Pika Models + Climate Change

Overview

In this lesson adapted from the "High School Three-Course Model Living Earth Snapshot 7.6: Shrinking Pika Habitat" vignette in the *2016 Science Framework for California Public Schools (pp. 839-841)*, students explore the life of pikas, tiny mammals that live in alpine areas, and how they are being impacted by climate change. After a brief introduction which includes a reading, short video, and story which includes a mathematical model, students engage in a kinesthetic simulation to gain first-hand experience of life as a pika, and how the animals can be impacted by shrinking habitat. Students then create line graphs with data from the simulation and analyze it.

Part II of the lesson allows students to create their own model to teach others about pikas and their connections to their ecosystem, and/or how the pika or another organism is being impacted by climate change and/or other human activities. Numerous adaptations/extensions are listed at the end of the lesson, including ways to explore additional data from online computer simulations and how they can incorporate current and projected climatic data into their models. **Note:** This lesson is targeted to grades 9 – 12; BAESI has another version of the lesson designed for grades 3 – 8.

Subjects: Science, Math, Writing, Speaking & Listening, Physical Education, Environmental Education, Art

Grades: 9 – 12

Duration: Two 50-minute periods or one long block of 90 minutes; additional time to complete projects and present them to the class

Vocabulary

- biodiversity
- ecosystem
- ecological community
- model
- pika
- species
- talus

Guiding Questions

- How might climate change impact alpine habitats and pika populations over time?
- How might other species of wildlife be impacted if their habitat becomes warmer or cooler, or wetter or drier?

An American pika forages in its alpine habitat

Objectives

- Students will participate in a kinesthetic pika population simulation, graph the data, and analyze it.
- Students will create a model to teach others about pikas and their connections to their ecosystem, and/or how the pika or another organism is being impacted by climate change and/or other human activities.
- Students will create written explanations of their models and oral presentations about them to the class about them and demonstrate their learning.
- Students will discuss how pika populations have been changing and how human activities may play an increasing role in their populations over time.

Next Generation Science Standards + Common Core State Standards		
NEXT GENERATION SCIENCE STANDARDS	**Performance Expectations**	**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.
	Crosscutting Concepts	• Stability and Change • Systems and System Models
	Science & Engineering Practices	• Asking Questions and Defining Problems • Analyzing and Interpreting Data • Developing and Using Models • Using Mathematics and Computational Thinking • Constructing Explanations and Designing Solutions • Engaging in Argument from Evidence • Obtaining, Evaluating, and Communicating Information
	Disciplinary Core Ideas	**LS1: From Molecules to Organisms: Structures and Processes** LS1.A: Structure and Function LS1.B: Growth and Development of Organisms **LS2: Ecosystems: Interactions, Energy, and Dynamics** LS2.A: Interdependent Relationships in Ecosystems LS2.C: Ecosystem Dynamics, Functioning, and Resilience HS-LS2-2: A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability. **LS4: Biological Evolution: Unity and Diversity** LS4.C: Adaptation **ESS3.C: Human Impacts on Earth Systems**
COMMON CORE STATE STANDARDS INITIATIVE **ELA**	**Writing**	4, 10
	Speaking & Listening	1, 2, 4, 6
	Language Standards	1, 2, 3, 6
	Writing Standards Science & Technical Subjects	4, 7, 10
California's Environmental Principles and Concepts	**Principle II—People Influence Natural Systems** The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are Influenced by their relationships with human society. **Concept A.** Direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.	

Teacher Background

This lesson is designed to help you teach and reinforce a variety of concepts and skills. It is tailored to high school biology students, but adaptable for a wide-range of grades and connections across the curriculum. For example, several different kinds of models are used, including diagrams, a kinesthetic model, and graphical representations of data, to help students understand the content presented, while simultaneously helping them to understand how to use models themselves to find deeper meaning in the science and better convey information to others. Your focus could be on pikas and how they are being impacted by rising temperatures as a poignant example of how anthropomorphic (human-caused) climate change is affecting organisms' ability to survive, or you might choose to focus on a concept such as adaptation, the importance of biodiversity in ecosystems, or all of the above.

A citizen scientist searches for pikas in the talus

One way to approach the lesson is to explain how different kinds of organisms (living things) have different needs. Some plants grow well only in full sun, for example, while others do better in shade. These traits that help organisms survive are their **adaptations**, which developed over millions of years through the process of **evolution** as individuals that were better adapted to survive in the **ecosystem** were able to pass on their genes.

An ecosystem is any group of living and nonliving things that interact with one another. Some are relatively small like the **talus** slopes of large rocks on mountainsides where pikas thrive, and others are large **biomes** like rainforests or grasslands. Average temperatures and rainfall are the two most important factors that make up an area's **climate** and determine what ecosystems will be found there. As our planet warms, with some areas such as the intermountain West warming more than other places, ecosystems are changing and forcing the organisms found in them to adapt or find new homes. Pikas, who are well-adapted for cold weather and already inhabit colder areas such as mountaintops, have limited options for places where they can move.

Biodiversity is a measure of the number of different species of organisms in a specific area, and it is also used as a general description of species richness, ecosystem complexity, and genetic variation. In general, the more biodiversity, the more stable the environment and the less it is impacted by changes in the environment. The organisms that interact with each other in their ecosystems are called **ecological communities**.

