



Harvard Forest Schoolyard Ecology Our Changing Forests; How Do Forests Grow and Change Over Time?

Project Introduction

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I. Schoolyard Study Questions:

A. Big Ideas- Questions for Long Term Study

1. How do forests grow and change over time in response to different environments and land use?
2. How will forest composition and growth respond to future natural and human-caused disturbances?

B. Concrete Concepts-Questions for Here and Now

1. What are the growth rates of trees in the forest? How do they differ among different species and different sized individuals?
2. How fast are trees of different species and size accumulating diameter growth and carbon from year to year within a site and on sites with different histories and soil moisture?
3. How does the tree composition differ in forests with different land-use histories or environments? Under what conditions do different tree species grow best?

C. Further questions your class may choose to address

1. What can you find out about the forests of your town 250-300 years ago? Refer to historical tree data. Some towns in Mass. have "witness tree" data from the time of colonial settlement, others have maps of the forest extent in 1830, and most have more recent aerial maps and photographs?. These maps can be found in the McConnell Archive at UMASS, Amherst. We have scanned copies available for all 6 pilot schools (2013).

2. How is forest composition likely to change over time in the different plots?
Using your plot data you can compare the composition of different sized individuals, such as large trees (>25 cm DBH) to smaller trees (< 25 cm DBH).
After a few years of data collection you may choose to examine changes in the forest composition over time. To take this comparison a step further would require adding more field work- specifically collecting data on tree seedlings.

II. Related Research

Ecologist Edward Faison studies long-term forest monitoring and change. Ed also co-leads the Ungulate-Forest Dynamics project at Harvard Forest's Long-term Ecological Research Site and is coordinator of the Wildlands and Woodlands Stewardship Science Project. Much of the content of this Schoolyard project has been adapted from the [Woodlands and Wildlands Stewardship-Science](#) project.

See more about Ed Faison's research at: <http://Edward Faison HF research>

III. Field Time

A. Minimum number of data collection field visits: **2 field sessions** total.

Autumn: 2 visits- This protocol would require a minimum of two field site visit(s) with students, in addition to teacher field site setup session(s) prior to the start of the school year.

B. Recommended number of data collection field visits:

1. **Autumn:** Begin field setup in August or early September. Collect data with your students in September or early October, before leaves on trees in your plot have turned brown or dropped (late Oct. through early November at most locations).
2. **Throughout the Year** –Optional: A number of optional supplementary activities are included here as resources to deepen the learning process for students.

IV. Project Objectives

- A. Middle School and H.S. Teachers and students engage in the study of how the landscape in their town and region has changed in the past, and how current-day forests will change over time.
- B. Students will participate in a plot study using a site within walking distance to their school.
- C. Student research will connect to Harvard Forest Long Term Ecological Research (LTER) studies related to land use change, forest dynamics, and carbon uptake.
- D. Activities will include data collection, measurement, plant identification, , and data analysis, including calculation of carbon storage

- E. Project data is given to Harvard Forest to post online and share with other participating schools, HF scientists, and the public.
- F. Students may compare the dynamics of their local woodlands to those of other participating schools in different locations, and/or those with different land-use histories.

V. Connections to Science Frameworks

Note that our projects incorporate all of the Scientific Inquiry Skills Standards in the Massachusetts frameworks especially well. See the list of the frameworks addressed in our Schoolyard projects and please skip over the standards for elementary levels. All of the standards listed from grades 6-8 and High School that we have listed relate to this project, depending on what aspects you choose to incorporate in your classroom teaching. We expect to be updating the national standards soon to match up with the new Next Generation Science Standards. We know our projects line up very well with the new emphasis on incorporating modern investigative science methods. Stay tuned for more on that. In the meantime, see the list at: [Mass. State Frameworks connections HF-sLTER](#)

