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Webinar Information: Please visit our News Spotlight for information about our Climate Change curriculum Webinar.

The Center for Essential Science (CES) is a research center committed to developing and evaluating educational materials for K–12 students that focus on some of the most pressing environmental issues of our time. Directed by Dr. Nancy Butler Songer, the center develops age-appropriate visualization and modeling tools, curricular units, and assessment instruments that serve as foundational, empirically based information on teaching and learning about the impacts of global climate change.

The Center brings together local and national partnerships, including a longitudinal collaboration with the Detroit Public Schools and partners in rural and small city schools in Michigan, Kansas, and North Carolina. CES is headquartered at the School of Education at the University of Michigan. Collaborating research partners include the Animal Diversity Web of the Museum of Zoology and the Department of Ecology and Evolutionary Biology at the University of Michigan, and the Lifemapper Project of the Biodiversity Institute, University of Kansas.
Welcome to the Critter Catalog!

Here is information about many common animals found in Michigan, and a few that live in other places. You could find many of these animals in or around your schoolyard. Remember that this is just a little bit of animal biodiversity. There are many many other kinds of animals in other places. If you want to learn about animals that don’t live in southeast Michigan, you can go to the Animal Diversity Web.

Mammals, birds, reptiles, amphibians, and fish are all vertebrates - they have a 'spinal column' made up of many bones.

While vertebrates are more familiar to most people, there are many, many more species of invertebrates. In Michigan alone there...
Projects

In education, there is an urgent need to build a solid, research-based foundation about a new and essential focus area within pre-college science education: students’ complex inquiry reasoning about the ecological impacts of global climate change. The Change Thinking for Global Science: Fostering and Evaluating the Ecological Impacts of Climate Change project serves as the major research vehicle for research questions in several interrelated areas. The research design involves a series of quasi-experimental studies that will complement each other and provide multiple lenses for understanding complex questions about learning. Our research questions are:

1. Which scientific content and reasoning skills are essential for 7–10th graders’ complex reasoning and modeling of the ecological impacts of climate change? How are these manifested in content and inquiry reasoning progressions?

2. What dynamic visualization and modeling resources support the development of deep thinking about the ecological impacts of climate change?

3. What scaffolding and instructional activities support the development of deep thinking about the ecological impacts of climate change, including both content (ecological impacts) and complex reasoning components (scientific practices) of this knowledge, within cohorts of 7–10th graders in two new curricular units?
Example Lessons from the *Climate Change and Impacts on Ecosystems* Curriculum

**Middle School:**

Lesson 3: *How does climate limit where your focal species lives?*

Lesson 4: *What is climate change and why does it matter?*

Lesson 7: *How has human activity changed Earth's temperature in the last 150 years?*

**High School:**

Lesson 6: *How do we know that ecosystems change over time?*

Lesson 7: *How has Earth's temperature changed through time?*

Lesson 9: *What is the greenhouse effect and how does it affect Earth's temperature?*

Lesson 13: *What is predicted distribution modeling?*
Welcome to SPECIES!

We would like to welcome you to SPECIES, the online learning environment for the Center for Essential Science’s Climate Change and Impacts on Ecosystems curriculum. As you work through the Learning Sets, you will be introduced to the many different features of this website. In addition to using the online notebook for your activities, you will also be using a number of fun learning resources, including videos, maps and charts, and a species distribution modeling tool.

This website works best in the following browsers: IE8+, Chrome, Safari and Firefox 3.6+.

We are really excited that you will be working with SPECIES, and hope that you have a great time exploring the environment and learning about climate change and climate change impacts.

The ChangeThinking Research Team

This material is based upon work supported by the National Science Foundation under Grant No. 0918590. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.
Lesson 4 Overview

**Driving Question:** What is the difference between weather and climate?

**Learning Goals:**
- Students analyze data to identify patterns of average temperature over the past 180 and 400 years.
- Create a scientific explanation about the difference between weather and climate, for global temperature change, that identifies key processes.
- Students use representations to investigate the impact a degree change in temperature on Earth's processes.

**Total Time:** 220 minutes or approximately 4 class periods

**Lesson Summary:**
Students will understand the difference between weather and climate. They will analyze weather and climate temperature data to learn about trends in temperature. Through a hands-on activity, students will see how small changes in global temperature can potentially have large impacts on the environment.

**Materials:**
- Students Acid Lab Materials
- Water bath, thermometers, and beakers (3)

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**Center for Essential Science**

**ADW Lifemapper**
Part 1. Prediction: Can your focal species live in your state?

Students then construct a justified prediction to answer the scientific question: “Can your focal species live in your state?”

Use information on the habitat conditions that are found throughout the distribution of your focal species to answer the following scientific question: “Can your focal species live in your state?”

**My Prediction**

**Claim:**
Northern flying squirrels can live in Michigan.

Does the distribution of your focal species overlap with any part of your state?

**Evidence:**
1. Average temperatures that northern flying squirrels can survive in are found in Michigan.
2. Average precipitation amounts that northern flying squirrels can survive in are found in Michigan.

Is there distribution of your focal species in your state?

**Distribution Maps**

**Temperature/precipitation and focal species map**
Part 5: Lesson Synthesis

Students construct a justified prediction to summarize their exploration of the question “how will climate change affect my focal species?”

