



Harvard LTER Schoolyard Program

Teacher Developed Lessons and Documents that integrate Harvard Forest Schoolyard Ecology Themes into curriculum.

- Lesson Title: Analyzing the data; “It’s time to tell the story” about Buds, Leaves, and Global Warming
- Teacher/Author: Lise LeTellier School:
- Level: High School
- Date: February, 2013

Holyoke Catholic High School Chicopee, MA
lletellier@holyokecatholichigh.org

Prerequisite skills:

- Basic knowledge of phenology- specifically for deciduous tree in the fall
- Basic skill in negotiating online programs.
- Basic skill in cut and paste operations with Microsoft WORD
- Climate Change concepts can be introduced prior or after

Length of time: 2 - 45 minute, class periods

Audience level: 9th -12th grade Science Students

Materials list:

Journal
Computers with Internet access- (1 for each student or team of 2, 3 students)
Excel Spread Sheet Program or Macintosh compatible program
Computer Printer

Objective: Students will be able to:

- Use an online graphing tool to make graphs from data

- Use graphs to analyze data
- Associate phenological events to data

Background Information:

This entire unit is developed in partnership and with full support of the Harvard Forest Schoolyard Long Term Ecological Research Program, specifically using the fall protocol for the Buds, Leaves and Global Warming Research Project, led by Ecologist, Dr. John O'Keefe. The Harvard Forest is part of a **national network of sites** that supports K-12 teachers and students in hands-on ecological research.

In the Harvard Forest Schoolyard LTER program, teachers learn about and initiate ecology research in their classrooms and schoolyards. Participants in this study are studying how our growing season might be affected by climate change. Study questions include: *How long is the growing season in our schoolyard?* And: *How is the length of the growing season related to climate?*

Students learn to collect data on important long-term ecological issues and processes. Student data is then shared on the Harvard Forest website. Students can access their data to graph and analyze, as well as accessing other school's data.

Freshmen Environmental Students at Holyoke Catholic High School in Massachusetts collected the data used in this series of activities. It took two school years to collect the proper data. In the first year, students collected fall and spring data. This data was exported to Harvard Forest's online database. The following fall, students again collected and exported data. The 2012 spring and fall data set is provided to determine the growing season length for 12 urban trees, then averaged and compared. The data will continue to be taken for subsequent years to determine long-term change. The data can be downloaded as an Excel-based Spreadsheet. It is strongly recommended to consider collecting your own data and working with Harvard Forest Schoolyard Long Term Ecological Research Program, who offer workshops and full support. Program Coordinator Pamela Snow, can be reached at: psnow@fas.harvard.edu. A series of introductory assignments are available to those who wish to collect your own data. See these lessons at: <http://harvardforest.schoolyard/lesson-plans>

This lesson can be used by anyone interested in using a large database of Schoolyard data to help explore how the timing of color change and leaf drop of deciduous trees in New England is changing. Anyone interested in this question is recommended to compare the shorter term schoolyard studies from various schools to Ecologist John O'Keefe's 21 year data set available at: <http://harvardforest.fas.harvard.edu:8080/exist/xquery/data.xq?id=hf003>

Graphs of Dr. O'Keefe's study through 2012 are available at: <http://tinyurl.com/O-Keefegraphs>

Harvard Forest Schoolyard Long Term Ecological Research – Data Analysis Online Graphing Tool: “Its Time to Tell the Story!”

Teacher notes:

- At the beginning of the unit, students should be introduced to the Harvard Forest LTER program and specifically John O’Keefe’s Study and the purpose of the Buds, Leaves and Global Warming protocol, and connect it to their own work.
- Phenology is the study of seasonal changes. This protocol was using the phenological event of leaf color change and leaf fall of deciduous trees in New England. If your students are unfamiliar with this event, pictures of New England Fall season should be shown and discussed.
- Following are student directions. These directions can be printed out and given to student to follow. Subsequently, you can go the Harvard Forest LTER Website at: <http://harvardforest.fas.harvard.edu/schoolyard-lter-program>
 - Choose *Schoolyard LTER Database*, choose *graph data*, choose *Fall Phenology*, and choose a school.
- The link above or on the student instruction sheet can be placed on a class website for ease of navigating.
- For the “ Its time to tell the story” Analysis of the Data section, students will need to be either discover or be instructed as to the difference between date and day of year. The date was recorded when the students collected their data, but researchers tend to use the day of year, known as Julian date, to do comparative work, as this gives a more accurate day that does not change with a leap year. Graphs are made using both to students can compare.
- Assign a specific tree number from the data set you want your students to analyze, to each of the students or pairs of students. Because of winter storm damage to trees, Recommended trees numbers to assign, where there is at least 2 years of data would be tree numbers 1,3-5,7-10,12-13,20 &21.