VI. Materials:

A. Required Materials

- Data sheets
- Clipboards
- Pencils
- Tree Field ID guides
- 50-Meter measuring tape
- Stakes or pins to anchor corner tapes (4 per plot)
- 1-5 DBH (Diameter at Breast Height) tapes to measure tree diameter
- Rebar or PVC pipes to permanently mark plot corners (4 per plot)
- Compass
- Hammer or mallet for pounding stakes
- Forestry chalk to mark trees
- aluminum nails for tree tags
- Metal tree tags
- 1.37-meter stick to standardize DBH measurements
- Plastic coated wire for attaching metal tag to small trees

B. Optional Materials:

- GPS unit

VII. Choosing a Schoolyard Study Site: Teachers choose and flag research sites based at a location within walking distance to school. Sites with a variety of trees, located in an easily monitored area, are best for this project. Ideally each class will add one more plot in the second year to their study so that students may compare different forest types. Some sites may have more hardwood trees, versus white pines or other evergreen species or some may have more invasive species or some may have larger (older) trees versus smaller. Teachers may decide on best sites based on what land is available to them in easy access and what their educational goals are.

VIII. Site Preparation

A. Lay the Plot:

- Using a compass*, place a permanent stake in one of the corners.
- Proceed to lay out a 10x10-meter square with aid of compass (using cardinal directions) and measuring tape (see Fig. 1). It is helpful to have one person stand at a corner with compass and to guide the other person running out the tape. The person running the tape out should look back frequently to ensure that the tape is straight.
- Strive for deviations of less than 10-200. centimeters for the total perimeter of the plot.
- If you will be sampling the plot immediately following establishment, leave measuring tapes laid out so plot boundaries are visible.
- Mark four corners permanently with metal or PVC pipe.
- At least one corner post should have the unique plot ID number and other identifying information either on a tag or stamped on a metal cap (it's helpful if all ID tags are on the same corner post at each plot).

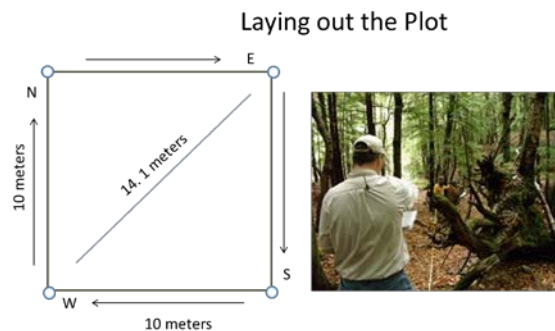


Figure 1*

Notes:

*We suggest that compasses be aligned to true north. Make sure that each user's compass is set to the correct declination before beginning. See <http://www.ngdc.noaa.gov/geomagmodels/Declination.jsp> to determine declinations for your geographic area. For more information about declinations and adjusting your compass: http://en.wikipedia.org/wiki/Magnetic_declination#Adjustable_compasses

*Laying out a plot correctly takes practice and will often take several attempts for beginners. Careful reading of the compass and attention to keeping the tape straight will ultimately save time.

*Figure 1 is from Woodlands and Wildlands Stewardship Science Manual for Long-Term Forest Monitoring.

B. Identify Trees: Use tree guides or other resources as needed to determine the species of each tree that is ≥ 2.5 cm. diameter, in your plot. Record these species, as you assign each tree a unique identifying number. It is important to have at least one person in the field with some experience in identifying the local flora. For additional help with identification, we recommend [A Field Guide to Trees and Shrubs: Northeastern and north-central United States and southeastern and south-central Canada \(Peterson Field Guides\)](#), and [Bark: A Field Guide to Trees of the Northeast](#), as well as the online tool: <http://gobotany.newenglandwild.org/simple/>

C. Make a key: Be sure to make a key to show the species of each tree by number. Store the key in your HF project notebook. See sample key below:

Site/School Name: _____ School Year: 20__-20__

Tree #	Tree Species
1	
2	
3	
4	
5	
6	

Tree #	Tree Species
1	Sugar Maple
2	Sugar Maple
3	Scarlet Oak
4	Black Cherry
5	Witch Hazel
6	Black Cherry

Figure 2: Sample Key to Study Trees

D. Label Trees: Now that you have assigned each tree a number and recorded each study tree by species on your key, nail a metal tree tag with the appropriate number onto the trunk at least 20 cm. below the 1.3 DBH line. If the tree is too narrow to nail a marker, attach the metal tag by wrapping a covered wire through the tag hole and around a low branch or the trunk if no branches are within reach.

