Harvard Forest Schoolyard LTER Research Project: Buds, Leaves, and Global Warming

Monitoring the Growing Season of Deciduous Trees

• Deciduous trees!
• Leaf out/ Bud burst – beginning of season
• Senescence (color change) and Leaf drop – end of season

• Data Trend: LENGTH of SEASON…. Increasing in Massachusetts
• Value to a high school classroom?
  • CITIZEN SCIENCE (contributing to database, group work, long term data, outside, field observation, organizing results in tables and graphs, data analysis, hands on kick off to climate science and tree identification)
  • CLIMATE SCIENCE: Understanding changes to PHENOLOGY…. More important

Yearlong Project…..
• Fall – Observe Leaf Drop (4 or more visits)
• Late fall – Data analysis of the growing season, spring to fall
• Spring – Observe next seasons Leaf Out for next year’s class
Unit 3: Harvard Forest Buds/Leaves/Global Warming and Climate Change

- FALL: September – Thanksgiving (at the same time as my soil/planting unit)
  - Harvard Forest Phenology Presentation
    - Focus on science between color change and leaf drop and tying it to climate
    - No explanation of how climate change works yet
  - Begin fall observations
  - Tree Identification – practice and start doing weekly Herbarium Entries
    - Students are creating scientific scrapbooks and using dichotomous keys
  - Climate Change: Greenhouse effect, effects in Massachusetts, effects worldwide
  - Finish fall observations
  - Screening of “Chasing Ice” documentary

- WINTER: Late December – January
  - 1-3 Data manipulation days
    - skills: (data manipulation and analysis, excel, tables, graphing, maintaining skills last exercised before thanksgiving)
    - content: (connecting Harvard Forest content fall to spring, climate change connection as we discuss biomes and expected changes)

- SPRING: April – June
  - Spring observations 6 or more
    - skills: (long term research, groupwork, field observation)
    - content: (gets us doing field work in 2 ways, we also do another spring field study, keeps climate in mind as we study energy)
Tree Identification: Try being my students!

- Each student brings a branch to school as a homework assignment
- I walk through the following power point
- At each slide, they consider what is true for their branch
- After, we use “Tree Finder” dichotomous keys and try to ID their tree.

- Ready to try it? Take out your branch and get ready to take notes!
Alternate
Everything else!

Opposite (MAD)
Very few native trees
Maple, ash, dogwood

http://www.butler.edu/herbarium/treeid/treeparts.html
SIMPLE vs. COMPOUND

WHERE IS THE BUD?        Leaf stalk: NOT AS WOODY AS BRANCHES

http://www.butler.edu/herbarium/treeid/treeparts.html
MARGINS: Like on paper, they are the EDGES

Margins lobed
Margins toothed or rough

2 common lobe patterns:

http://www.butler.edu/herbarium/treeid/treeparts.html
Leaf Veins and Bristles

One main vein (L)  Many main veins (R)

Bristle (L)  No bristle (R)

Pinnately Veined (lower side of blue beech)  Palmately Veined (lower side of sweet gum)

Bristle-tipped  Not

Example ID using this information

- The leaves are opposite, which means it must be a maple, ash, or dogwood
- The leaves are NOT compound, so it must be a maple or a dogwood
- The leaves have 3 big lobes, dogwoods don’t have lobed leaves but maple leaves have 3 lobes
- The notches in the lobes are V shaped, not U shaped, so it cannot be a sugar maple or a Norway maple
- It is a Red Maple! *Acer rubrum*

- I used Mrs. Matthei’s slides and some maple tree searches on leaf snap for my identification
Try to do your own ID!

• Instead of the “Tree Finder” you can start with the information you just gathered and use websites if you are on the internet.

• Great site my student found (based in Ohio but the ecology is usually similar enough):

http://www.oplin.org/tree/leaf/byleaf.html
Japanese Maple
Acer palmatum

Location:
This tree is located in the middle of my front yard. It is a secluded tree away from any others.

Identification Steps & Sources

Virginia Tech Acer palmatum Fact Sheet:
- leaves:
  - opposite and simple meaning
  - they are set across from each other and they are not composed of leaflets
  - there are 5-7 lobes that are in deep Y shapes
  - the lobes have serrated teeth
  - the color of the leaves is commonly a deep red color
- bark:
  - the bark is relatively smooth all over
  - the trunk color is a light grey
- form:
  - the tree is small and stands usually 10-25 feet high
  - the tree's canopy is rounded and branches hang low to the ground
  - the tree is definitely a Japanese Maple or Acer palmatum judging by this website

Mrs. Mattei Powerpoint:
- the leaves are opposite which means that it could be either a maple, dogwood, or ash
- leaves are simple and not composed of any leaflets
- the leaves are not entire
- the leaves have 5 lobes
- the lobes have serrated teeth on all of the lobes
- there are 5 main veins radiating through each of the lobes
- the leaves are not bristled
- the tree is some kind of maple but definitely is not any sort of dogwood

