Phenology of Blueberries: How does Plant Data Reflect Climate Changes?

Lesson Plan for Secondary Science Teachers

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I. Overview:

Phenology is the study of the timing of plant and animal life cycle events and how these events are influenced by variation in the environment, such as temperature. Using historical data on the timing of various life cycle events of plants in a specific region, such as flowering date, can therefore give us valuable data about the temperature trends in that area, which we can then use to make predictions about what changes in various organisms' life cycles may occur in the future.

Because of the long-term nature of the data required to carry out a phenological study, sharing data is an integral part of this field. Many internet resources to this effect exist, and are continuously added to by "citizen scientists" who upload their small portion of data to contribute to the larger dataset. This data is then collected by organizations such as the USA National Phenology Network and made available to the public.

In this lesson, we will be using data collected by writer Henry David Thoreau (from 1852-1858), and botanist Alfred Hosmer (1878, 1888-1902) to examine the changes in the flowering date of Highbush and/or Lowbush Blueberries. As the distribution of plants is highly variable on school campuses, it may be that a different species will be a better fit for you. If this is the case, the original data set, comprising many additional species, can be found on the USANPN website.

To find this data set, navigate to the URL listed under "Resources," or follow these instructions in your own browser.

First, go to USANPN[dot]org. From there, highlight the "Get Data" menu, click on "Data Search Tools," and then select "USA-NPN Dataset Search Tool." The dataset I used was called "Plant flowering dates in Concord, MA, first collected by Henry David Thoreau," though there are many available if you want to look through them.

To register to submit data, click on "Nature's Notebook Home" at the top of any page, then click "Log In" in the upper right corner, and then select the "Join Nature's Notebook" tab.

Through this lesson, students will be introduced to phenology, and go out onto their school campus to monitor the progress of the blueberries and record their flowering date for that year. Students will then use this data to compare it to the flowering dates in Thoreau and Hosmer's time, which should be considerably different. This data can then be used to address the questions, "Can phenology of plants and animals be used as evidence for climate change?" and "How will climate change affect the life cycles of plants and animals?"

II. Lesson Layout:

Length of Lesson:

2 – 90 minute blocks

Additional Resources:

https://www.usanpn.org/node/2177

Learning Objectives

As a result of this lesson, students will be able to:

- Define phenology and give examples of its uses
- Describe the correlation between changes in life cycle events and global warming
- Predict the effect of further warming on the life cycle events of plants and animals
- Identify at least one location where they may contribute their own citizen science data

Language Objective

Students will describe, in writing, their observations about the impact of climate change on the life-cycle events of plants

Students will write a prediction about what impact further climate change may have on ecosystems

Materials

Thoreau PowerPoint
Blueberry Life Stage Key
Worksheet
Graph Paper
Global Temperature Graph

Standards Covered

Next Generation Science Standards:
- HS-ESS3-5
- HS-LS2-6

NGSS Crosscutting Concepts Addressed

Cause and Effect
Stability and Change
Systems and System Models

Key Vocabulary (emphasized)

Phenology
Life-cycle event
Climate Change

Lesson Sequence

Begin day 1 with a warm up activity:
- Students Think, Pair, Share on the question: How do plants know when they should flower?
- Class should come up with a working definition of phenology, so give them the vocabulary word

Introduce Henry David Thoreau
- Use the short PowerPoint included with this exercise to give the background story of Thoreau, focusing on his work at Walden Pond and his efforts to record his observations

Introduce "Citizen Scientists"
- Show class USAPN site's "Nature's Notebook" section and describe how the data is added

Examine Blueberries
- Take students out to a pre-identified location on the school campus where blueberries are present (If blueberries are not present on the school's campus, many other species were observed by Thoreau, the data will need to be adjusted on the included worksheet)

  Using a life-stage key, students should work together to identify the life stages present on as many blueberry bushes as possible

Enter Data

Return to the classroom and enter the data onto the USAPN website (USANPN[dot]org - Registration is required)

Day 1 Wrap Up:

Exit Slip: Give an example of at least one way that phenology data could be used.

Day 2 Warm UP:

Students Think, Pair, Share on the question: What happens to plant and animal life cycles if there is too much variation in the seasonal temperature?