1. Adding Trees-After the first year, as trees grow, you may find more trees in your plot when you go back to resample. To add a new tree to your study, please make sure that a tag is used with a number that has not been used before in that plot.

IX. Data Collection

A. Field Site Description Sheet

- 1. Record General information** including: school name, date (month, day, year), teacher name, plot ID number, and time of start and end of data collection.
- 2. Record Plot Location information** including: County, State, latitude and longitude Coordinates, and additional directions to Plot.
- 3. Record the Topographical Features** of your plot.

a. Determine the **landscape position** of your plot. Check one of the following options: ridge/hilltop; hillside; dry flat; wet flat; or rolling upland.

b. To determine the **Aspect** of your plot, locate the center of the plot. Point compass in direction that the land is sloping and record the number in degrees (A good way to think about aspect is to ask 'which direction would water flow down the hill?') If the plot is on level ground, record the aspect as NA.

c. **Determine the Slope** of your plot. Check one of the following options: None, slight, moderate, or steep.

d. **Rock Cover:** Look to see whether any rocks are evident in the plot. If so, check one of the following options:
<1% ;1-5%;6-25% ; 26-50% ;51-75%; or >75%.

e. **Water in Plot:** If there is water present in your plot, check one or more of the following options: stream; temporary stream; flooded area; vernal pool.

4. Forest Canopy Characteristics: From the center of the plot, look up and estimate the percentage of canopy closure over the plot (How much the tree branches are obscuring the view of the sky). Check one of the following choices: 10-25%; 26-50%; 51-75%; or 76-100%.

5. Evidence of Disturbance:

a. **Forest Pests and Pathogens.** If you positively identify any forest pests or pathogens, check one or more of the following options: Hemlock Woolly Adelgid; Gypsy Moth; Ash Yellows; Asian Long-horned Beetle; Beech Bark Disease; Emerald Ash Borer; Hemlock Borer; or add another species if found.

b. **Human Activity** in or Near Plot. If you see any evidence of human activity in the plot, check one or more of the following choices: cut stumps; footpath; stone wall; forest road; building; cellar hole; barbed wire; open field; skid trail; or add any other evidence you find in the blank for "other" .

c. **Weather Events:** If you see evidence of weather events in or near your plot, check one or more of the following: uprooted trees; snapped trees; large downed branches; fire scars; river flooding; or other.

d. **Downed Woody Debris Cover** in Plot. If you find pieces of wood on the ground, that are at least 10 cm in diameter, check one of the following options: <1%, 1-5%, 6-25%, 26-50%,51-75%, or >75%.

e. **Wildlife Sign:** If you see evidence of wildlife in your plot, check one or more of the following: deer pellets; moose pellets; deer/moose browsing; moose bark-stripping; deer antler rubs; tree girdling [porcupine]; beaver felled trees; woodpecker holes; bear claw marks on beech; rabbit/porcupine browse; or add different signs or animals in blank for "other".

f. **Invasive Plant Species.** If you find any invasive species in your plot, check one or more of the following: Garlic Mustard; Oriental Bittersweet; Japanese Barberry; Burning Bush; Multiflora Rose; Honeysuckle; Autumn Olive; Buckthorn; Japanese Stilt Grass or add another species.

