

Why fly south?

How climate change alters the phenology of plants and animals

Overview

The timing of recurring life cycle events for plants and animals, like flowering and migration, are largely determined by cues organisms take from the climate. Scientists who study phenology, or the timing of these natural events, are interested in how climate change, particularly rising global temperatures and unpredictable transitions between seasons, will influence the timing of phenological events. For example, what can we expect to happen to the migration timing of birds, the mating season for animals, or the flowering times in plants? Further, how might abiotic seasonal changes like melt dates for lakes and rivers respond to climate change? To answer these questions, scientists turn to long-term datasets to examine whether shifts in phenological events are occurring over extended periods of time.

Long-term datasets are extremely useful because scientists can examine average trends in timing shifts over periods of decades and often in different regions. Citizen science has played a major role in curating many of these datasets. Citizen science is essentially research conducted by “crowdsourcing” – individuals collect data and contribute to a large dataset that can then be analyzed to address scientific questions. Phenology data is easy to collect and involves observations that we make every day, but hardly ever record. Technology makes it extremely easy to record, aggregate, and store citizen science data online for future use.

In this lesson we will use a few of these datasets to go through the scientific process of forming and testing hypotheses using real data. Students will be able to examine changes in phenology over 30+ year timespans, and address the scientific question, “*Do we see evidence for climate change in the phenology of plants and animals?*” We will also discuss how students as a class can start curating their own long-term phenological datasets by observing organisms in your schoolyard or BEST Plots!

Objectives

At the conclusion of the lesson, students will be able to:

- Define phenology and give examples in plants and animals
- Graph phenology data
- Interpret results from a graph
- Make claims about organismal responses to climate change
- Identify locations where they can submit citizen science data they collect

Length of Lesson

The lesson introducing the topic of phenology can be completed in 30 minutes. Graphing exercises for phenology data can occur in a 30-minute period per graph, or can serve as point of discussion at the beginning of class periods to further students’ abilities to interpret graphs. Phenology data can be collected long term over many years.

Grade Levels

When including the graphing exercises, this lesson is most appropriate for grades 6-12. However, the lesson could be modified to accommodate elementary students if, instead of graphing the data provided, students were brought outside to make phenology observations of their own.

Standards covered

E.ES.07.71 Compare and contrast the difference and relationship between climate and weather.

K-7 Standard S.IP: *Develop an understanding that scientific inquiry and reasoning involves observing, questioning, investigating, recording, and developing solutions to problems*

S.IP.00.11 Make purposeful observation of the natural world using the appropriate senses.

S.IP.00.13 Plan and conduct simple investigations.

S.IP.00.16 Construct simple charts from data and observations.

K-7 Standard S.IA: *Develop an understanding that scientific inquiry and investigations require analysis and communication of findings, using appropriate technology.*

S.IA.00.12 Share ideas about science through purposeful conversation.

S.IA.00.13 Communicate and present findings of observations.

S.IA.00.14 Develop strategies for information gathering (ask an expert, use a book, make observations, conduct simple investigations, and watch a video).

K-7 Standard S.RS: *Develop an understanding that claims and evidence for their scientific merit should be analyzed. Understand how scientists decide what constitutes scientific knowledge. Develop an understanding of the importance of reflection on scientific knowledge and its application to new situations to better understand the role of science in society and technology*

S.RS.00.11 Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.

S.RS.07.11 Evaluate the strengths and weaknesses of claims, arguments, and data. Describe limitations in personal and scientific knowledge.

S.RS.07.12 Describe limitations in personal and scientific knowledge.

S.RS.07.13 Identify the need for evidence in making scientific decisions. Evaluate scientific explanations based on current evidence and scientific principles.

S.RS.07.14 Evaluate scientific explanations based on current evidence and scientific principles.

S.RS.07.15 Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.

Materials

- Climate change and phenology PowerPoint
- Student Worksheet
- Graphing materials:
 - Straight edge
 - Colored pencils

Background

Weather is how our atmosphere behaves over a short period of time, whereas climate is the average of daily weather over long periods of time (e.g., 30 or more years); therefore, when we discuss climate change, we need long-term datasets. Earth's temperature is regulated by the greenhouse effect: gasses in the atmosphere (e.g., water vapor, carbon dioxide, methane, nitrous oxide, and ozone) capture heat before it is radiated back into space. Without this very important phenomenon Earth would be approximately 60°F cooler on average.

Because climate changes slowly and occurs over such long timescales, populations of plants and animals in a geographic region are adapted to the climatic conditions they have experienced in the past. Our climate today, however, is changing rapidly. Since the Industrial Revolution the amount of carbon dioxide (CO₂) in the atmosphere has increased by 30%. Climatologists estimate that this dramatic increase in CO₂ may ultimately result in a 2 to 7°F increase in the average global temperature. This rate of change is significantly more rapid than most temperature changes climatologists have examined in geological history.