Use Worksheet

Students will compare the trend of first flowering date to the trend of increasing global temperatures by graphing flowering dates and comparing them to the average temperature graph

If a student found a plant with a flower on the previous day, use this as this year's flowering date, if not, find a first flowering date from your area from the prior year online

Students make predictions about what the temperature trends have been based on the flowering data

Students then use recent temperature data (from the graph provided) to predict future trends in flowering dates, including what impact these trends will have on the plants, and the wider ecosystem

Day 2 Wrap Up:

Exit slip: As climate change continues on it's current trend, what impact do you think this will have on the life cycle events of plants and animals?

Assessment

Each "Warm Up" activity can serve as a formative assessment of students current thinking, and can be used to modify future lessons in order to address any misconceptions that may become evident.

Each "Wrap Up" activity can also serve as a formative assessment in order to monitor how students' thinking is impacted by each lesson, and can be used to track their progress.

The worksheet included in this lesson can serve as an assessment of students' ability to both produce and interpret graphs, as well as their ability to describe the connections and trends that they discern.

Extensions and Modifications

Extensions:

Students can record phenological data pertaining to a number of species on campus, upload them to a citizen science website, and use the data to examine trends in the ecosystem around them.

Students can also set up a long-term data set to be continued by future students who consistently record data from the same plants and areas.

For ESL students:

For students who are in the process of learning English, it would be helpful to provide them with translations of difficult words in their native language.

In addition, pairing them with another student will be mutually beneficial, as the ESL student will benefit from having assistance with the reading portions, and the native English speaking student will benefit from assisting a peer

For IEP students:

Assistance for students with an IEP for literacy difficulties should be paired with another student who can help them with both the reading and the graphing activities.

Assistance for students with an IEP for writing difficulties should, depending on their needs, either be given additional time to complete the activities, or be given the opportunity to respond orally to the prompts

Name:_____ Date:_____

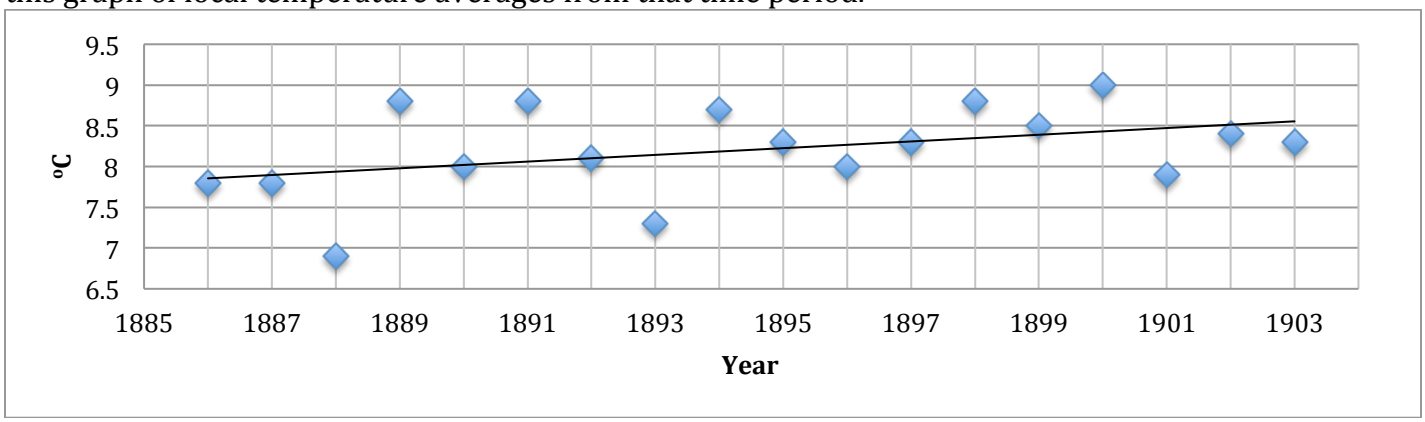
Blueberry Phenology

Blueberry phenological data has been collected since Thoreau's Walden Pond Experiment. This data was collected in part by Thoreau, and in part by botanist Alfred Hosmer, but all at Concord, Massachusetts. The flowering date was recorded as the number of days after December 31st of the previous year. (For example, January 1st would be recorded as 1 day after December 31st, and so on.)

1) Graph this data on the accompanying sheet of graphing paper, being sure to use appropriate scale.

Year	Flowering Date
1852	141
1854	135
1855	134
1856	138
1857	138
1858	135
1878	134
1889	125
1890	131
1891	122
1892	129
1894	125
1895	132
1896	130
1897	122
1898	121
1899	127
1901	128

2) Now that you have a visual representation of the flowering data from this time period, compare it to this graph of local temperature averages from that time period.



Each diamond represents an annual average, while the solid line represents a general trend.

What connections do you see between the trends of the flowering dates and the trends of the temperature data?

3) Based on the connections between the two graphs, as well as the data you recorded in the field, what do you think the average temperature graph would look like if it was extended to present day? You may describe or draw your prediction.

4) Looking to the future, what do you expect to happen to the flowering dates of these plants? Do you think the effects on the ecosystem will be positive or negative? Explain your thinking.

Growth stages table

Dormant or tight bud	Bud swell	Early green tip
		
Plant part: Flower bud. **Description:** No visible swelling of the fruit buds. Bud scales tightly closed. No visible signs of growth.	**Plant part:** Flower bud. **Description:** First sign of growth as plant growth begins in the spring. Visible swelling of the flower buds; outer bud scales begin to separate at the tip revealing paler interior bud scales. This bud stage can usually tolerate cold temperatures of 10 to 15°F (-12 to -9°C).	**Plant part:** Leaf bud. **Description:** Bud scales are separating at leaf bud tips. Green leaf tissue is emerging from the leaf bud tips. From 1/16 to 3/16 inch (2 to 5 mm) of green tissue is exposed. Leaves are tightly rolled.

Bud break or bud burst	Late green tip	Tight cluster
		
Plant part: Flower bud. **Description:** Flower buds open and the individual flowers can be seen between the bud scales. Can tolerate cold temperatures of about 20°F (-7°C).	**Plant part:** Leaf bud. **Description:** Leaves are beginning to unfold. More green leaf tissue is visible, ¼ to ½ inch (6 – 13 mm). This stage generally occurs around flower bud burst.	**Plant part:** Flower. **Description:** Individual flowers are distinguishable in the flower cluster. This bud stage can tolerate 20 to 23°F (-7 to -5°C).

Shoot expansion	Early pink bud	Late pink bud
		
Plant part: Shoot expansion. **Description:** Multiple leaves have emerged from the vegetative buds and unfolded. Leaves are enlarging and shoot growth has begun.	**Plant part:** Flower. **Description:** Expanding flowers are readily visible and have separated. The pink corolla tubes (petals) are short and closed. This bud stage can tolerate 23 to 25°F (-5 to -4°C).	**Plant part:** Flower. **Description:** Individual flowers fully developed. Expanded corollas are now white but still closed. This bud stage can tolerate 24 to 27°F (-4.4 to -2.8°C).

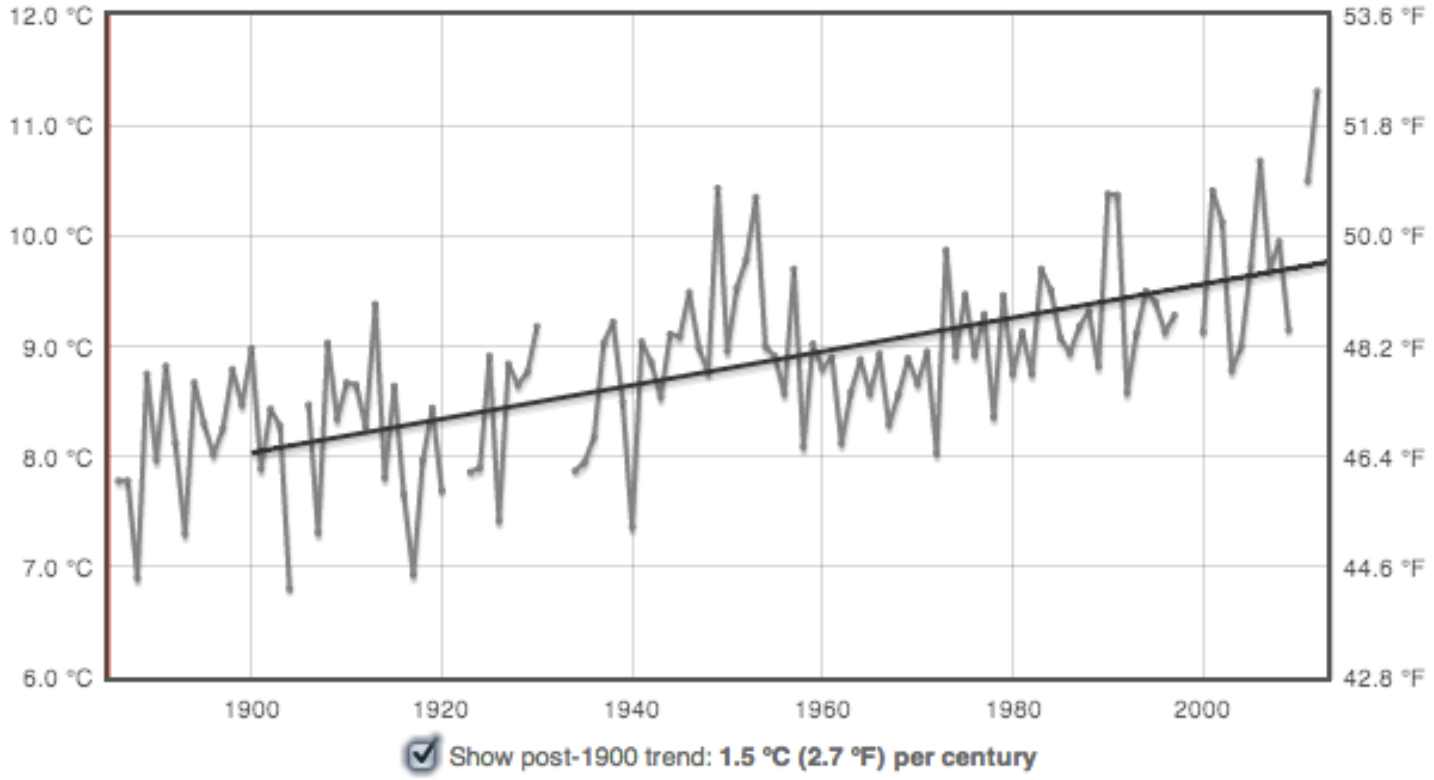
Early bloom	Full bloom	Petal fall
		
Plant part: Flower. **Description:** Some of the corollas are completely expanded and open. Many flowers are still closed. The bloom stages can tolerate 25 to 28°F (-4 to -2.2°C).	**Plant part:** Flower. **Description:** Most of the flowers on the bush have opened. The bloom stages can tolerate 28° F (-2.2°C).	**Plant part:** Flower. **Description:** The corolla tubes are falling off the flowers, revealing small green fruit. This is the most vulnerable stage to freeze injury. Damage can occur at 32°F (0°C).

Early green fruit	Late green fruit	Shoot tip set; end of shoot growth
		
Plant part: Flower. **Description:** Small green berries are expanding. Fruit in the cluster varies from large to small pea-sized. Early fruit growth is by cell division.	**Plant part:** Fruit. **Description:** Growth of large fruit slows. Fruit becomes pale green. Exposed fruit may develop a red blush.	**Plant part:** Shoot. **Description:** Shoot tips die and shoot growth stops. No new small leaves can be seen emerging from the shoot tip. The dead shoot tip may be visible as a small dead leaf at the base of the last leaf on the shoot. In Michigan, there is typically one flush of growth in the spring, which ends before harvest. After harvest, some shoots will start growing again, for a second or third growth flush. These later growth flushes usually occur with moist soil conditions and moderate temperatures.
Fruit coloring	**10% Blue**	**25% Blue**
		
Plant part: Fruit. **Description:** Oldest, largest fruit in the cluster begin to change color from green to pink to blue. Fruit begins to soften. Cell division has stopped and fruit growth is by cell expansion.	**Plant part**: Fruit. **Description:** Single berries in the fruit clusters are ripe and ready to harvest. About ten percent of the fruits, on a bush or in the field, are ready to harvest. This stage is often used to begin the preharvest fungicides for fruit rots.	**Plant part:** Fruit. **Description:** 25 percent of the berries are ripe. 25% blue often coincides with first hand harvest of ripe berries.

75% Blue	Fruit bud set	Fall color
		
Plant part: Fruit. **Description:** Blueberries are picked several times as the fruit ripens with 2 to 5 pickings. Often the first harvest is by hand and then later by machines that shake berries off the bush. 75% blue often coincides with the first of 2 machine harvests in the field.	**Plant part:** Shoot. **Description:** After harvest the blueberry bush stores reserves for next year's growth. Shoot growth may begin again. Flower buds for next year's crop form in September and October. These flower buds form first at the shoot tips. These large, clearly visible buds can be used to estimate next year's crop potential.	**Plant part:** Shoot. **Description:** At the end of the growing season, the leaves change color as nutrients are mobilized back into the shoots for growth next spring.

Tables accessed at: http://blueberries[dot]msu.edu/growing_blueberries/growth_stages_table

V. Long-Term Local Temperature Graph



Graph obtained from:
http://www.wunderground.com/climate/local.html?id=42500190736&var=TAVG&MR=1