Student directions:

- Go the following Harvard Forest Link, Schoolyard LTER Database- Graph Data- Webpage
 - http://harvardforest2.fas.harvard.edu/asp/hf/php/k12/k12_graph.php?project=fall_phenology
- Choose “Fall Phenology.” Click submit

Harvard Forest > Schoolyard LTER Database

Schoolyard LTER Database

Graph Data

Welcome to the Harvard Forest Schoolyard LTER Database. To create a graph, select a project and press Submit. Graphs are created using the R statistical language.

Project *	<input checked="" type="radio"/> Fall Phenology
	<input type="radio"/> Spring Phenology
	<input type="radio"/> Hemlock Woolly Adelgid
	<input type="radio"/> Vernal Pools
	<input type="radio"/> Streams

- Go to school drop down menu and choose “Holyoke Catholic High School (HCH)” or whichever school you’d like to analyze. However, some schools will have more than one teacher, at Holyoke Catholic High there is only one, so you do not need to enter teacher name nor a date. Click “submit”.

Harvard Forest > Schoolyard LTER Database

Schoolyard LTER Database

Fall Phenology

Select a different project

Please select a school. You may also optionally enter a teacher's last name, a start date, and/or an end date. When your selections are complete, press Submit.

>>>

School *	Holyoke Catholic High School (HCH)
Teacher Last Name	<input type="text"/>
Start Date (m/d/yyyy)	<input type="text"/>
End Date (m/d/yyyy)	<input type="text"/>

- Go to the tree drop down menu and choose the “number” of the tree you have been assigned by the teacher. Record the tree number in your journal, and record the 2-letter code that corresponds to your tree, such as EC or RM. Click submit.

Harvard Forest > Schoolyard LTER Database

Schoolyard LTER Database

Fall Phenology / HCH

Select a different project

Select a different school, teacher, or range of dates

Select one or more individual trees, pools, or locations (or select ALL) to plot by date. Select just one individual to plot by day of the year. Note: if two or more data points share the same coordinates, only one data point will appear in the graph.

Tree	<input type="checkbox"/> ALL	<input type="checkbox"/> 1 HO	<input type="checkbox"/> 2 HO	<input type="checkbox"/> 3 HA	<input type="checkbox"/> 4 HA	<input type="checkbox"/> 5 HA	<input type="checkbox"/> 6 HO	<input type="checkbox"/> 7 HO	<input type="checkbox"/> 8 HO
	<input type="checkbox"/> 9 RM	<input type="checkbox"/> 10 EC	<input type="checkbox"/> 11 EC	<input type="checkbox"/> 12 EC	<input type="checkbox"/> 13 EC	<input type="checkbox"/> 14 AP	<input type="checkbox"/> 15 AP	<input type="checkbox"/> 16 AP	<input type="checkbox"/> 17 AP
	<input type="checkbox"/> 19 WB	<input type="checkbox"/> 20 RM	<input type="checkbox"/> 21 RM	<input type="checkbox"/> 22 RM	<input type="checkbox"/> 23 RM	<input type="checkbox"/> 24 AP	<input type="checkbox"/> 25 AP	<input type="checkbox"/> 26 AP	

- Read the short paragraph that gives a bit of information that corresponds to how the data was collected and recorded by students. There is also a hyperlink for **species code**. **Click on species code** and record the species name that correlates to the 2-letter code recorded in the previous step.

Schoolyard LTER Database

Fall Phenology / HCH

Select a different project

Select a different school, teacher, or range of dates

Select a different individual

The graphs show the selected variable as a function of date (one or more trees) or day of the year (one tree). The legend shows the ID number and **species code** for each tree. **Percent of leaves fallen** is the number of leaves fallen divided by the number of leaves observed (per tree) times 100. **Tree color** is the fraction of the whole tree that has changed color (1=0-25%, 2=26-50%, 3=51-75%, 4=76-100%).

PLEASE SELECT A VARIABLE TO GRAPH:

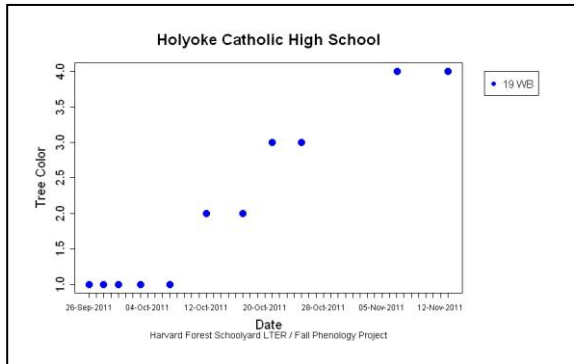
By Date

- **Percent of leaves fallen**
- **Tree color**

By Day of Year

- **Percent of leaves fallen**
- **Tree color**

- Talk to other student groups and make a list of all the different species being studied. There should be 4 different types.
- Make a prediction/hypothesis as to which species loses its leaves earliest in the fall.
- SELECT A VARIABLE TO GRAPH, one at a time, starting with **By Date * Percent of Leaves Fallen**, through **By Day of Year Tree Color**.
- Print each graph, label it with a title that corresponds to what is selected or copy and paste each graph into a WORD document with a title so all four can be placed on one page. (Follow instructors direction)
 - Example: Tree Color by Date:



- Now that you have the graphs, “It’s time to tell the story!”
- **Analyzing the data;**
- First, we will look only at the tree assigned to you and compare the different graphs to see what story the graphs tell. Then we will compare the stories.
- Each graph represents the data, yet each tells a slightly different story.
 - Look at the Harvard Forest Schoolyard LTER Database generated graphs; write a result statement that compares 2011 data to 2012 data for each of the following.
 - Tree Color by Date
 - Percent of Leaves fallen by Date
 - Now write a result statement that compares 2011 data to 2012 data for each of the following.
 - Tree Color by Day of Year
 - Percent of Leaves fallen by Day of Year
- Compare your result statement with other students who have the same and different species of tree.
- **Final Assessment:** Summarize- tell the story of your tree. Write a properly formatted and typed conclusion including purpose of study, your result statement for the ‘Day of Year’ graphs, a statement that restates your prediction/hypothesis and whether it was supported, partially supported or rejected. Include a comparison of the results from other trees. Include if the leaves changed color earlier or later in 2012 compared to 2011 and if the leaves fall off the tree earlier or later in 2012 compared to 2011, discuss if results were unexpected and finish the conclusion with possible explanation for any differences between the two years, or between trees and recommendations for further study.

➤ **Rubric for Grading Conclusion paragraph**

Excellent	Proficient	Developing	Needs improvement
All 7 aspects of the conclusion were included	1-2 aspects of conclusion were missing	3-4 aspects of the conclusion were missing	5-6 aspects of the conclusion were missing
Conclusion was a very accurate analysis of the data	Conclusion was a mostly accurate analysis of the data	Conclusion was a somewhat accurate analysis of the data	Conclusion was not an accurate analysis of the data
Transitions between all aspects of the conclusion were well constructed and flowed smoothly	Transitions between most aspects of the conclusion were fairly smooth	Transitions between a few of the aspects of the conclusion were smooth, but some were not.	Transitions do not flow well.
No errors in spelling, grammar and mechanics	1-2 errors in spelling, grammar and mechanics	3-5 errors in spelling, grammar and mechanics	Errors were so frequent it made reading it difficult.

Samples of Student conclusion paragraphs:

Danielle- Honors Student
1/29/13

The purpose of this experiment was to study and compare when trees lost their leaves and when the leaves turned green in 2011 and 2012 by date and day of the year. For the tree color findings by date, the major findings were in 2011, the leaves stayed green until October and then gradually lost their color by mid-October. In 2012, the leaves stayed green until late September, and then gradually lost its color by mid-October. For the tree color findings by day of the year, the major findings were in 2011, the tree stayed green until approximately day 298 of 365, and then began to lose green until there was no green left at day 316 of 365. In 2012, the tree stayed green until approximately day 293 of 365, and then began to lose green until there was no green left at day 331 of 365. Ultimately, the leaves changed color earlier compared to last year's data. For the percent of leaves fallen by date, the major findings were in 2011, the leaves remained on the tree until the beginning of October and then rapidly lost all its leaves by mid-October. In 2012, the leaves remained on the tree until the beginning of October and then gradually lost its leaves by mid-October. For the percent of leaves fallen by day of the year, the major findings were in 2011, the tree kept its leaves until approximately day 311 of 365, and then the tree rapidly lost its leaves by day 315 of 365. In 2012, the tree kept its leaves until approximately day 299 of 365, and then the tree gradually lost its leaves by day 332 of 365. Ultimately, the trees lost their leaves later in 2012 than 2011. Our findings compared with those of others, because their tree lost its color faster in 2012 than 2011 such as us, but their percentage of leaves lost did not compare to our data. I did not expect the tree to lose its color quicker than last year. A possible cause for the differences may be changes in the climate, such as colder temperatures that came sooner. To improve this experiment, another year of data could have been recorded. For further study, I recommend that we study the trees for longer amounts of time.

Ashley – IEP Accommodation Student
1/29/13

The purpose of The Harvard Forest Tree study was to find out if the leaves falling in 2012 were earlier or later then the leaves in 2011 and also the same thing with the leaves changing color. The major findings were that in 2012 the leaves fell earlier then the leaves in 2011. The leaves in 2011 started falling around day 295 and 2012 started falling around day 275. The major findings for the color of the trees were that

in 2011 the tree color lasted later then in 2012 because 2011 started changing at day 300 and 2012 started changing in day 275. In comparison to the other classmates graphs their leaves fell and also changed color later in 2011. I did not expect tree number 4 to be different from everyone else's, but I am now thinking that I only checked with the classmates who had their tree on the opposite side then mine. In conclusion, the reason for the different ways all the trees have fallen or changed faster or slower could've been because of where your tree was or also because of the weather or also the leap year that happened in 2012.

Extension for Leaf Study: Comparing trees-researchable questions.

- Students from Holyoke Catholic High are not the only students involved in collecting data on trees for the *Buds, Leaves and Global Warming* project at Harvard Forest. We are part of a greater research project that has been going on for many years. Using the data available from Harvard Forest Schoolyard LTER project, make a list of possible researchable questions you could answer just by looking and analyzing the data from different school. In other words, make a list of 5+ questions that you could ask about the tree and how it might compare with another tree.

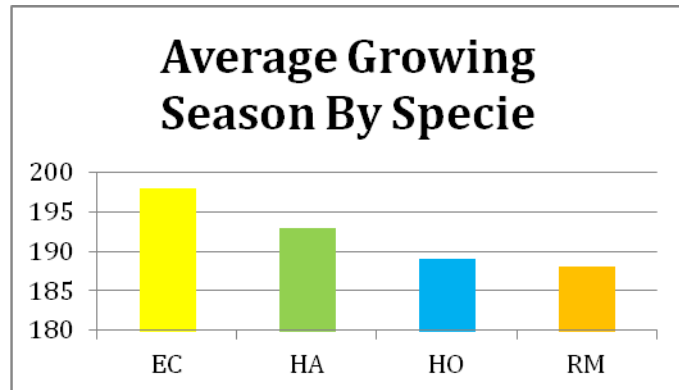
- Calculate, graph and compare growing length of trees for 2012 using Excel.

Trees we have full 2012 data						Calculate growing length by tree (Day of 50% fall - Day of 50% Bud burst)	Calculate Average growing season by species (Total of growing length / number of trees of specie)	Copy Data from Column H to this column
School Code	Teacher	Tree ID	Species Code	date of 50%budsburst	date of 50% fall			
HCH	LeTellier	10	EC	94	307			
HCH	LeTellier	12	EC	97	294			
HCH	LeTellier	13	EC	100	283			
HCH	LeTellier	3	HA	110	299		EC	
HCH	LeTellier	4	HA	106	299		HA	
HCH	LeTellier	5	HA	101	299		HO	
HCH	LeTellier	1	HO	110	310		RM	
HCH	LeTellier	7	HO	146	321			
HCH	LeTellier	8	HO	109	326			
HCH	LeTellier	9	RM	109	301			
HCH	LeTellier	20	RM	114	299			
HCH	LeTellier	21	RM	110	298			

- Data can be downloaded as a CSV (comma-separated-value) file, and analyzed in a variety of ways.

Extension student sample: Data analysis and result statement from 'Growing length of trees' for 2012 using Excel.

Kacie -2-2-13



Result Statement: *The tree species that has the longest growing season is the Exotic Cherry. The Hawthorn has the second longest growing season and the Hornbeam has the third longest growing season. The tree species with the shortest growing season is the Red Maple.*

Climate Change Literacy Alignments: While this lesson aligns with all of the Climate Literacy principles due to its connection to broader climate change themes, we feel the strongest, most concrete links for this lesson are with the Guiding Principle and Principle#5 as quoted below:

Guiding Principle for informed climate decisions:
Humans can take actions to reduce climate change and its impacts.

a. Climate information can be used to reduce vulnerabilities or enhance the resilience of communities and ecosystems affected by climate change. Continuing to improve scientific understanding of the climate system and the quality of reports to policy and decision-makers is crucial.

Teaching Essential Principle 5:

Our understanding of the climate system is improved through observations, theoretical studies, and modeling.

b. Environmental observations are the foundation for understanding the climate system. From the bottom of the ocean to the surface of the Sun, instruments on weather stations, buoys, satellites, and other platforms collect climate data. To learn about past climates, scientists use natural records, such as tree rings, ice cores, and sedimentary layers. Historical observations, such as native knowledge and personal journals, also document past climate change.

c. Observations, experiments, and theory are used to construct and refine computer models that represent the climate system and make predictions about its future behavior. Results from these models lead to better understanding of the linkages between the atmosphere-ocean system and climate conditions and inspire more observations and experiments. Over time, this iterative process will result in more reliable projections of future climate conditions.

d. Our understanding of climate differs in important ways from our understanding of weather. Climate scientists' ability to predict climate patterns months, years, or decades into the future is constrained by different limitations than those faced by meteorologists in forecasting weather days to weeks into the future.

e. Scientists have conducted extensive research on the fundamental characteristics of the climate system and their understanding will continue to improve. Current climate change projections are reliable enough to help humans evaluate potential decisions and actions in response to climate change.