I am 100% confident that the ID of my leaf is a Japanese Maple or Acer palmatum. Likewise with my last herbarium entry, the Japanese Maple was deliberately deposited in my front yard so it was easy to get a direct identification of it. I attempted to use the Tree Finder in order to specify exactly what the tree was, but the book led me to every other type of maple but the Japanese Maple. The powerpoint that I used helped me rule out the possibility of the leaf belonging to any kind of dogwood or ash tree and I was also able to conclude that it was a maple tree. Also, the website where I obtained half of my information was the basis for my ID. This resource let me know that I was correct in my self-identification and that there was no other tree that it could possibly have been.

Citations:
**Tree Identification:**

- The leaves are alternate, they are not maple, ash, or dogwood.
- Leaves are simple there are no clear leaflets and a bud is seen where the leaves are connected to the branch.
- The margins are not toothed; they are lobed. It is probably an oak since they have a similar lobed style to the oak on the slates.
- There is one main vein and the leaf clearly has pointed bristles at the ends.

I am positive that it is an oak but I am not sure what species of oak it is.

**Confidence in My ID:**

I am very confident that my tree is an oak tree due to its alternating leaves, lobes, and because it has simple leaves. I am confident because Tree Finder confirmed that it is an oak tree. I am pretty confident that my oak tree is a scarlet oak because the leaf is very thin and delicate, and because it has enclosing lobes. I am 100% sure my tree is an oak, and I am 90% sure my tree is a scarlet oak. If I messed up and my tree is not a scarlet oak, I think it could be a hick or jack oak because they share many similar characteristics. However, I don't believe it is either of these types of oaks however, because my leaf is not shiny or dark green, and the tree is not untidy.

**Resource: Tree Finder**
- Page 5, tree has leaves
- Page 14, leaves with buds are alternate
- Page 25, leaves are simple, no leaflets
- Page 28, leaves are lobed
- Page 33, leaf is not evergreen
- Page 34, tree has no thorns, and is deeply lobed
- Page 35, the leaf is lobed
- Page 36, leaf has more than 4 lobes
- Page 39, leaf is bristle pointed and deeply lobed
- Page 56, end of leaf is not narrow or long
- Page 57, lobes broaden toward tips

I believe that my tree is a Scarlet Oak because it is thin and has enclosing lobes and it has a yellowish rib.

**Scarlet Oak**

*Quercus coccinea*

**Location:**

The large tree in front of my house.
Student Fall Season and DATA..... NDA Hingham

Fall Observations: Mid September – Mid November
- 9/24 – 11/13 last year; 9/28 - ? this year
- Once a week
- ~6 observations total
- groups of 2/3 to a tree
- Each 15-20 minutes after the first 40 minute observation

Assessments (Grade each observation):
- Sketch both branches; sketch changes after
- Fill out individual branch pages each time
- Add to Louise Levy’s summary page, taped to a folder containing sketches and individual branch pages
Student Spring Season..... NDA Hingham

Spring Observations: Late March– Late May
• 3/29 – 5/31 this year
• Once a week
• 6 observations total
• Same students working in the same groups of 2/3
• Each 15-20 minutes after the first 40 minute observation

Assessments (Grade each observation):
• Sketch both branches; sketch changes after
• Add to Louise Levy’s summary page, taped to a folder containing sketches and individual branch pages

Overall Growing Season – Spring to Fall
• Data manipulation occurs in the late fall, using their data and Spring data from the last class
Data Manipulation

- I submitted data to Harvard Forest
- I created a blank data table spreadsheet file (using data from the Harvard Forest website)
- Students saved the blank file as their own and added to it
- Graded as a lab grade; took 80 minute class and then two 40 minute follow ups; completed for homework.

Harvard Forest Schoolyard Database.....

- Submit data
- Download any data in excel format
- Graph data online

Database:
http://harvardforest2.fas.harvard.edu/asp/hf/php/k12/k12_project.php
Data file: want to be my student again?

http://harvardforest.fas.harvard.edu/schoolyard/lesson-plans

• Go to this page, find Matthei.2016. MAST Student Data Worksheet
My Student Data File: Overview

- **(1 and 2) TABLE** Creating a Table with This Year’s Data
  - Copy from other tab
  - Review for accuracy

- **(3) GRAPH**: tree color and percentage of leaves fallen
  - Use data from table 1
  - Calculate date when 50% have fallen.
  - **(4) Consider 50% leaf drop data accuracy**...