Some members of a community, such as pikas, are particularly important for ecosystems. For example, pikas recycle nutrients in the generally nutrient-poor alpine soils through the hay piles they create to survive the winter, as well as with their dung and urine. They are also an important food source for predators in their sparsely inhabited alpine environments. Their hay piles can provide nourishment for other organisms, as well, plus they disperse and fertilize seeds for plants. Because of all these important roles, pikas can be considered a **keystone species** for their ecosystem; just like the keystone at the top of an arch which helps hold the whole structure together, a keystone species is vital to the stability of an ecosystem. If it is in trouble, the whole ecosystem can be negatively impacted.

In some cases, whole ecosystems can even collapse due to the loss of one species, as was the case when fur traders killed nearly all the sea otters; it turned out that sea otters were one of the main predators of spiny sea urchins, which quickly became overpopulated and ate through the holdfasts that secure kelp to the ocean floor. Kelp forests—and all the fish and other marine life that depend on them—were

drastically depleted, but with the recovery of sea otters to help control the urchin population, kelp forests, too, are recovering. Hopefully pika populations can be stabilized and continue for many years to come through human efforts to mitigate the effects of climate change and to help protect their fragile talus ecosystems.

In the second part of the lesson, students create visual models to guide their understanding and give oral presentations to demonstrate their learning. Numerous other project ideas are listed in the Extend / Enrich section of the lesson. A rubric to assist with student self-evaluation and teacher evaluation is provided after the lesson plan.

Materials + Preparation

1. Make copies of the handouts at the end of the lesson for each student or pairs of students:
    - "Pika Population Over Time"
    - "American Pika" reading
    - "Model / Presentation / Written Explanation Rubric"
2. Gather about 360 natural sticks, craft sticks, or popsicle sticks, or enough so that each student in your class can have 12 of them.
3. Prepare to show a short video about pikas, such as those listed at the end of the lesson and this fun 3-minute clip narrated by Sir David Attenborough: youtube.com/watch?v=0aP4WZEy9GI
4. Computer and data projector
5. Large sheets of paper to create visual models and/or computers for students to use
6. Colored pencils, markers, and/or crayons for students to share
7. ***Optional:*** Read additional sources such as those listed at the end of the lesson for additional background information, and/or make copies of them for students to read and discuss.

Teaching Suggestions in the 5E Model

Part I: Modeling Pika Population Changes

Engage

1. Ask students an essential question to engage them and prime them for learning, such as "How might wildlife be impacted if their habitat becomes warmer or cooler, or wetter or drier?" Suggest they discuss the question with a neighbor and write down their ideas while you circulate to answer questions. After a couple minutes, ask for a group to share their thoughts. Explain that you will explore that question in class today as it relates to animals called the pikas.
2. Ask the students to again turn to their neighbor and discuss what they know about pikas, including what they look like, where they live, and how they survive. After a minute, ask for a group to share what they already know about the little rabbit relatives.

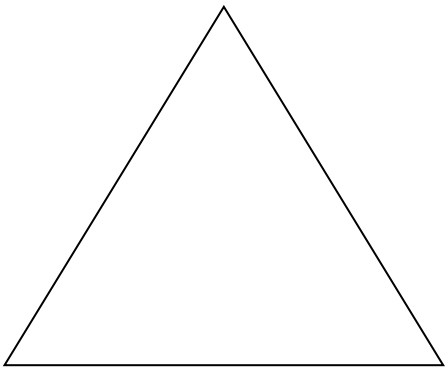
Explore

3. Pass out the "American Pika" handout found at the end of the lesson and ask the student pairs to read it together and discuss it. Or you might direct the students to good online resources to learn more about pikas, such as the National Wildlife Federation page from which the handout is adapted: nwf.org/Educational-Resources/Wildlife-Guide/Mammals/American-Pika.
4. Ask the student pairs to watch one or more short video clips that show pikas in the wild, and/or you could show and discuss a clip with the whole class. Good choices include:

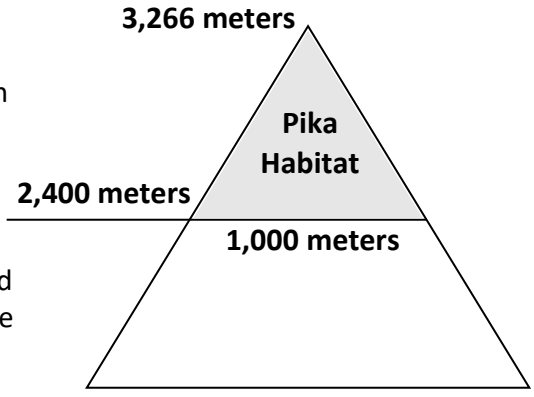
- A fun 3-minute clip from the BBC Life Collection narrated by Sir David Attenborough that shows their alpine habitat and how they run around all summer creating hay piles to last through the winter: youtube.com/watch?v=0aP4WZEy9GI.
- "The Adventures of the American Pika" trailer (2:00): vimeo.com/234885043
- "Pikas" by Mitch Chapman (4:33): vimeo.com/17925621

Explain

5. Tell students they will be playing a game to simulate the pika's life in their mountain habitat. But first they need to do a little problem solving to plan the simulation game space:



- Ask students to draw a large equilateral triangle in their science notebooks or on a sheet of paper. (Depending on the level of your students, you can also model it on the board.) Explain that it represents a mountain in the Sierra Nevadas of California where scientists have found pikas. However, the pikas have been disappearing from part of their historical range at lower elevations. Ask students to share their ideas about why that might be the case and discuss. (As explained in the "American Pika" reading, scientists suspect this may be linked to rising temperatures, because pikas are very sensitive to heat; pikas are usually only found where summer temperatures rarely exceed 75˚F (24˚C). In fact, they can die within only an hour of being exposed to temperatures of 78˚F (26˚C) or more.)
- Explain that a research project is being done to study the pikas who can still be found on the north side of the mountain in an area of talus (large rocks) on a steep slope at the top of the mountain. Tell them that that the scientists have observed signs of pikas, and discuss student ideas about what those could be (hay piles, dung, and their distinctive calls).
- Ask students to use their triangles to help them model the habitat range of the pikas starting at about 2,400 meters (7,900 feet) of elevation, where it is cooler than lower elevations, up to the top of the mountain at 3,266 meters (10,715 feet). Then ask a volunteer to come to the board and share their ideas for how to do that, one of which is to draw a line about half-way up the "mountain" that stretches horizontally across it and write 2,400 meters next to it. Then 3,266 meters can be written at the top and the triangular area above the 2,400 line can be shaded and labeled "Pika Habitat."



- Explain that the scientists have measured that the talus slope and nearby meadow areas where pikas live and gather food is about 1,000 meters (3,300 feet) long at the 2,400-meter mark. Ask the students to label the

line 1,000 meters on their models, then tell them that the scientists have already determined that there is an average of 1 pika for every 100 square meters of habitat area. Now the scientists want to calculate the AREA of the habitat where the pikas live so they can determine the total approximate population of pikas. Ask the students to create a visual representation of 1 pika / 100 m^2 density. (One option would be to draw a square and label one of the sides 10 meters. Inside the square they could draw a quick, cute pika or pika face).

1 pika per 100 m^2

- If most of your students have already learned how to calculate the area of triangles, ask them to work with a neighbor to calculate the size of the habitat. If they succeed with that, they can attempt to calculate the approximate number of pikas on the mountain. You can circulate through the room and answer questions, as needed. If students are struggling, ask them to try to how to calculate the area of triangles, or if necessary, they can research it on the Internet or in a math book. They can then use the formula below and to find the answer based on the known information.

  Area = ½ (base) (height)

  base = length of one side of the triangle

  height = length of a perpendicular line drawn from the base to the angle across from it on the triangle

- The students should then be able to calculate the area and approximate number of pikas:

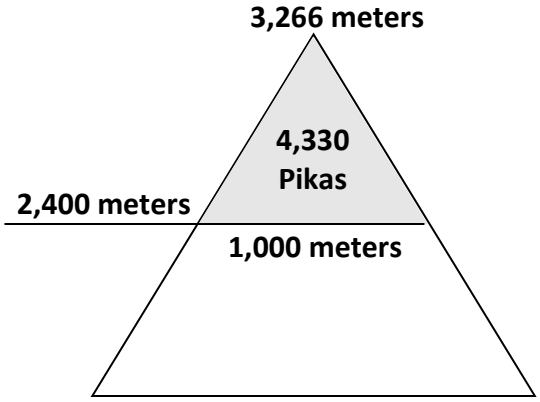
  Area of the habitat = ½ (1,000 m) (3,266 m - 2,400 m)

  ½ (1,000 m) (866 m) = **433,000 m^2**

  (The habitat is between 3,266 m and 2,400 m, so the height is 866 m).

  Approximate number of pikas

  433,000 m^2 / 100 m^2 = 4,330 pikas
  (Since the scientists determined there was an average of 1 pika per 100 m^2.)



6. Tell students that they will now create a kinesthetic model—a model in which they will get to move around—of the pikas in their habitat.

   - Pass out paper cups, one per student, and ask them to write their names on the cups—or what they would like their name to be if they were a pika.
   - Ask the class to bring their cups with them as you move to an area with lots of room to move around, preferably a field or other outdoor space.

- If you have not yet done so, create a large triangular game area that is about 10 meters long on each side. You could use a tape measure or simply mark approximate meters with long strides. The area should be large enough for your whole class to more around in without running into each other. Tell them that the model is at a scale of 1 to 100, since the actual habitat was about 100 times larger: 1,000 meters on each boundary of it. You could mark the area with orange cones and a rope, safety flagging, etc. Tell students that this represents the alpine habitat (mountain region with rocks and plants) where they will need to gather enough plant material to eat for the whole winter.
- **Round 1**:
  Ask the class to help you distribute the sticks—either natural or craft/popsicle sticks, about 12 per class member—evenly throughout the area, with a few beyond the boundary of one side of the triangle. Explain that these sticks beyond the boundary represent plants in an area at a lower elevation that it is too hot for the pikas; if they go in that area they will overheat and die. The other two sides of the triangle represent the air above their mountain home where there is no food for them.
- Direct students to put their cups in the play area, representing their nests. Explain that when you (or a student who is physically unable to play) says "SPRING!" the "pikas" will dash from their nests to gather new plants (sticks), being careful not to run into each other. They will have 30 seconds to gather sticks and return them to their "nests" (cups) ONE AT A TIME, since pikas are small and cannot carry much. They will continue this process to form hay piles until you (or the student assistant) shouts "WINTER!" Then they will return to their "nests" and count the number of sticks they gathered.
- Tell students that they will need to gather at least 10 sticks to survive the winter, but if they gather 12 or more sticks, they will have enough energy to be able to reproduce (have baby pikas).
- Shout out "SPRING!" and time the players for 30 seconds. Then shout "WINTER!" and ask the players to count their sticks. If they do not have 10 of them, they did not survive and must exit the game; they should take their cups but leave their sticks behind on the "mountain." You and the class can count those students who did not survive and record the data on a chart like the one at the top of the next page.

