LESSON 12: CITIZEN SCIENCE TO THE RESCUE!
Trends in Spring Arrival Using Project BudBurst

PURPOSE/QUESTION
Students will collect and record data on plant phenology, add their data to the Project BudBurst database, and compare their results to satellite observations.

GRADE LEVEL
9-12

TIME TO COMPLETE
2- 50 minute time periods for introduction then additional time for ongoing data collection and analysis

STANDARDS
See appendix below-page 8

LEARNING OUTCOMES
- Students will understand what an indicator species is.
- Students will add to growing body of scientific knowledge.
- Students will consider the advantages and limitations of direct observations versus satellite-based observations.

STUDENT OBJECTIVES
- Learn basic phenology
- Observe and record local phenological data.
- Understand the importance of collecting phenological data in relationship to climate change.

TEACHER BACKGROUND
Phenology is the study of regularly occurring biological phenomena such as animal migrations or plant budding, especially influenced by climatic conditions. Students need to know what an "indicator species" is and what it tells us. An "indicator species" is a plant or animal that responds to a particular trait in its environment. For example, plant growth may be triggered by temperature, day length, precipitation levels, or freeze-thaw cycles. The species targeted in Project BudBurst are those that respond to temperature to trigger phenological events. Some of the indicator species on the Project Budburst website are lilacs, goldenrod, butterfly milkweed. A common fall species along fencerows, abandoned lots, edges, etc is Goldenrod *Solidago canadensis.* This would be ideal to observe in August or early September. On this day you will begin or continue data collection. The timeline can be adjusted due to weather or extent of previous budburst use by a particular class.

PREREQUISITES
- Skill at making detailed observations
- How to label a scientific sketch – found in the ***Rubrics*** folder

MATERIALS & TOOLS
- Access to Excel or graph paper
- Field Notebooks
- Digital camera
- Field Guides or printable field guides found on the BudBurst Website

VOCABULARY
- Indicator species
- phenophase including first leaf, all leaves unfolded, first flower, full flower, end of flowering, first ripe fruit, 50% color, and 50% leaf fall

LESSON LINKS
- Generic Field Journal (student observation form)
- Project Budburst Website

Photo credit: Norman G. Flaigg, Blackfoot Daisy, 2002, Ladybird Johnson Wildflower Center

REFERENCES
Adapted from Chicago Botanic Garden Climate Change Education

ESSENTIAL QUESTIONS DAY 1

1. What other indicator species would you add?
2. Why did you choose those species?

Photo credit: Norman G. Flaigg, Eastern Redbud seed, 1998, Ladybird Johnson Wildflower Center

Photo credit: Julie Makin, Eastern Redbud first bloom, 2011, Ladybird Johnson Wildflower Center

Photo credit: Sally and Andy Wasowski, Aloe Yucca, 1991, Ladybird Johnson Wildflower Center

PROCEDURE DAY 1

1. Ask students how they think plants know when to start growing in the spring. Write student answers on the board. Explain that different species react to different environmental stimuli and that some react to temperature, day length, precipitation levels, and freeze/thaw cycles.

2. Introduce the idea of an indicator species and ask students how they think researching indicator species can help us understand climate change. Refer to essential questions 1 and 2.

3. Describe project BudBurst to students. Project BudBurst is a national database where citizen-scientists (including students) collect data on the phenology of plants. Phenology is the study of timing in living things, and BudBurst phenology data includes: first leaf, first flower, full flower, first fruit, and senescence. Since BudBurst looks for connections between phenology and climate change, BudBurst indicator species are generally plants that respond to temperature for their growth cues.

4. Have students research indicator species and choose species to analyze using budburst site either at home or on school property as a class using budburst site. You may want to provide students with a list of species that were historically collected from Concord, Massachusetts and the Cook Country Forest Preserve to choose from. Be sure that at least some of the plants chosen are in these data sets.

5. Research and prepare for phenological observations of chosen species.

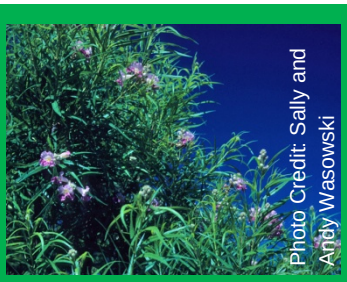
6. As a class define criteria for life cycle stage chosen, etc.

7. Hand out the field guide criteria and student worksheet so students know what they should be collecting.

8. Look at the Budburst website so students are familiar with what they will be entering in the database. Hand out field guides.

ESSENTIAL QUESTIONS DAY 2

1. Are your observations consistent with the results reported by other observers near where your school is located? Why or why not?
2. Any surprise results?
3. How would you explain these results?



4. Are the BudBurst observations consistent with the satellite observations of the fraction of photosnythetically active radiation? Why or why not?
5. What are the advantages and limitations of the BudBurst data as compared to the satellite observations? Which approach provides a more precise measurement of when spring arrives in your location? Which approach is more useful for evaluating broader spatial patterns in the arrival of spring?

PROCEDURE DAY 2

1. Go outside and collect data on indicator species. Students should take notes and pictures of the following events as they occur:

First Leaf	All Leaves Unfolded	First Flower	Full Flower
End of Flowering	First Ripe Fruit	50% Color	50% Leaf Fall

2. Have a class discussion about findings. Check the level of detail in students' field notebooks. Once approved by teacher upload student data on Budburst website: http://neoninc.org/budburst/getstarted.php
3. As a class look at the Budburst website for the results of the observations made in your state and/or specific location. http://neoninc.org/budburst/results.php. Are the results consistent with the results where your school is located? Any surprise results? How would you explain these results?
4. Now, let's compare the Project Budburst data to satellite observations of how much radiation is being absorbed by photosynthesis, which is a good indicator of how much vegetation is present in a location.
    a. Go to the data section of the Project Budburst website (http://neoninc.org/budburst/results_data.php) and download the 2009 Excel spreadsheet.
    b. Sort the spreadsheet so that all the "BudBurst/First Leaf" entries are at the top. Then sort by latitude (treating all entries as numbers). (Select all; click on custom sort; sort by "Phenophase", then sort by "Latitude".) This will make it easier to see when plants started to have leaves.
    c. Pick three locations at different latitudes (e.g., Texas, Colorado, and Montana). For each location, find the dates that deciduous trees had their first leaf. You may need to use your field guide to determine which species are deciduous trees. Write the dates in your notebook.
    d. Now, go to the My NASA Data Live Access Server (Advanced Edition). Click on the ***Choose Dataset*** button. Then choose ***Biosphere*** > ***Monthly Fractional absorbed Photosynthetically Active Radiation (MISR)***. A map will automatically appear.
    e. Use the small map to select a box encompassing the continental United States. Select the date ***Feb 2009***. Then click ***Update Plot***. A new map will be generated.
    f. Click the ***Compare*** button. A new window will pop up with 4 identical maps. Under each map you can select the month and year. Change the months, so that you can see ***Feb, Mar, Apr, and May of 2009***. Then click ***Update Plots.*** In order to compare the four resulting maps, we need to make sure they all have the same color bar. Click ***Plot Options*** then enter the following in the spot for "Color Fill Levels: (-inf)(0.05, 0.6, 0.05)(inf). Click ***OK*** and the maps will be automatically redrawn.
    g. Print out these maps and compare the maps to the dates of BudBurst/First Leaf at the three locations you selected.

NOTE: Lesson could be adapted for other seasons. For example, students could look at the 50% Leaf Fall data from BudBurst and the Sep, Oct, Nov, and Dec maps of PAR.

ESSENTIAL QUESTIONS – ONGOING

1. Are the results consistent with the results where your school is located?
2. Any surprise results?
3. How would you explain these results?


Photo credit: Joseph A. Marcus

PROCEDURE- ONGOING

1. Have students collect data on their chosen species throughout the growing season, making observations at least weekly during the fall and spring. Students should take notes and pictures of the following events as they occur:

First Leaf	All Leaves Unfolded	First Flower	Full Flower
End of Flowering	First Ripe Fruit	50% Color	50% Leaf Fall

2. Have a class discussion about findings. Check the level of detail in students' field notebooks. Once approved by teacher upload student data on Budburst website: http://neoninc.org/budburst/mybudburst.php

3. As a class look at the Budburst website for the observations results made in the most recent calendar year. http://neoninc.org/budburst/results.php.

Project BudBurst Timing is everything!
A National Phenology and Climate Change Field Campaign for Citizen Scientists

TOOLS FOR ASSESSMENT

- Generic Field Journal
- Concept Quiz – found on pg. 11
- Essay – found on pg. 14
- Foldables®
- Science Notebook and Student Reading Assessment Tool – found in the ***Rubrics*** folder

WEBSITES FOR FURTHER LEARNING

- **Historical data from Concord, MA dating back to the 1850's – found in the folder for this lesson**
- **EEK! Phenology**
- **National Phenology Network-Cloned Plants Project**

STUDENT READING RESOURCES

- Phenology and Climate Change
- Climate Change Could Severely Impact California's Unique Native Plants
- Plant's Internal Clock Can Improve Climate Change Models
- Will Plants and Pollinators Get Out of Sync?
- Climate Change Opens New Avenue for Spread of Invasive Species
- Drought Slows Plant Growth, 2000-2009

LESSON 12-APPENDIX

Tech Tips for Eco-Schools USA Climate Change Connections Curriculum

How do I import data into an Excel spreadsheet?

1. Access data from My NASA Data:
    a. Once you have all the parameters set for your desired data set (and have clicked "Update Plot" to have your preferences processed), click the "Show Values" button. A new window will pop up with a Table of Values.
    b. The first several lines of the Table will provide information that describes the data set, often called "metadata", such as the name of the variable, what subset of the data is included in the file, and what time range. Make sure to keep this metadata with the rest of the data when you copy it into Excel. This way you'll be able to easily keep track of which data you have!
2. Copy the data from the browser (note that these instructions are for Internet Explorer running on a PC, and may need to be modified for other platforms):
    a. In this new window, select all. You can do this by clicking anywhere in the window and then typing "Ctrl-A". Or you can right-click in the window, which will pop up a menu, and then choosing "Select All" from the options.
    b. Next, copy this data. Again there are two options. You can use the keyboard shortcuts, and type "Ctrl-C". Or you can right-click and choose "Copy" from the pop-up menu.
3. Paste the data into Excel:
    a. Now open your Excel worksheet and go to the tab where you want to put the raw data. Click in the A1 cell.
    b. Paste the data, either by typing "Ctrl-V", by clicking "Paste" (located at the left under the "Home" tab), or by right-clicking in the A1 cell and choosing "Paste".
4. Convert the data from text to columns:
    a. Now, we have the data in Excel, but we can't manipulate it very well because all the data for each row is lumped into one cell. We want to split out each data value into its own cell.
    b. Starting at the row where the column headers are located (probably around row 7), highlight the A column down to the end of the data.
    c. Click on the Data tab at the top of the window, and then choose the "Text to Columns" wizard (located a little to the right of center).
    d. A dialogue box will pop up to help you through the process.
    e. The first page of the wizard asks you to identify whether the data is "Delimited" or "Fixed width". In most cases, the My NASA Data data will be "Fixed Width", so select that option and click "Next".
    f. The next page of the wizard gives you a chance to check whether the column breaks make sense and to adjust them as necessary. Make any changes that are needed. Or, go back and switch to "Delimited" on page 1 if you notice that the columns are not lining up as you expected. Once you are satisfied with the columns, click "Next".
    g. The final page of the wizard allows you to designate what kind of data values are in each column and a destination for the data. For the purposes of the CCC curriculum, we'll just accept the defaults and click "Finish".
    h. Now your data should be in beautiful columns and the values should make sense. It's always a good idea to double check that nothing crazy happened!

My NASA Data isn't working! What should I do?

1. Double check that you entered everything correctly. Especially check that you have the right data set and that you have entered dates and latitude/longitude values within the range of available data. Usually the user interface will prevent you from entering invalid data ranges, but sometimes there are glitches.
2. Refresh the browser and/or restart the browser. Occasionally, a fresh start is the easiest way to clear out any mistakes or glitches.
3. Update your browser and/or JAVA. If you have older versions of the software, then you might find that some functionality is lost.
4. If you're still struggling, consider whether problem might be at the My NASA Data website. It might be a temporary problem, in which case taking a break and returning to the site at a later time could be a good choice. Or it could be a more significant problem, in which case you'll want to explore the "help" resources provided by My NASA Data (link in upper right hand corner of page).
5. Ask your Eco-Schools contact for help or email eco-schoolsusa@nwf.org!

How do I print or save a map or graph?

1. Use the "Print" button to generate a version of your map or graph that is suitable for saving or printing. Once you click on the "Print" button, a new window will pop up with your map or graph.
2. Print a map or graph by using the print option on your browser.
3. Save a map or graph in one of two ways:
    a. By choosing "Save as" in the browser. Use the defaults to save as a "Web Archive, single file (*.mht)".
    b. By right clicking and choosing "Save picture as…" Use the defaults to save as a *.png file.
4. When saving, make sure to give your new file a descriptive name and put it somewhere that you'll remember!

How do I find my latitude and longitude?

A number of sites help you find your latitude and longitude. For example:

1. http://itouchmap.com/latlong.html
2. http://www.findlatitudeandlongitude.com/

WEB ADDRESSES FOR HYPERLINKS

PREREQUISITES

- **Making detailed observations**
  http://www.ehow.com/how_2052859_make-observations-using-scientific-method.html

MATERIALS AND TOOLS

- **Field guides**
  http://neoninc.org/budburst/plantresources.php

VOCABULARY

- **Indicator species**
  http://www.answers.com/topic/indicator-species
- **Phenophase**
  http://neoninc.org/budburst/phenology.php

LEARNING LINKS

- **Student observation record**
  http://neoninc.org/budburst/pdfs/Generic-Field-Journal.pdf
- **Project Budburst website**
  http://neoninc.org/budburst/

WEBSITES FOR FURTHER LEARNING

- **EEK! Phenology – the website explains phenology on a lower level and is updated monthly.**
  http://dnr.wi.gov/eek/nature/season/pheno.asp
- **Cloned Plants Project**
  http://www.usanpn.org/lilac

STUDENT READING RESOURCES

- **Phenology and Climate Change**
  http://www.windows2universe.org/life/phenology_climate_change.html
- **Climate Change Could Severely Impact California's Unique Native Plants**
  http://earthobservatory.nasa.gov/Newsroom/view.php?id=34808
- **Plant's Internal Clock Can Improve Climate Change Models**
  http://earthobservatory.nasa.gov/Newsroom/view.php?id=39267
- **Will Plants and Pollinators Get Out of Sync?**
  http://earthobservatory.nasa.gov/Features/Bees/bees3.php
- **Climate Change Opens new Avenues for Spread of Invasive Species**
  http://earthobservatory.nasa.gov/Newsroom/view.php?id=36032
- **Drought Slows Plant Growth – 2000-2009**
  http://earthobservatory.nasa.gov/IOTD/view.php?id=45380

LESSON 12-STANDARDS

National Science Education Standards

Unifying Concepts and Processes

- Systems, Order, and Organization
- Evidence, Models, and Explanations
- Change, Constancy, and Measurement
- Equilibrium

Standard A – Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Standard B – Physical Science

- Conservation of energy
- Interactions of energy and matter

Standard C – Life Science

- Interdependence of organisms
- Matter, energy, and organization in living systems

Standard D – Earth and Space Science

- Energy in the earth system
- Geochemical cycles

Standard E – Science and Technology

- Abilities of technological design
- Understandings about science and technology

Standard F – Science in Personal and Social Perspectives

- Environmental quality
- Natural and human induced hazards
- Science and technology in local, national, and global challenges

Standard G – History and Nature of Science

- Science as a human endeavor
- Nature of scientific perspective
- Historical perspective

National Education Technology Standards

Standard 1: Creativity and Innovation

- Use models and simulations to explore complex systems and issues
- Identify trends and forecast possibilities

Standard 4: Critical Thinking, Problem Solving, and Decision Making

- Collect and analyze data to identify solutions and/or make informed decisions.