- **(5) CONSIDER PATTERNS (HISTORY, FOR A SPECIES)** Consider your trees historical data and compare it to others of its species

- **(6) Explore data**... Ask your own question that you will answer with a graph, create the tables needed to make the graph, analyze your graph.
Beginning of Student Data Page

- Fun group name
- Tree Species Code and #

Blue Cells –
Orange Cells –

1. Find your tree's fall phenology data under the tab "2012-2015 Fall All NDA". Many trees have fall data for many years, find the data for 2015 ONLY, this is what you collected. Copy it below. At most you should have 6 observations, not all trees had 6 - this is okay. (1 pt)
1. Find YOUR tree’s fall phenology data under the tab "2012-2015 Fall All NDA". Many trees have fall data for many years, find the data for 2015 ONLY, this is what you collected. Copy it below. At most you should have 6 observations, not all trees had 6 - this is okay. (1 pt)

<table>
<thead>
<tr>
<th>School Code</th>
<th>Teacher</th>
<th>Date</th>
<th>Julian Date</th>
<th>Tree ID</th>
<th>Species Code</th>
<th>Total Leaves</th>
<th>Fallen Leaves</th>
<th>Tree Color (see key above)</th>
<th>Percent Fallen</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

2. Look over the numbers, do you see how they relate to the folder? Check the data - was it entered correctly? If not, fix it and explain why in the blue cell below. If it was correct, change the cell below to "correct, no change" (0.5 pt)

Not correct- what did you change and why? (delete all text that was here when you answer)

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1. Find YOUR tree’s fall phenology data under the tab "2012-2015 Fall All NDA". Many trees have fall data for many years, find the data for 2015 ONLY, this is what you collected. Copy it below. At most you should have 6 observations, not all trees had 6 - this is okay. (1 pt)

<table>
<thead>
<tr>
<th>Fun Group Name:</th>
<th>Loco Honey Locust</th>
<th>Code</th>
<th>% Not Green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Name:</td>
<td>Honey Locust</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree Species Code (not spreadsheet)</td>
<td>HL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDA Tree #:</td>
<td>6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Look over the numbers, do you see how they relate to the folder? Check the data - was it entered correctly? If not, fix it and explain why in the blue cell below. If it was correct, change the cell below to "correct, no change" (0.5 pt)

Correct, no change
3. 2 graphs: tree color and percentage of leaves fallen
   - Use data from table 1
3. 2 graphs: tree color and percentage of leaves fallen
   - Calculate date when 50% have fallen.
5. Look at the Historical Data NDA tab. Copy the rows for your tree species below (ALL NDA study trees with your species code). Did you calculate the same 50% leaf drop day as me and the HF data managers? What else do you notice about your study tree (compared to all other study trees, compared to others of its species).

Fill in table below with data (1 pt)

<table>
<thead>
<tr>
<th>Tree Identification</th>
<th>Start of Growing Period JUNIAN Date (50% Leaf Emergence) 2012</th>
<th>End of Growing Period JUNIAN Date (50% Leaf Drop) 2012</th>
<th>Start of Growing Period JUNIAN Date (50% Leaf Emergence) 2013</th>
<th>End of Growing Period JUNIAN Date (50% Leaf Drop) 2013</th>
<th>Start of Growing Period JUNIAN Date (50% Leaf Emergence) 2014</th>
<th>End of Growing Period JUNIAN Date (50% Leaf Drop) 2014</th>
<th>Overall Growing Period 2014</th>
<th>Start of Growing Period JUNIAN Date (50% Leaf Emergence) 2015</th>
<th>End of Growing Period JUNIAN Date (50% Leaf Drop) 2015</th>
<th>Overall Growing Period 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree Common Name</td>
<td>Tree #</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black Cherry</td>
<td>2</td>
<td>10/22/2012</td>
<td>10/4/2013</td>
<td>278</td>
<td>11/14/2013</td>
<td>287</td>
<td>165</td>
<td>5/2/2015</td>
<td>123</td>
<td></td>
</tr>
</tbody>
</table>

Answer 2 P’s for 5 here. Questions restated in the answer box, you can delete them as you answer. (1 pt)

Did you calculate the same 50% leaf drop day as me and the HF data managers? What else do you notice about your study tree (compared to all other study trees, compared to others of its species)
A. Look through the spreadsheet.
B. How does the end date of the growing season of the Honey Locust in 2015 compare to those of 2012, 2013, 2014, and 2016?

- Re-sort data before copying in the original spreadsheet (if necessary/ wanted)
- Your E-copy each table below as you need, taking all spaces that you want.
- Your E-place graphs below the tables, finalize them, then analyze them in the large merged space above (2 pts tables, 5 pts graph)

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Honey Locust</td>
<td>6</td>
<td>111B</td>
<td>311</td>
<td>10/26</td>
<td>10/29</td>
<td>10/12</td>
<td>10/16</td>
<td>10/16</td>
<td>311</td>
<td>10/26</td>
<td>10/29</td>
</tr>
</tbody>
</table>

B. My graph shows the end of growing period dates of the Honey Locust from 2012 to 2015. It was hard to graph because the axes would get messed up every time I attempted to graph the data. My data table had to be transformed, and one column of the data table had to be graphed at time. With the exception of 2012, the growing period ends later and later each year. In fact, the growing period of the Honey Locust ends four days later each year from 2013 to 2015. This is what we would expect because of climate change, as a warmer climate lengthens the growing period of trees. Because 2012 does not follow this pattern and there is an eleven day gap between 2012 and 2013, 2012 might be an anomaly.
A - look through the spreadsheets
I will look through all the data for Honey locust trees in Massachusetts and by using dates, see which growing season was better than the rest.
I used the data from the HF data sheet for all the Honey Locust trees who's data was charted over an eight year period.

D - re-sort data before copying in the original spreadsheet (if you need/want to)
Your E - copy Data tables below.
Your F - reorganize tables as you need to, take all the space that you want.
Your G - place graphs below the tables, finalize them, then analyze them in the large merged space above. (2 pts - tables; 5 pts - graph)

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<th>School Code</th>
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<th>Year</th>
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<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<tbody>
<tr>
<td>WNM</td>
<td>Lucia</td>
<td>Tree 4</td>
<td>190</td>
<td>175</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>SHS</td>
<td>McDermott</td>
<td>Tree 6</td>
<td>178</td>
<td>190</td>
<td>195</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NDH</td>
<td>Loux-Turner</td>
<td>Tree 6</td>
<td></td>
<td></td>
<td></td>
<td>166</td>
<td>177</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCE</td>
<td>Capeless</td>
<td>Tree 10</td>
<td>129</td>
<td>154</td>
<td>157</td>
<td>129</td>
<td>148</td>
<td>129</td>
<td>145</td>
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<tr>
<td>WSM</td>
<td>Greene</td>
<td>Tree 12</td>
<td>181</td>
<td>157</td>
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<td></td>
</tr>
</tbody>
</table>

Growing Season

- WNM Luca Tree 4
- SHS McDermott Tree 6
- NDH Loux-Turner Tree 6
- CCE Capeless Tree 10
- WSM Greene Tree 12
Your G - place graphs below the tables, finalize them, then analyze them in the large merged space above. (2 pts - tables; 5 pts - graph)

<table>
<thead>
<tr>
<th>School Code</th>
<th>Teacher</th>
<th>Date</th>
<th>Julian</th>
<th>Tree ID</th>
<th>Species Code</th>
<th>Total Leaves</th>
<th>Fallen Leaves</th>
<th>Tree Color</th>
<th>Percent Fallen</th>
</tr>
</thead>
<tbody>
<tr>
<td>NDH</td>
<td>Lockett</td>
<td>9/26/12</td>
<td>270</td>
<td>7BH</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>NDH</td>
<td>Lockett</td>
<td>9/27/12</td>
<td>271</td>
<td>7BH</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0%</td>
<td></td>
</tr>
<tr>
<td>NDH</td>
<td>Lockett</td>
<td>10/12/12</td>
<td>286</td>
<td>7BH</td>
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<td>1</td>
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<tr>
<td>NDH</td>
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<td>10/18/12</td>
<td>282</td>
<td>7BH</td>
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<td>0</td>
<td>2</td>
<td>0%</td>
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<tr>
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<td>10/26/12</td>
<td>306</td>
<td>7BH</td>
<td>12</td>
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<tr>
<td>NDH</td>
<td>Lockett</td>
<td>11/19/12</td>
<td>324</td>
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<td>12</td>
<td>4</td>
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<tr>
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<td>9/26/13</td>
<td>269</td>
<td>7BH</td>
<td>12</td>
<td>0</td>
<td>1</td>
<td>0%</td>
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<td>11/4/13</td>
<td>308</td>
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<td>12</td>
<td>3</td>
<td>4</td>
<td>25%</td>
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<tr>
<td>NDH</td>
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<td>11/22/13</td>
<td>326</td>
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<tr>
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<td>10/2/14</td>
<td>275</td>
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<td>10/7/14</td>
<td>280</td>
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<td>10/20/14</td>
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<td>302</td>
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<td>60%</td>
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Graph: Percent of Leaves Fallen over the Fall for Bitternut Hickory 7 from 2012-2015

- Percent Fallen (2012)
- Percent Fallen (2013)
- Percent Fallen (2014)
- Percent Fallen (2015)
As we can see, since 2013 the tree color started after. This is caused by the climate change because the weather gets warmer and alterate the fenology. Then the three lines goes at the same point but again, the leaves needs more days to change their color because the weather.

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![Graph showing tree color changes](image.png)