Pika Survival	Round 1	Round 2	Round 2	Round 3	Round 4	Round 5	Round 6
Did not survive							
Survived only							
Survived and reproduced							

- Ask students who collected 10 or 11 sticks to raise their hands and record that number of survivors on the chart under "survived only." Finally, count the hands of the students with 12 sticks and record the number under "survived and reproduced."
- **Round 2:**
  Tell students that due to warming temperatures, you need to move the game boundary line which represents the lowest part of the mountain on which the pikas can survive, so that their habitat is 10% smaller. As you do so, explain to students that all of the food on that part of the mountain is now in an area that is too hot for them, so any players remaining in that area will have to move their nests and find food in the smaller area. As they do so, they should be sure to be at least 1 arm length away from the next nearest pika nest, since pikas are very territorial.
- For every student who was able to reproduce in the first round, a student who did not survive can return to the game as a young pika.
- For round 2, one student can be a predator, such as a coyote or another predator found in your state. When the round starts, the predator runs after the pikas and tries to tag them. Tagged students have become the predator's lunch and must leave the game.
- You might want to ask a few questions about pikas and their habitat to determine who gets to be the predator, as well as who gets to return to the game as young pikas. To encourage students who are still in the game to stay engaged and think about the questions, you might give those students a bonus stick for the round if they answer a question correctly that none of the students who are out of the game can answer.

  Optional questions you might ask at this time and/or later in the lesson for review:

  - In what habitats are pikas found? (North American species are only found in rocky areas at higher elevations, although you might mention that some Asian species construct burrows.)
  - What adaptations do pikas have that allow them to survive? (Thick fur coats and short, thick bodies to conserve heat; camouflage; high metabolism and body temperature; large, round ears to hear predators and other pikas, although to conserve heat their ears are shorter than those of other animals in the rabbit family)
  - What do pikas eat? (A large variety of herbaceous (green) plants: grasses, wildflowers (forbs), sedges, thistles, etc.; will eat mosses if more nutritious plants not available; they sometimes also eat their dung or store it for later to get more nutrition from their plant foods)

- What do pikas do that helps them survive the winter? (Create hay piles to store food, which also removes toxins from the plants; find shelter in rocky areas)
- How might snow help pikas to survive the winter? (Insulates their nests to help keep them warm; source of water)
- Do some pikas hibernate like bears? (No, they must eat all winter to survive)
- Do pikas share nests with large groups? (No, but they live in colonies and alert each other to danger)
- What is a U.S. state or Canadian province where pikas are found? (Range includes mountainous areas of California, Nevada, Oregon, Washington, Idaho, Colorado, Utah, Montana, New Mexico, Alaska, British Columbia, and Alberta)
- What factors might limit the pika population (total number of them)? (Available food, water, shelter, and space; predators; shrinking habitat)
- What is one animal that eats pikas? (Predators include hawks, foxes, coyotes, weasels, martins, prairie falcons, bobcats, and ravens)
- How many species of pika are found in North America? (Two: American pika *(Ochotona princeps)* and collared pika *(Ochotona collaris)*—found only in Alaska, Yukon territory, and British Columbia; there are 36 known subspecies of pika found in North America, 7 of which are listed as vulnerable)
- How do pikas communicate? (Loud calls to mark their territory and announce predators; scent markings; males also use song during the breeding season to attract mates, with mated pairs of males and females sometimes singing duets; both males and females have been found to use song in fall)
- What important roles might pikas play in their ecosystem? (Their hay piles and dung recycle nutrients and fertilize soil; spreading seeds; important food source for many species of predators)
- Do pikas cause problems for humans? If so, what are they? (None are known)

- Repeat the same process explained above and record the data on the chart.
- **Round 3:**
  Move the boundary layer so that the triangular game space is 20% smaller than the original space and complete the round with the remaining players, including any "young pikas" who were able to join the round of the game due to reproduction from the last round.
- Record the data on the chart and congratulate the "pikas" who were able to survive and/or reproduce. If time allows, you could play more rounds in which the habitat is another 10% smaller than the original space each round, and record the data on the chart. If the pikas become so crowded in the smaller game area that a player needs to move their nest closer than one arm length away from the nearest pika, they have died from lack of habitat and must leave the game.

7. Return to the classroom and present the data to the class, either with a document camera and/or data projector or on the board. Ask the class to plot the data and create line graphs to show the changes over time; you might offer them a choice of using the "Pika Population Over Time" handout that follows the lesson or a computer spreadsheet, such as Microsoft Excel or Google Sheets.

8. While students complete the activity, circulate through the room to answer questions and help students, as necessary.
9. After all the students have completed the graphs, discuss them with the class and/or have them reflect on the questions in writing in science notebooks. Use a data projector and/or document camera (if available) to more easily share a couple examples of student graphs.
    - How can students describe the data changes over time?
    - Was there anything surprising about the results of the model?
    - How might the pika population change in the future if the model continued?
    - How can models be helpful in understanding and predicting changes in populations and ecosystems?
    - Do students have any ideas about how the model might be improved to make it more reflective of pika biology and their alpine ecosystems?
10. Have a brief discussion with the class about how pika populations will likely be impacted by human activities over time. You might also want to discuss student feelings about how climate change might affect pikas, other wildlife, and humans.