B. Student Field Data Sheet:

1. **Vegetation Sampling –Trees:** Identify and measure all standing trees in the plot that are 2.5 centimeters in diameter or greater at breast height (DBH*) with a DBH tape. We recommend using DBH sticks to position from the ground up to the proper height. The sticks are precut at the standard length of 1.3 meters to ensure consistent measurements at the proper height.

a. Record **tree identification number and species** for each study tree, on Student Field Data Sheet.

b. Record **Diameter at Breast Height (DBH)** for each study tree.

c. Record **condition of tree** using one of two classes:

- *Living*
- *Dead*

2. **Optional Field Notes:** We recommend that students record any additional notes about field conditions and observations on the weather, animals, plants, etc. that interest them. Once the basic field data sheet is complete, notes can be kept informally on the back of the HF field data sheet, or on specially designed observation sheets. Teachers may want to discuss what kinds of observations they would like students to be on the lookout for in the field. Teachers may choose to develop additional field sheets based on their specific goals for their studies and time out in the field.

X. Data Coordination:

The **Schoolyard LTER Database** allows you to share your data with scientists, other students, and citizens who are interested in finding out about how the trees in your plot are changing over time. You may submit data, download data, graph data, and view other pertinent information such as site elevation/lat./long./address, etc. at: [HF schoolyard Database](#)

A. Data Submission:

1. **Data Submission Deadlines:** Teachers must submit autumn data by **January 1st**.
2. **To Submit Data:**

- a. Click the Submit Data link

Note: You will need to login to view this page. If you do not have a login and password, you will need to create them at this point. If you already have an account, simply login as usual. Upon submission of your contact information, your password will be sent immediately to the e-mail address provided. Please be aware that the message containing your password may be blocked by your spam filter. It will be sent from the following address: hfweb@fas.harvard.edu.

- b. Select your **Project**. (*Changing Forests*)
- c. Select your **School** from the dropdown menu (If your school does not appear contact Pamela Snow at psnow@fas.harvard.edu to add your school to the system)
- d. Select your **Last Name** (if your name does not appear contact Pamela Snow at psnow@fas.harvard.edu to add your name to the system).
- e. At this point, you will have access to a page containing metadata for your selected project.
- f. Click **Add a New Observation**.
- g. Enter the **Date** of the observation in the format shown.
- h. Enter the requested information
- i. Click **Submit**.

Please Note: Data will be reviewed by HF staff before being uploaded to the database to be available for downloading and graphing. We expect data to be available for downloading and graphing within a week of submission.

D. Data Storage: Save the original data sheets. Often, questions about the data will arise months or years later when someone goes to graph or otherwise analyze the data. It's important that you have the original data to refer to when needed.

E. Data Download: To get an electronic copy of your data, or if you'd like to graph project data, documents can be downloaded in a spreadsheet form in a program such as Excel, at: [Downloading Data Link](#).

XI. Data Analysis: Teachers may choose to analyze data in a number of ways.

A. Analysis Questions: No matter which activities are used, the main thing is to ask students:

1. Do you think we have enough data to answer our *Big Idea* study questions:
 - a. "How do forests grow and change over time in response to different environments and land use?"
 - b. "How will forest composition and growth respond to future natural and human-caused disturbances?"

2. Do you think we have enough data to answer our Concrete Concepts study questions?
 - a. "What are the growth rates of trees in the forest? How do they differ among different species and size classes?"
 - b. "How are different trees growing year to year within a site and in different environments? (i.e. historically cleared and/or moist site vs. historically wooded and/or dry site)"
 - c. "How does tree species composition differ between two plots with different land use histories or environmental profiles? What do these differences tell us about where different species grow and how past land use influences current vegetation?"

3. What can you tell about the composition of your forest plot (species makeup)
4. What does a stand density analysis tell you about your forest?
5. What does the basal area of the trees in your plot indicate?
6. What is the difference between stand density and basal area?
7. How much carbon is being stored by the trees in your plot? Which species are storing more or less carbon than others
8. How do this year's data compare with previous years' data?
9. Do you think you have enough data to contribute to the overall study?