Using citizen science data, we can ask the scientific question: *“Do we see evidence for climate change in the timing of phenological events of plants and animals?”*

Activities of the session

1. Begin the lesson with a discussion of climate change (see Background Information, and Climate Change FAQ document in Resources). As a class, discuss the following questions: What effects will this have on our seasons? What about the life cycles of plants and animals?
2. Introduce the topic of phenology - the study of periodic plant and animal life cycle events and how these are influenced by seasonal changes and variations in climate.
3. Discuss examples of phenology changes and ask students if they have any observations of phenology changes during their lifetime, or large phenology events that stand out to them:
 - a. Lowell Cemetery – for background information, see link in Resources section
 - b. Lake Mendota – data on duration of ice cover
4. Now that we understand how our climate is changing, and how this alters the timing of life events for plants and animals, discuss as a class how you think these changes could affect communities of plants and animals. What if all species in an ecosystem do not shift their phenologies the same way?
 - a. An example of this could be flowering plants and their pollinators. What if plants begin to flower earlier, but pollinators are not yet there to pollinate them? What would this do to our fruit crops?
 - b. Phenology mismatch occurs for migrating birds, and may be one of the major drivers of their decline. One reason for this mismatch is that our all regions of our planet are not warming at the same rate or magnitude. For example, temperatures warm more at the poles than near the equator. As birds migrate earlier from their northern latitudes, food sources they rely on for the journey may not be available at this earlier time.
5. Discuss citizen science datasets and how they are a great way to accumulate the vast amounts of long-term needed to address the impacts of climate change on phenology.
6. Begin phenology-plotting activities.
 - a. **First bloom date for North American lilac shrubs:** The data table below displays the yearly first bloom date (given as day of year) for lilac shrubs (i.e., *Syringa chinensis* clone) for two regions:
 - i. NE = Northeast (average day each year from Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, and New York)
 - ii. LMW = Lower Midwest (average day each year from Kansas and Nebraska)

The data record spans from 1961-2003, and every other year is displayed in the table on the worksheet.

- iii. Plot the data for the northeastern states (NE) in graph 1.
 - iv. Plot the data for the lower Midwestern states (LMW) in graph 2.
 - v. Using a straight edge, estimate and draw a linear trend line that best fits the data in the graphs.
 - vi. Discuss the findings on the graph:
 1. Is the yearly first bloom date for lilac shrubs changing over time?
 2. Does the trend differ between regions? If yes, then describe the difference(s) you see.
 3. Would you draw the same conclusions if you just looked at a period of 5 years, for example, 1980 – 1985?
 4. Why might the yearly first bloom date for lilac shrubs be changing over time?
 5. Do you think this might have implications for other organisms like birds or insects?
- b. **Ice cover duration on Gull Lake:** The data table on the worksheet shows the number of consecutive days that Gull Lake, in Michigan, was fully covered in ice from 1925-2011.
- i. Create a line graph (i.e., plot the data and connect the data points with a line) of the ice cover data from the table on the worksheet.
 - ii. Discuss the findings on the graph:
 1. After graphing the ice cover data for Gull Lake, what might you conclude about how the duration of ice cover is changing over time?
 2. What implications might this have for humans and other organisms that use or live in this lake?
7. Complete the class with a discussion of the citizen science data that can be collected in your schoolyard, using apps that access data recorded by other citizens, or a long-term dataset that can be started for your own school to use for years to come. Ask students, what are some of the phenology measurements that students think could be made in your schoolyard? In their backyards?

Resources

- Climate Change FAQ: <https://www2.ucar.edu/climate/faq#t2506n1342>
- Lowell Cemetery Article “Springing Forward”:
<http://www.sciencenewsforkids.org/2009/04/springing-forward-2/>
- Build your own phenology garden: <http://highlandspenologygarden.org>
- Phenology datasets available online:
 - Full lilac dataset: ftp://ftp.ncdc.noaa.gov/pub/data/paleo/phenology/north_america_lilac.txt
 - Full Gull Lake ice duration dataset:
http://www.kbs.msu.edu/images/stories/docs/K12/TotalIceCoverFile_v_teacher.xls
 - Nature's Notebook, a national plant and animal phenology observation program, where students can contribute their phenology data: <http://www.usanpn.org/participate/observe>
 - Nature's Notebook Phenology Visualization Tool:
<http://www.usanpn.org/results/visualizations>
 - ebird.org
 - hummingbirds.net
- Citizen Science apps for cellphones and tablets:
 - Climate Watch – record phenology data for plants and animals
 - iNaturalist – record wildlife observations and contribute to an online network of naturalists
 - Birdlog – transfer your bird sightings to Cornell’s eBird database
 - Project Noah – share wildlife encounters and record Earth’s biodiversity

Extensions and Modifications

This lesson could be extended in many ways. You may want to take your classes outside to explore different phenology recordings that they could make around your schoolyard. There could be a period for journaling and observation as they record different phenological states that plants and animals are in on the day of the lesson.

A further modification for schools with access to iPads and other tablets/phones, would be to download some of the Eco-Apps that allow students to record observations. For a class project, students could use these apps and then go into the larger pool of data to make a graph and address a scientific question.

Assessment

Teachers can assess understanding by reading over student answers on the worksheet, and looking at graphs. Graphs should clearly portray the data and responses to questions should indicate an understanding of the link between climate change and changes in the timing of life events for plants and animals.