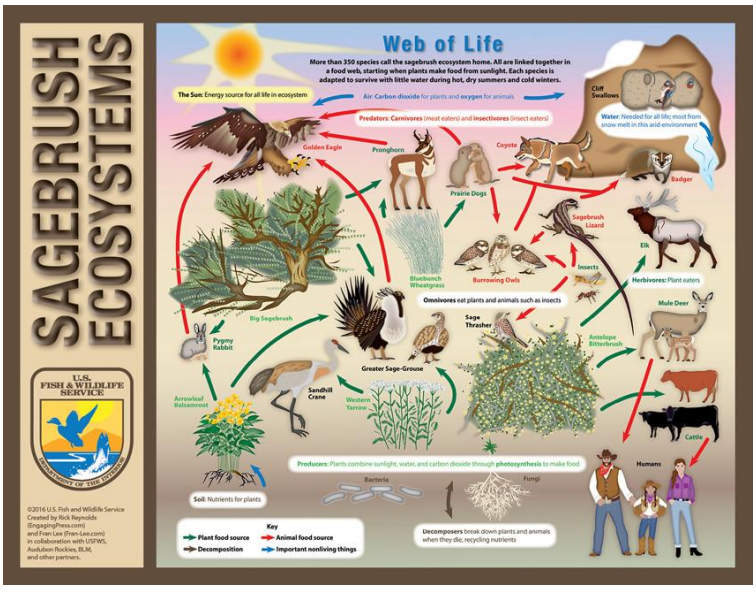
Part II: Student-Created Models (for another class period or one long block)

Engage

11. Ask students to turn to a neighbor and quickly brainstorm all the ways they could model a scientific phenomenon, whether by moving around like they did in the pika simulation, with math, pictures, graphs, etc. After a minute, ask the groups to share their ideas and discuss them as a class.

Explore

12. Tell students that they will be able to create their own model to teach others about pikas and their connections to their alpine ecosystem. For example, they might create a visual diagram of their ecosystem similar to the one shown to the right and at the link below focused on the sagebrush ecosystem. Or they could choose to model another important scientific phenomenon related to an organism, such as how the pika or another organism is being impacted by climate change and/or other human activities. Please note the simulation activity under "Extend / Enrich" below and see an 8.5x11" version of the Sagebrush Ecosystems diagram suitable for printing here: fws.gov/greatersagegrouse/documents/Education/Sagebrush_8.5x11%20(1).pdf.



Students could create a visual model on paper (larger sheets are better) or using a computer. For example, they could add an illustration of the organism they are focusing on, other organisms in

the ecosystem, and important nonliving components of it, such as sunlight, snow, soil, and rocks. Students could also cut out images printed from websites or magazines, and/or simply use words and/or other symbols to represent the concepts. Then they can add arrows pointing from the animals to the organisms they eat, etc., as shown in the example above, or use arrows and other symbols to help model another important scientific phenomenon, such as how the pika is being impacted by climate change and/or other human activities.

13. Explain that students can reference the "American Pika" handout and/or conduct additional research and take notes on their topic. As the students do that and begin planning their project, circulate through the room answering questions. Point students to additional sources of information, as necessary, such as those listed at the end of the lesson. Tell students that they will also be preparing a written description of the model and making a brief 1 – 2-minute presentation to the class about it.

14. Allow students to work on their projects for the rest of the period, then allow additional time to complete the project during or outside of class, if needed. Pass out the rubric at the end of the lesson which explains how they will be assessed; ask the students to complete their portion of the rubric and turn it in to you with the project on or before the due date.

15. On the day the assignments are due, ask the students to share their models with the class as part of a short oral presentation about it. After all the presentations are complete, close with a pair-share in which students discuss what they learned about wildlife, ecosystems, and models from the presentations, and how might they use different kinds of models in the future.

Explain

16. Discuss the importance of **biodiversity** and write the word on the board. Talk about how the student projects help to model how the more variety there is among an **ecological community** of organisms found in an ecosystem, the more stable it is and the less it is impacted by changes in the environment. Also write COMMUNITY on the board to reinforce its importance, explaining that you are referring to an ecological community of living things and their interactions. Then ask students about other types of communities they might have experienced, and how human diversity in all its forms can be a strength in those, as well. (Ideas could include your school, city, community centers, churches, etc., and how a rich variety of backgrounds, cultures, ideas, etc. can lead to better decision making, more equitable outcomes, etc. Relate the concept of biodiversity to human diversity and how a wide variety of physical and emotional traits can be beneficial for long-term **sustainability** in all types of communities.)

Extend / Enrich

- Have students run this computer simulation about pika population and effects of temperature change developed in Scratch, while they track the data and then analyze it: scratch.mit.edu/projects/128765571. Students can adjust the temperature and watch how the size of the pika habitat shrinks and grows.
    - Ask students to explain in writing what they thought was good about the simulation and what they think could be done to improve it.
    - They should suggest at least two changes that could improve the model, as well as additional information or data that could be included in the simulation.
- Students can visit the California Energy Commission's Cal-Adapt website at cal-adapt.org and find specific temperature forecasts for the habitat of the pika in the Eastern Sierras. For example, they could see that the average temperature in August is expected to rise by 10°F between 2000 and

2100 under one scenario, but only 3°F if humans emit less carbon dioxide from their use of fossil fuels. Students can enter temperature changes into the simulator to explore the impact of the predictions on the pika. Through this activity, students should recognize that pikas do much better under the low-emission scenario than the high-emission scenario. They can analyze the problem and write about what humans can do to help the pikas and their ecosystem.