B. **Graphing:** Students can graph their own data to see if they can find patterns in the data.

1. **Online Graphing Tool:** Once your data have been uploaded to the database, the online graphing tool may be used to create time series graphs of Stand Density, Basal Area, and Carbon Biomass Graphs can be downloaded to your computer as jpeg files. To use the online graphing tool, please see: [Online Graphing Tool](#)
2. **Graphing Manual:** Dr. Betsy Colburn has published a [graphing manual](#) and related [Graphing Exercises.pdf](#) that provide specific examples and instructions for creating a variety of graphs, using Harvard Forest Schoolyard Data, in addition to

what can be created on our online graphing tool. Note that sample exercises are using data from Buds, Vernal Pool and Woolly Bully Studies currently. We expect to add an example or two from the new study once we have sample data sets available.

3. Harvard Forest Ecologist Data:

a. Data from the Woodlands and Wildlands Stewardship Science study can be found at: [W+W Stewardship Science Data](#).

b. Data from a diverse array of studies looking at Land use change over time can be found at: [HF historical ecology studies](#).

4. **Data Workshops for Teachers:** Harvard Forest hosts teacher workshops to support analyzing and graphing project data. Come and try your hand at graphing with the support of professionals. Email Pamela Snow for dates and information.

a. **Level I Data Workshop** provides an introduction to data management and use of the online database. Time is spent practicing data input, creating simple graphs, and working with HF Information Manager and Project Ecologist.

b. **Level II Data Workshop** provides an introduction to graphing Schoolyard project data. Workshop content is largely based on the Graphing Manual and Exercises listed above.

c. **Level III Data Workshop** allows teacher with multiple years of data to make use of HF mentors as they work to develop graphs based on their own educational objectives.

XII. Optional Supplemental Activities: Teachers may choose to supplement this field research study with a number of related activities depending on their time available and curriculum needs. Below are some suggestions:

A. Field trip to Harvard Forest: Students see what an ecological research forest/ institution looks like. An indoor slide show and [fisher-museum dioramas](#) tell the story of HF and the changing forests of our region. Outdoors, students can tour the [Sanderson-farm-trail](#) to see how land use change has impacted the landscape at Harvard Forest. Groups may choose to visit the research site of Ed Faison's [Moose and Deer](#) Enclosures and Dr. Orwig's Long term "Mega Plot" study.

B. "If Trees Could Talk; From Forest to Farm And Back Again" by Cheryl Oakes (coakes@duke.edu). Forest History Society 2000-2009.
The rich history of Petersham, Massachusetts makes an excellent case study for understanding what happened to the New England forest ecosystem after European colonists arrived. Although specific dates for the change from forest to farm and back again may vary from region to region, a similar pattern of clearing forests, farm abandonment, and returning second-growth forests occurred in most regions of the

(northeastern) *United States*. See this entire curriculum at:
<http://www.foresthistory.org/Education/Curriculum/Activity/activ2/activ2.html>

- C. **Historical Research:** Teachers and students are encouraged to contact their local historical societies and libraries to dig up images and descriptions of the land around their field sites, from the past.
- D. **The PLACE Program Resources:** (<http://www.uvm.edu/place>): This Vermont based program provides support in encouraging *exploration and understanding of the local landscape by providing an engaging and accessible framework for residents to learn more about their town's natural and cultural heritage*. Check out their helpful resources and directions on how to approach the study of land/communities.
- E. **Aerial Photo and Land Use Change Map Analysis:** Historical land use maps and aerial photos are available at the McConnell Archives in the Special Collections and University Archives, UMass Amherst Libraries. We have scanned and photocopied some of these maps and photos for your towns in an effort to get you started. Access to these documents will be included in the Spring Workshop-stay tuned. If you need them sooner, contact Pam and/or the McConnell Archives directly.
- F. **Teacher developed Curriculum Materials:** Teachers know best what kinds of related activities are needed to provide students with an understanding of concepts related to project themes. Many of our experienced Schoolyard teachers working on our other Schoolyard projects have generously shared their materials on our website. We hope to be adding some of your lesson plans, which will more specifically relate to Changing Forests, here soon. See what others' have contributed at: [schoolyard/lesson-plans](#).
- G. **HF Ecologist developed Resources:** Ecologists will be developing presentations for our upcoming Workshops. We expect to post them online at: [schoolyard/presentations](#)
- H. **Other HF-sLTER Resources:** [teacher-resources](#)