Standard 6: Technology Operations and Concepts

- Understand and use technology concepts
- Select and use applications effectively and productively
- Troubleshoot systems and applications
- Transfer current knowledge to learning of new technologies

National Council of Teachers of Mathematics Education Standards

Process

- Connections
  - Recognize and apply mathematics in contexts outside of mathematics
- Representation
  - Use representations to model and interpret physical, social, and mathematical phenomena

Climate Literacy Principles

Principle 1: The sun is the primary source of energy for Earth's climate system.
Principle 2: Climate is regulated by interactions among components of the Earth system.
Principle 3: Life on Earth depends on, is shaped by, and affects climate.
Principle 4: Climate varies over space and time through both natural and man-made processes.
Principle 5: Our understanding of the climate system is improved through observations, theoretical studies, and modeling.
Principle 6: Human activities are impacting the climate system.
Principle 7: Climate change will have consequences on the Earth system and human lives.

Energy Literacy Principles

Principle 3: Biological Earth processes depend on energy flow through the earth system.

LESSON 12-ESSENTIAL QUESTIONS ANSWER KEY

Essential Questions Day 1

All answers will vary as it will be based on student understanding and opinion

Essential Questions Day 2

Questions 1 – 4

[Answers will vary as it will be based on student understanding and opinion]

5. What are the advantages and limitations of the BudBurst data as compared to the satellite observations? Which approach provides a more precise measurement of when spring arrives in your location? Which approach is more useful for evaluating broader spatial patterns in the arrival of spring?

   [The BudBurst data are direct observations and provide high spatial and time resolution. With this data, one can pinpoint exactly when spring arrived for a specific species and a specific location. However, it is limited in the extent to which is provides information about broad spatial patterns. In theory it could provide that sort of information, but there would need to be many, many more observers from lots of different locations to provide the necessary coverage.

   The satellite data provides a broad-brush image of the arrival of spring. Because the data is available only as monthly averages, it is not possible to pinpoint the date of spring arrival. But it is possible to see spatial patterns of approximately when spring arrived in different locations.]

Name: _____ Date: _____

Science Concept Quiz

Lesson 12: Citizen Science to the Rescue!

An indicator species is a plant or animal that responds to a particular trait in the environment. For example, plant growth may be triggered by temperature, length of day, precipitation levels, or freeze-thaw cycles. **How could the early arrival of spring affect bird populations?**

A. Early spring arrival will not impact bird populations

B. Early spring arrival will cause many bird species to have fewer offspring.

C. As a result of changing temperatures bird migration patterns will change causing depletion in the available food sources as the size of the lands are not able to accommodate larger numbers of birds.

D. As a result of changing temperatures bird populations will increase.

_____ points out of 20

I. Answer

A.◯ B.◯ C.◯ D.◯

_____ points out of 15

II. What is the main concept behind the question?

1. Formulating a hypothesis
2. Phenology
3. Bird migration
4. Climate changes affect on natural systems

_____ points out of 25

III. Provide the reasoning for choosing your answer in part II.

_____points out of 40

IV. Why are the other responses in part I not the best answer choice?

1.

2.

3.

4.

Use the rest of this page if more room is needed to fully communicate your thoughts.

Teacher Answer Key

1. C

2. 4

3. Answers may vary. The main idea behind the question has to do with how climate affects natural systems such as bird migration and not specifically on the phenology or bird migration.

4. Answers may vary.

   A) Research and the phenology lesson provide evidence that phenology changes will affect bird migration patterns and will create concerns over lack of space and food supply.

   B) There is no evidence to support that phonological changes will stop birds from producing the same numbers of offspring.

   C) This is the correct answer. Birds migrate to areas where there is space and food. If bird migration patterns change there is evidence that there could be too much competition for food and space.

   D) Changes in temperatures that affect phonological changes will not increase bird populations but will instead cause bird population to decrease over time.

Student Name
Teacher/Class
Date

Lesson12: Citizen Scientist to the Rescue!
Trends in Spring Arrival Using Project BudBurst

Based on your analyses, collaborations, and writings provide evidence for understanding what phenology is, including knowledge of indicator species and phenophases. Elaborate on the BudBurst experience sharing both new found knowledge and difficulties. Lastly, explain phenology's role in understanding climate change-what can it tell us?

What Is the Expectation?

Accurate science relating to phenology and its role in understanding climate change.

Evidence supporting your claims

Visual representations
Key vocabulary

Evidence of on grade level spelling and grammar usage