- Give students more examples of choices of types of models other than 2-dimension visual diagrams. For example, students could choose to create:
    - A short video showing how changes in temperature and/or moisture over time might impact an organism's survival
    - A computer simulation like the one mentioned above in the first adaptation
    - Additional graph(s) of scientific data available on the web or collected themselves, with a written explanation of the methodology and significance of the research
    - A play or skit which explains the interactions in an ecosystem in a humorous way
    - A "web of life" that has them each representing an organism from the ecosystem linked together by yarn that shows interactions between them; students could create a set of cards to represent the organisms that could be distributed to the whole class in a circle—preferably outside
    - 3-D models or dioramas with labels and/or annotations on the important living and nonliving components of the ecosystem.
- Completed student models can be displayed in your school and in your local community to educate others about pikas and their fragile ecosystems.
- Take students on a field trip to explore an area of talus slope pika habitat (or a more accessible natural area) first-hand. Have students engage in an activity such as creating a nature journal or field guide of the organisms they observe. A lesson plan entitled "Field Journaling" can be found on the Idaho Rangeland Resource Commission education website: idrange.org/_literature_156764/Field_Journaling. Excellent information on creating nature journals can also be found on the BirdSleuth website: birdsleuth.org/nature-journaling.
- Explore the effects of climate change on pikas more fully. Resources are listed at the end of the lesson, including this video from *Smithsonian* which discusses how loss of snow pack, for instance, is a problem: smithsonianmag.com/videos/category/science/pikas-and-climate-change/
- Explore the link between population growth and extinction with your students. Learn more from the Center for Biological Diversity: biologicaldiversity.org/programs/population_and_sustainability/extinction
  Excellent Population Education resources can be found here: populationeducation.org
- Have students sketch the pika in its habitat, including its food, shelter, and other organisms in its biological community. Provide colored pencils, crayons, and/or markers to color the illustrations, or they can be created using a computer and software such as Adobe Illustrator or Photoshop. Volunteers can share their illustrations with the class and/or display them on classroom or school walls, etc.
- Incorporate the wonderful Wildlife Skull Activities from the University of Arizona Extension for a thorough, hands-on set of activities focused on adaptation: extension.arizona.edu/sites/extension.arizona.edu/files/pubs/az1145.pdf

Evaluate

17. Lead a discussion about the guiding questions of the lesson. Students can also reflect on these questions in writing.
    - How might climate change impact alpine habitats and pika populations over time?
    - How might other species of wildlife be impacted if their habitat becomes warmer or cooler, or wetter or drier?
    - How might human communities be impacted by climate change over the next 50 or 100 years?
    - What steps can we take to reduce and/or reverse our adverse impacts on ecological communities, as well as human populations?
18. Review student models, graphs, and written reflections.

Expand Knowledge + Skills

Pika Background / News / Research

- Video of ecologist discussing pikas and her research: youtube.com/watch?v=f6c2cZf0ULI&feature=youtu.be
- Another ecologist discusses the "Perilous Plight of the Pikas": youtube.com/watch?v=US_Hy_eGPtg
- American pika: *Ochotona princeps.* BioKIDS. biokids.umich.edu/critters/Ochotona_princeps
- "Effect of Snow Pack and Connectivity on Pika" lesson plan. Biological Sciences Initiative: docs.wixstatic.com/ugd/f6b310_6c8648f749834da3a5c71d397d0f190a.pdf
- Stone, K. "Climate Change Threatens California Pikas." GotScience Magazine. Feb. 4, 2015: gotscience.org/2015/02/climate-change-threatens-california-pikas
- "Behavioral Ecology of American Pikas (Ochotona princeps) at Mono Craters, California: Living on the Edge (2016). Western North American Naturalist 76(4): 459-484: fs.fed.us/psw/publications/millar/psw_2016_millar006_smith.pdf
- "Pikas Disappearing from Parts of the West Due to Climate Change." USGS. 25 Aug. 2016. Accessed 28 Feb. 2018: usgs.gov/news/pikas-disappearing-parts-west-due-climate-change-0
- Moyer-Horner, L. et al (2016). "Predictors of Current and Longer-Term Patterns of Abundance of American Pikas (Ochotona princeps) across a Leading-Edge Protected Area." PLOS ONE: journals.plos.org/plosone/article?id=10.1371/journal.pone.0167051
- Stewart, J.A. et al. (2015, Jan. 29). "Revisiting the past to foretell the future: summer temperature and habitat area predict pika extirpations in California." Journal of Biogeography. onlinelibrary.wiley.com/doi/10.1111/jbi.12466/abstract
- Stephens, T. (2015, Feb. 6). Shrinking range of pikas in California mountains linked to climate change. University of California Santa Cruz. news.ucsc.edu/2015/02/pika-study.html