XIII. Recommended Reading

- A. **From the Harvard Forest Bookstore:**
Descriptions below were taken from our Online Bookstore at:
<http://harvardforest.fas.harvard.edu/publications-sale>
 - 1. **Forests in Time The Environmental Consequences of 1000 Years of Change in New England.** David R. Foster and John D. Aber, eds., 2003
Forests in Time offers a unique look at combining history and science in ecological studies and environmental management and applies this approach to one of the most remarkably transformed landscapes in North

America: the New England countryside. Written in accessible prose and profusely illustrated with photographs, maps, and graphs, the book relates the history of changes in New England and then explores the results of integrated studies and experiments in this largely forested landscape.

2. **New England Forests Through Time: Insights from the Harvard Forest Dioramas** .David R. Foster and John F. O'Keefe, 2000

This fascinating natural history is essential background for anyone interested in New England's ecology, wildlife, or landscape. In New England Forests through time these historical and environmental lessons are told through the world-renowned dioramas in Harvard's Fisher Museum. These remarkable models have introduced New England's Landscape to countless visitors and have appeared in many ecology, forestry, and natural history texts. This first book based on the dioramas conveys the phenomenal history of the land, the beauty of the models, and new insights into nature.

3. **Stepping Back to Look Forward: A History of the Massachusetts Forest**

Charles H. W. Foster, Editor

Written to celebrate the centennial of the forest and parks system in Massachusetts, this multiauthor volume provides an overview of the ecological, economic, social, and educational history of forest in the Commonwealth.

4. **Thoreau's Country: Journey Through a Transformed Landscape**
David R. Foster

Insights into the conservation and ecology of the New England Landscape based on an interpretation of its history, using as a source the journal writings of Henry David Thoreau.

5. **Agrarian Landscapes in Transition**

Charles Redman and David R. Foster, 2008

The introduction, spread, and abandonment of agriculture represents the most pervasive alteration of the earth's environment in recorded history. This new volume edited by Charles Redman from Arizona State University and David Foster from Harvard Forest, draws on research at six U.S. Long-Term Ecological Research sites, to describe what happens when humans alter natural ecological regimes through agricultural practices. Although each research site has its own unique agricultural history, patterns emerge that help us understand the impact of our actions on the earth, and how the earth pushes back.

B. Other Helpful Books and Guides:

1. **Reading the Forested Landscape: A Natural History of New England**

Tom Wessels, Brian D. Cohen and Ann H. Zwinger, 2005

Descriptions below were adapted from Amazon.com

*Etched into the land is the history of how we have inhabited it, the storms and fires that have shaped it and its response to these and other changes. An intrepid sleuth and articulate tutor, Wessels teaches us to read a landscape the way we might solve a mystery. What exactly is the meaning of all those stone walls in the middle of the forest? Why do beech and birch trees have smooth bark when the bark of all other northern species is rough? How do you tell the age of a beaver pond and determine if beavers still live there? Why are pine trees dominant in one patch of forest and maples in another? What happened to the American chestnut? Turn to this book for the answers, and no walk in the woods will ever be the same. 60 black-and-white etchings and illustrations**

2. **Forest Forensics: A Field Guide to Reading the Forested Landscape**

Tom Wessels.

*Now Wessels takes that wonderful ability to discern much of the history of the forest from visual clues and boils it all down to a manageable field guide that you can take out to the woods and use to start playing forest detective yourself. Wessels has created a key—a fascinating series of either/or questions—to guide you through the process of analyzing what you see. You'll feel like a woodland Sherlock Holmes. No walk in the woods will ever be the same. 50 color photographs**
