Lesson Plan: Global Warming

General Description
This activity is designed to expose students to the potential influences of climate change on species physiology, distributions, and interactions within a community. Students explore some of the ecological consequences of global warming by interpreting data sets and answering questions.

Objectives
1. Students will learn how global warming affects physiology, distribution, and phenology of selected organisms.
2. Students will learn the influence of global warming on species interactions within a community.
3. Students will practice interpreting data sets.

Concepts
This activity is integrative, and so discrete concepts are limited to global warming, climate change, and evaluating data.

Time
50 minutes

Prerequisite Skills
None

Materials
Student handouts
Global Warming flow chart overhead
UTI Instructions: Global Warming

**Introduction:**
This activity is designed to familiarize students with the impact that global warming may have on organisms and species interactions within a community. In addition, it provides students with an opportunity to interpret previously collected scientific data.

**Procedure:**
1. Introduce the activity by explaining that several studies suggest that global temperatures are increasing. In the pre-activity worksheet students drew a diagram depicting how an increase in temperatures may influence organisms and species interactions within a community. If students have filled out the worksheet, solicit potential diagrams from the group. Then put up the global warming overhead and discuss how a change in temperature could influence physiology, distribution, phenology, and interactions among species (5 minutes).

2. Have students to form groups of 2-4 to complete the student handout. The student handout has several examples of previously collected data sets. The students should work together within their groups to examine and interpret the data, and answer questions. Circulate throughout the class to answer questions and help students if they are struggling (30 minutes).

3. Use the overhead that you introduced in the beginning of class to lead a summary discussion of the activity. Have a different group report on each of the four data sets (effects on physiology, distribution, phenology, and species interactions) (10 minutes).

4. If instructed by your professor, have students complete the accountability worksheet (5 minutes).
Global Warming
Increasing global mean temperatures

Physiology
Changes in photosynthesis and metabolic rates

Distribution
Shifts in location towards the poles or upwards in elevation

Phenology
Advances in reproductive dates or developmental rates

Species Interactions
Breakdown of predator-prey interactions, mutualisms, competition, and parasitic associations
Pre-Activity Worksheet: Global Warming

General Description
In the activity you will do this week during your learning/discussion group, you will be examining the ecological consequences of climate change on organisms and species interactions within a community. In order to be prepared for this activity, complete this worksheet.

Reading
Browse the “Ecosystems” chapter in your text. Pay particular attention to figure 54.26, and examine also figures 50.5, 50.10, 50.16, and 52.19. Read the section on Human Impact on Ecosystems and the Biosphere beginning on pg. 1214.

Definitions
Write a definition of the following words. Use your text, textbook glossary, and your previous knowledge to create the best definition possible.

1) climate change

2) greenhouse effect

3) phenology

4) species distribution

Questions
Answer the following questions using the figure below. You will explore your answers to these questions in-depth during learning/discussion group.

1) During which century has the greatest change in mean annual surface temperature occurred? How large has this change been? What was the pattern in mean temperature prior to and after that century? Make sure you understand the axes in the figure.

2) These data demonstrate a 0.7°C temperature increase in the most recent century. Will this temperature change have important biological consequences? Defend your answer.

3) Predict how increased temperature will affect an organism’s physiology, distribution, and phenology. Choose any organism, and create a diagram that represents your predictions.
Fig. 1. Reconstruction of Northern hemisphere mean annual surface temperature over the past millennium (AD 1000–1998). Reconstructed temperature (40-year smoothed; solid line), linear trend from AD 1000–1850 (white line), 1902–1980 calibration mean (dashed line), 0.07°C temperature anomaly relative to 1902–1998 calibration mean (dotted line), and two standard errors around the mean (gray area). Reproduced, with permission, from Ref. 1.
Global Warming

In this activity, you will examine the effects of global warming on the physiology, distribution, and phenology of different organisms. Then you will look at how climate change may influence species interactions. For each characteristic, you will make predictions and evaluate data about the ecological consequences of global warming.

Physiology

Some species of reptiles have temperature-dependent sex determination (TSD). In these species whether male or female offspring are produced is determined by the temperature experienced during development rather than genetic differences between the sexes. An increase in temperature would be expected to affect the sex ratio of species with TSD. Examine the figure and answer the questions below:

1. Are more male offspring produced at warmer or cooler temperatures?

2. If global temperatures are increasing will the percentage of males produced increase or decrease?

3. How warm would the mean July temperature need to be for only females to be produced?

4. Climate change models predict that mean July temperatures will increase by 4°C during the next century. If this temperature change occurs, what consequences might these changes have for this painted turtle population?

5. If you examined changes in mean July temperature at this study site only between the years of 1988-1992 would these data support the claim that global temperatures are increasing? Defend your answer in 2-3 sentences.
**Distribution**

Edith’s checkerspot butterflies occur in discrete populations throughout their range and have been the subject of long-term population research studies. Therefore, you can examine how population distribution has changed over time with respect to latitude and altitude. Examine the figure and answer the questions below:

1. What is the relationship between Edith’s checkerspot butterfly population extinction rates and latitude?

2. What is the relationship between Edith’s checkerspot butterfly population extinction rates and altitude?

3. How are Edith’s checkerspot butterfly population distributions changing with respect to both latitude and altitude over time?

4. Why might some species be more likely to show change in population distributions than other types of species? What types of species are likely to be strongly influenced by global warming in terms of species distributions? Defend your answer in 3-4 sentences.
Phenology
Global warming may also affect the phenology of organisms. One important aspect of organism phenology is when to begin breeding. Examine the figures and answer the questions below:

1. Describe the relationship between winter weather and the timing of breeding in amphibians and birds.

2. Are some measures of breeding time more convincing than others? If so, are these measures more or less closely matched with changes in NAO?
1. Describe how first flowering dates (FFD) have changed during the past decade with respect to the mean FFD during 1954-1990.

2. An additional finding of this study is that plant species pollinated by insects have an earlier FFD than plants that are wind pollinated. Do you think that species pollinated by insects might be more likely to show changes in FFD than those pollinated by wind? Defend your answer in 2-3 sentences.
Species Interactions
Great European Tits are dependent on high abundance of caterpillar larvae during the breeding season because caterpillars are the primary source of food for their nestling offspring. Examine the figures and answer the questions below:

1. What is the relationship between temperature and peak caterpillar abundance?

2. How does bird laying date change over time?

3. How does caterpillar peak abundance date change over time?

4. Draw a picture that depicts the relationship between bird laying date and peak caterpillar abundance date over time.

5. Describe how the relationship between bird laying date and peak caterpillar abundance date probably influences nestling survival rates. Defend your answer in 2-3 sentences.
Individual Accountability: Global Warming

Demonstrate your new understanding of the ecological consequences of climate change by answering the following question:

Describe the ecological consequences of changes in distribution and physiology on species interactions, similar to what you examined for phenology. Treat distribution and physiology separately. Defend your answer in five or six sentences.