Lessons / Units

- "Biological Diversity: The World's Riches." California Education and the Environment Initiative. californiaeei.org/curriculum/unit?unitid=64
- "The Greenhouse Effect on Natural Systems." California Education and the Environment Initiative: californiaeei.org/curriculum/unit?unitid=66
- "High School Three-Course Model Living Earth Snapshot 7.6: Shrinking Pika Habitat" vignette in the *2016 Science Framework for California Public Schools:* cde.ca.gov/ci/sc/cf/documents/scifwchapter7.pdf
- You can receive free posters with the sagebrush ecosystem diagram, curriculum, and more from the U.S. Fish and Wildlife Service: fws.gov/greatersagegrouse/education.php
- Video explaining how to calculate the area of triangles from Khan Academy: khanacademy.org/math/geometry-home/geometry-area-perimeter/advanced-area-with-triangles/v/area-of-an-equilateral-triangle

Standards

- More examples of what NGSS looks like for high school students can be found in Chapter 7 of the *2016 Science Framework for California Public Schools:* cde.ca.gov/ci/sc/cf/documents/scifwchapter7.pdf
- More information about the Next Generation Science Standards, including a link to the *Framework for K-12 Science Education* to which this lesson was aligned, can be found at nextgenscience.org/framework-k%E2%80%9312-science-education.
- More information about the Common Core State Standards and links to the complete documents: corestandards.org

American Pika

Genus: *Ochotona* Species: *princeps*

American pikas are small, rodent-like mammals. Although they look like a lot like hamsters and other rodents, they're actually more closely related to rabbits and hares. Pikas have short, thick bodies with big, round ears. They do not have a visible tail.

Pikas have brown and black fur. The fur is colored to camouflage them in the rocks where they live. Pika fur is thick to keep them warm in the winter. During the summer, they put on a much lighter coat of fur--however, the fur is still thick enough that pikas can easily overheat if exposed to high temperatures.

Size: Adult pikas are about the size of hamsters, usually 18 – 20 centimeters (7 – 8 inches) long.

Diet: Pikas are herbivores (plant eaters). They especially love grasses, weeds, and tall wildflowers that grow in their rocky, high mountain habitat.

Pikas like to be prepared! In the winter months, there are a lot less grasses and flowers growing in the mountains. To prepare for the lean times, pikas like to save up food during the summer. A pika will collect a pile of extra wildflowers and grasses and lay them out in the sun to create hay piles. The sun's heat dries the plants so they do not get moldy. Then the hay is stored in the pika's den until winter.

Typical Lifespan: American pikas can live 6 - 7 years, but many die after 3 or 4 years.

Habitat: American pikas are found in alpine (mountain) areas, above the tree line. They usually live in talus (areas of large rocks) near meadows with grass and wildflowers.

Range: American pikas live on high-elevation cool mountains in the western United States and Canada. They can be found in Montana, Wyoming, Colorado, Idaho, Washington, Oregon, California, Nevada, Utah and New Mexico, as well as British Columbia and Alberta in Canada.

Communication

American pikas are often heard before they are seen. They make calls and sing to define and protect their territory, alert others to the presence of dangers and attract mates. The call sounds like a lamb's bleat, but more high-pitched and squeaky.

Lifestyle and Reproduction

American pikas have adapted to living in very inhospitable environments. They live where most other mammals do not venture to go—the treeless, rocky slopes of mountains.

It is very cold and treacherous for the tiny pika. Pikas help protect themselves by living in colonies. They live near other pikas and will alert the group to predators by sending out a warning call. Weasels, hawks, foxes, and coyotes are a few of the animals that prey on pikas. However, they find protection from predators, especially larger ones, by their rocky habitat.

Although pikas live in colonies, they are very territorial over their den and surrounding area. They will give off territorial calls to define the boundaries between each pika neighbor. They make their dens and nests among rocks.

Pikas are active in the daytime and they do not hibernate in winter. They are active throughout the year, but they tend to spend most of their time inside the den in the winter. Pikas eat stored grasses to survive and venture out to forage when the weather permits.

In early to mid-spring, American pikas begin to breed. Many pikas breed twice--once in the spring and again in the summer. Females are pregnant for a month before giving birth to a litter of 2 – 6 young. When they are born, the young are blind, mostly hairless, and they depend on their mother for milk. It takes about a month for the young to be weaned off milk and 3 months to reach an adult size. After a year, the young develop into breeding adult pikas.

Sensitivity to Climate Change

Pikas are very sensitive to heat; they are usually only found where summer temperatures rarely exceed 75˚F (24˚C). In fact, they can die within only an hour of being exposed to temperatures of 78˚F (26˚C) or more. Pikas have been disappearing from some of their historical ranges at lower elevations. Scientists hypothesize that this is linked to rising temperatures due to anthropomorphic (human-caused) climate change.

Sources

Adapted with permission from “American Pika.” National Wildlife Federation: nwf.org/Educational-Resources/Wildlife-Guide/Mammals/American-Pika

