked Up
Face Cards	16	16
Numbered Cards	32	10

Step 11: Costs and benefits of habitat use

Ask students why your animal might choose its preferred habitat.

Questions to facilitate discussion include:

- What resources do students use in their habitats?
- Do some places have more resources than others?
- What resources do they think are most valuable to wild animals and why?
- How might those resources help animal populations to grow?

Step 12: Conservation

Ask students what would happen if we removed all preferred habitat and replaced it with the habitat that your animal avoids (e.g., if we cut all the trees down and paved all the grass). Animals with diminishing habitat may move, begin using other available habitats, or go extinct. Explain that radio telemetry helps biologists know what habitats animals prefer so that biologists can work to provide those habitats for wildlife populations.

Step 13: Points and prizes

Distribute rewards and/or award privileges.

Modifications and extensions

1. Expand the activity by using more than one kind of animal, each with different habitat preferences.
2. Conduct only the indoor classroom activity. Skip steps 3–6 and provide students with animal locations on a map of available habitat.
3. Modifications for more advanced students (grades 9 through 12):
   a. Omit the card game as a metaphor for habitat preference.
   b. Incorporate technology by using Google Earth and Excel functions to calculate habitat availability:

   Materials:

   1. Computers with Internet access
   2. Google Earth
   3. Microsoft Excel

   Activity:

   1. Open Google Earth and search your geographic area.

2. Zoom so that your outdoor classroom fills the screen.
3. Highlight "my places" by clicking on it and add a folder by clicking on "add folder."
4. Name your folder "Habitats."
5. Highlight your "Habitats" folder by clicking on it once and then click the "add polygon" icon on the top of the screen.
6. A pop-up box will appear. Leave it open and create a polygon around one habitat type (e.g., a group of trees, a field of grass, a cluster of buildings).
7. Within the pop-up box that appears, name your polygon (e.g., trees, grass, water).
8. You can change the fill color of the polygon using the "Style, Color" tab of the pop-up box.
9. Click OK to complete your polygon.
10. Repeat steps 5–9 until you have labeled all available habitat within your outdoor classroom.
11. Copy your habitat folder by right-clicking and selecting "Copy."
12. Navigate to the following website to calculate the area of your polygons. http://www.earthpoint.us/Shapes.aspx (It is possible to calculate the polygon area within Google Earth Pro, also free for download).
13. Paste your folder into the box provided on the website.
14. Choose the units you would like to use (e.g., "Sq feet," "Sq meters") and "Export to Excel."
15. Instruct students to calculate the percentage area that each habitat type covers in Excel using the SUM and divide ("/") functions. Compare estimates among students.

c. Teach trigonometry through telemetry triangulation.

Triangulation is a technique used to determine the approximate location of animals from a distance so that biologists do not have to approach and disturb animals (Smith et al. 2014). Biologists determine the cardinal direction of the animal from three to four locations. Using trigonometry, biologists can calculate where the lines of the triangle intersect—the animal's approximate location. Students can use compasses to obtain the approximate direction of the "animal" from different locations in the outdoor classroom. Inside, students can use trigonometry to calculate the remaining angles and leg lengths of their triangles. Students may also use GPS (devices or free mobile-phone apps) to record coordinates (Universal Transverse Mercator or UTMs) of the known locations. Student can then use trigonometry to calculate the approximate UTMs of the transmitter and test their triangulation accuracy by locating the transmitter in the outdoor classroom. See Additional Resources for detailed information regarding telemetry triangulation.

Observations and discussion

We taught this lesson to 12 students in grades 6 through 11 at the Lincoln Lighthouse (Lincoln, NE), an after-school-program that offers academic support, meals, and recreation for middle and high school–aged youth. We found the outdoor portion of the lesson (steps 1–6) took approximately 1 hr. When we asked students for examples of their own habitats (step 1), students gave examples such as their house and their room. We broadened their understanding by discussing additional examples such as their school, town, and state. Similarly, when we asked students for examples of wildlife habitat, students gave examples such as trees, grass, and rocks, and we initiated discussion about broader habitat types such as the rainforest, mountains, and ocean. After this, students quickly identified a variety of habitats in their outdoor classroom (e.g., grass, trees, bushes, buildings) (step 2).

When using telemetry equipment to locate the fictional "black tiger cat" (step 6), each group of students (six groups) needed individual assistance for 5 to 10 min at a time, enabling assistants to rotate among groups. After each group located one to two transmitters, the indoor discussion lasted approximately 45 min. Initially, when students estimated percentage of habitat availability of different habitat types in the outdoor classroom (step 8), their estimates added to more than 100%. We worked with students so that percentages of habitats added up to exactly 100% by asking students if specific estimates seemed too high and by how much. Most students were able to convert proportions of transmitters in each habitat to percentages

(step 9). However, some students struggled to complete the math on their own, reflecting the diversity in age groups and educational backgrounds within our group. Students were easily able to identify what habitat(s) the black tiger cat preferred (trees), avoided (grass, the roof), and neither preferred nor avoided (pavement, dirt), but most students were unsure of the definition of preference (step 10). Using the card game analogy helped to clarify that preference is when an animal uses a habitat more than expected by its availability. When we asked the students what might happen to the black tiger cat if we cut down all the trees and constructed more buildings in the outdoor classroom (step 12), students suggested that cats might move into the trees in their backyards, or the cats might disappear. We reinforced that animals with diminishing habitat may move, begin using other available habitats, or go extinct.

We taught the concepts of wildlife habitat selection and preference by relating animals' use of habitats to the student's everyday lives. Students were excited to go outdoors and locate "animals." Within 2 hr, students collected data using wildlife tracking equipment, applied math skills to calculate their animal's habitat preference, and discussed how habitat loss impacts wildlife populations.

Conclusion

Active learning helps to engage students and to teach abstract scientific concepts (e.g., habitat selection) (Laws et al. 1999). Our outlined curriculum provides an opportunity for students to act as biologists and collect data using wildlife tracking equipment outdoors. Students develop critical thinking skills by assessing habitat selection using their own data. Additionally, students use math skills to calculate habitat selection, integrating math and science material. We hope the outlined curriculum will teach students how animals choose where to live and how habitat selection and conservation efforts can affect individual animals and entire populations.

Additional resources

Dr. Paul Krausman provides definitions associated with wildlife habitat selection and discusses how knowledge of habitat selection guides wildlife conservation.

- http://www.webpages.uidaho.edu/range456/readings/krausman.pdf
- The following website lists state wildlife agencies and contact information.
- http://www.fws.gov/offices/statelinks.html
- Browne and Paszkowski (2010) track toads using radio telemetry, determine the types of habitat toads use, and make conservation recommendations.
- http://sccp.ca/sites/default/files/species-habitat/documents/hibernation%20sites%20of%20western%20-toad_Browne_Paszkowski_2010.pdf
- The Wildlands School in Wisconsin posted instructional videos on telemetry triangulation and generating triangles from telemetry results.
- http://www.wildlandschool.net/video_library.phtml
- Various organizations share online, real-time mapping of collared wildlife animals using GPS satellite tracking data.
- http://wwf.panda.org/what_we_do/where_we_work/arctic/wildlife/polar_bear/tracker/
- http://www.wildlifetracking.org/
- http://www.movebank.org

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