Making a Prediction:

Construct a justified prediction answering the following question:


determine how climate change might impact your focal species:

My Prediction

<table>
<thead>
<tr>
<th>Claim</th>
<th>Reasoning</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, climate change will impact my focal species in future 3.</td>
<td>Climate is predicted to change in the future and the distribution of my focal species will move to cooler/wetter climates and environmental conditions are appropriate for them.</td>
<td>The predicted distribution of my species shows that it will change in the future as climate changes.</td>
</tr>
</tbody>
</table>

- The distribution of my focal species will shift because it is adapted to favor plants that have the ability to grow in drier and more sensitive, high latitude environments, whereas existing conditions will shift right in the future.
- The predicted distribution of my focal species could be shifting, and it could be possible.

LESSON 11: How will climate change affect my focal species?
Part 4: Are there barriers in the future of your species?

Students answer questions about potential habitat barriers that would impede the movement of their focal species to their new distributions under future climate scenarios. They can turn on the land cover layer if they are having trouble seeing potential barriers to dispersal.

Lesson 13 Part 4: Are there barriers in the future of your species?
Next work out on whether there are barriers between where your focal species is found now (the current distribution) and where it might be found in the future (part of the potential future distribution). On the right side a flag widget is also a viewer for your land cover layer. It can help you identify information about it.

- Turn on the land cover layer and compare it to the current distribution of your focal species. Identify any large water bodies, steep terrain, or any other type of landscape that may be limiting the species' movement. Discuss the factors that may influence the species' ability to move to new areas.
- Next turn on the future potential distribution along with the current distribution and the land cover layer. Compare the distributions.
- Are any of the barriers you noted present in both the current and future potential distributions? What barriers will change?
- How might these changes impact the species' ability to disperse and adapt to new environments?
Welcome to SPECIES!

SPECIES is the online learning environment for the Climate Change and Impacts on Ecosystems project. When logged in to SPECIES, students are able to record their learning experiences. As a teacher, you can access any part of the curriculum and student data. There is a feedback section at the end of each page. You will also be given a paper notebook to record your thoughts and write them down.

Thank you for your help! The Climate Change and Impacts on Ecosystems project is funded by the National Science Foundation.

University of Michigan, Ann Arbor
Lesson 13 Part 1: How will climate change affect my focal species?

You looked at predicted distribution modeling using Sasquatch data. Now you are going to explore the impacts of future climate change on your focal species. In a previous activity (Lesson 4) you used abiotic conditions to make a claim about whether your focal species could live in a particular area. In this lesson, you will be able to predict where your focal species could live under different future climate scenarios, where a prey of your focal species could live under different future climate scenarios, and conclude with how habitat impacts where your focal species could be found. You will conclude the lesson by synthesizing all of the information to answer the scientific question, “How will climate change affect my focal species?”

After working with the Sasquatch example from the previous lesson, you will apply your predicted distribution modeling skills to your focal species. You already know the current distribution of your focal species from Lesson 3.

As a refresher, look over the current distribution of your focal species, and the precipitation and temperature layers, to remind yourself of the abiotic conditions that limit where your focal species is found.

Next, you will examine the impacts of the IPCC Climate Scenarios for Futures 1-3 on your focal species and a prey species. We will consider not only how these futures might influence global climate, but also how they might impact the distribution and interactions of species on Earth. The description of the IPCC futures is on page 20 of your student binder.
Black rat snake
Elaphe obsoleta

What do they look like?

The common rat snake is medium-sized, averaging 42-72 inches (106.7-183 cm) in length (Conant and Collins 1998). At the widest point of the snake's body, the average diameter is 1.5 inches (3.8 cm) (Staszko and Walls 1994). Rat snakes are covered with keeled scales. They have a powerful slender body with a wedge-shaped head (Mattison 1990). These snakes come in a variety of subspecies. The black rat snake is the one most commonly found in Michigan.
Lesson 13 Part 2: How will climate change affect my focal species?

- Open the map viewer resource on the right. Turn on the layer for the current distribution of your focal species. Take a look and then turn on the layer for Future 1. Compare the current distribution of your focal species with the predicted distribution under Future 1. Read the description of Future 1 (you learned about this Future in Lesson 8, see page 20 in your student notebook).
Lesson 13 Part 3: Where will the prey of your focal species live under different future climate scenarios?

You have just looked at how three possible future climate scenarios affect the distribution of your focal species. Remember that these scenarios only consider abiotic information, such as temperature and precipitation. Next, look at information on a prey of your focal species and think about how the distribution of that prey species might influence your focal species in the future. Compare the distributions of your focal species and its prey under Future 3 and Future 1.

Refresher: What are prey?

Prey are animals that another animal eats.

Why are prey important for the survival of your focal species?

Northern flying squirrels eat mainly fungi and nuts. They eat eggs and insects sometimes, but I don't think they rely on their prey.

Do you expect the distribution of your focal species to overlap with the distribution of a species that it eats (prey)?

Yes, a predator wouldn't be able
Future Distributions of Focal Species and Prey

- **rat snake (Elaphe obsoleta)**: ON
- **southern red-backed vole (Myodes gapperi)**: ON

Future 1
- **rat snake (Elaphe obsoleta)**: OFF
- **southern red-backed vole (Myodes gapperi)**: OFF

Future 2
- **rat snake (Elaphe obsoleta)**: OFF
Future Distributions of Focal Species and Prey

Species...

- rat snake (Elaphe obsoleta)
- southern red-backed vole (Myodes gapperi)

Future 1

- rat snake (Elaphe obsoleta)
- southern red-backed vole (Myodes gapperi)

Future 2

- rat snake (Elaphe obsoleta)