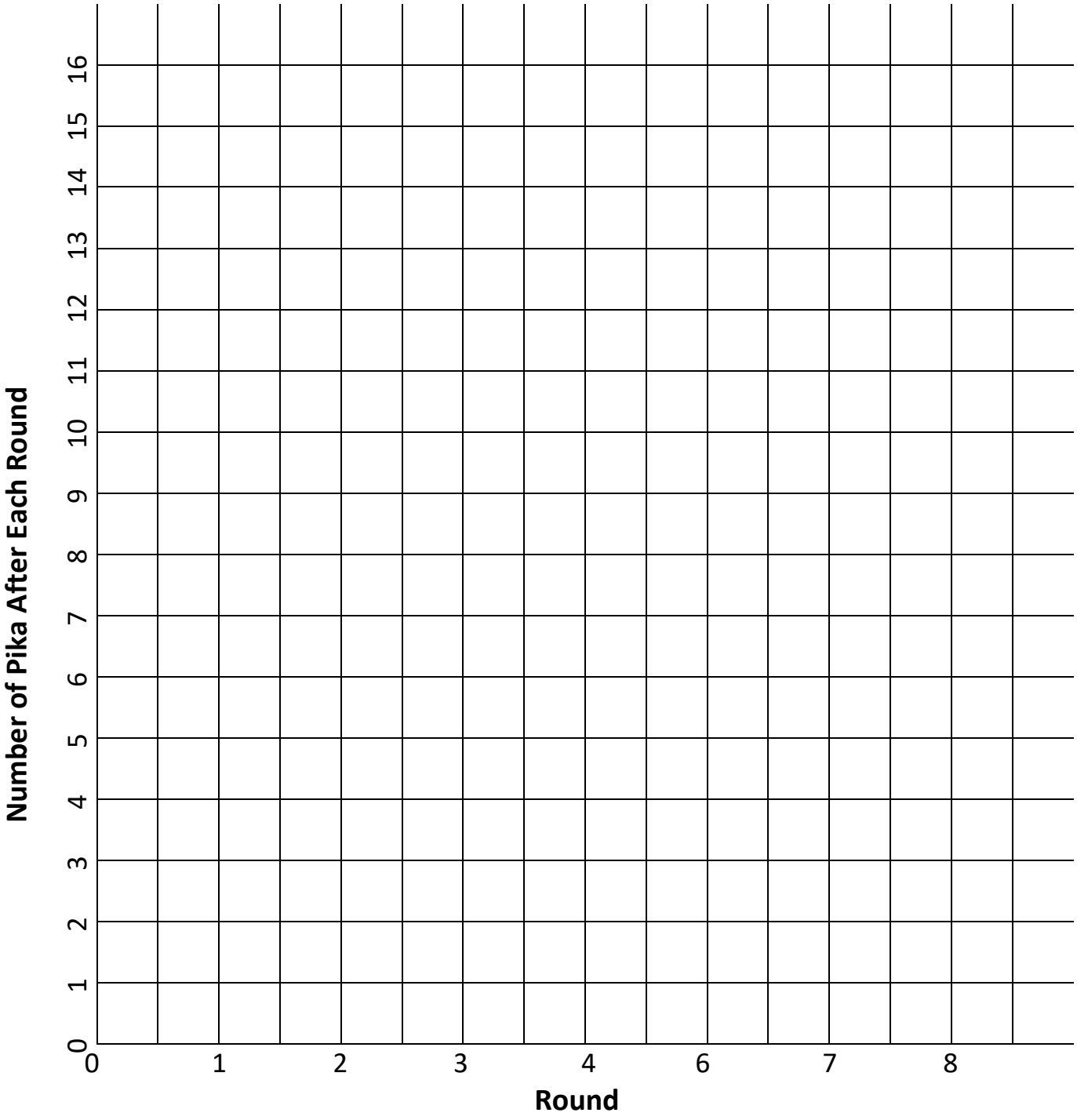
Additional sources:

- “American Pika.” BioKIDS: biokids.umich.edu/critters/Ochotona_princeps
- “American Pika.” U.S. Fish and Wildlife Service: fws.gov/mountain-prairie/es/species/mammals/americanpika
- “American Pika.” Washington NatureMapping Program: naturemappingfoundation.org/natmap/facts/american_pika_712.html
- “American Pika.” Colorado Parks & Wildlife: cpw.state.co.us/learn/Lists/Wildlife%20Species/DispForm.aspx?ID=1

Name(s): _____ Per: _____ Date: _____

Pika Population Over Time

1. **Add data points from the table** using 3 different colors.
2. **Label the colors** in the legend.
3. **Connect the points** in the 3 sets of data with straight lines of the same colors. This will create **line graphs** which show the changes over time.



Name(s): _____ Per: _____ Date: _____

Model / Presentation / Written Explanation Rubric

Title: _____

Presentation Component	**Maximum Points Possible**	**Self-Score** (fill out before presentation)	**Teacher Score**
Part 1: Content			
Subject and purpose of model clearly introduced	10		
Key concepts identified on model and clearly explained in well-organized way; interactions with other organisms including humans shown	10		
Ideas supported by examples, data, graphs, etc.; All information accurate and obtained from reliable sources	10		
Conclusion summarizes key points in persuasive way; Questions answered thoroughly and accurately	10		
Part 2: Delivery / Audience Engagement			
Speech delivered clearly at appropriate volume and speed (not too fast, slow, loud, or soft)	5		
Speed, volume, and voice inflection are varied to engage audience and emphasize key points	5		
Speaker connects with audience through eye contact and does not spend too much time looking at notes or screen	5		
Speaker demonstrates enthusiasm for topic throughout presentation; audience is persuaded by speaker	5		
Part 3: Visuals			
Visuals help to clearly explain concepts	10		
Model contains clear labels, as necessary	10		
Part 4: Written Explanation / Writing Conventions			
Written explanation of model is well written, organized, and easy to understand	10		
Grammatical and spelling conventions followed in written materials and in model	10		
TOTALS:	**100**		

Teacher comments: