Campus Trees Project:
Using Phenology to Engage Students in the Process of Science

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Overview

- Project Context
- Learning Outcomes
- Project Overview – Faculty Perspective
- Project Overview – Student Perspective
- Student Methods
- Common Challenges
- Theme & Variation
- Q&A

Project Context

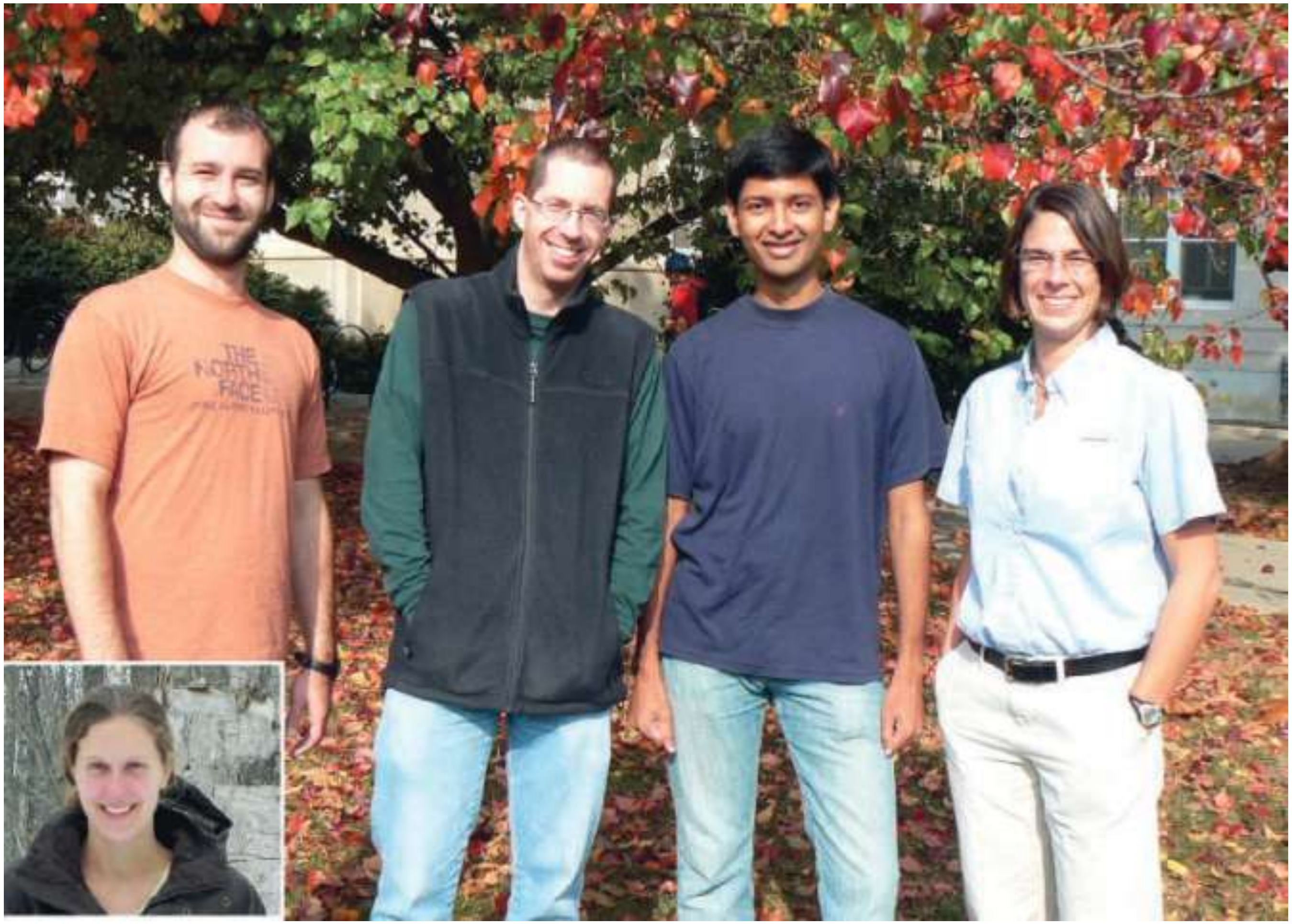
- Student work collaboratively to engage with local phenology on their campus by designing, testing and evaluating original methods.

Engagement in the *process*

- Teaching science as science is practiced (Handelsman *et al.* 2004)
- Reform of "Bio1"

Point of Comparison	Pre-Reform Bio1	Reformed Bio1
Student Role	Passive consumer	Active participant
Faculty Role	Source of knowledge	Guide, coach
TA Role	Passive consumer and doer	Active participants, innovative and drivers of change

Team of TAs



Phenology Team: (L-R) Jeffrey Pierce, Todd Robinson, Mridul Thomas, Sherry Martin & Kristen Schmitt (inset)

Why Phenology?

- Important area of study
- Complex
- Cheap
- Easily accessible to all regardless of location
- Innovation required

Learning Outcomes

- Students will:
  - Observe phenologic variation in a natural system;
  - Develop methods for quantifying and documenting phenologic events;
  - Field-test original experimental methods and evaluate them against alternatives
  - Construct solutions to novel problems that arise in the context of your experiment;

Learning Outcomes

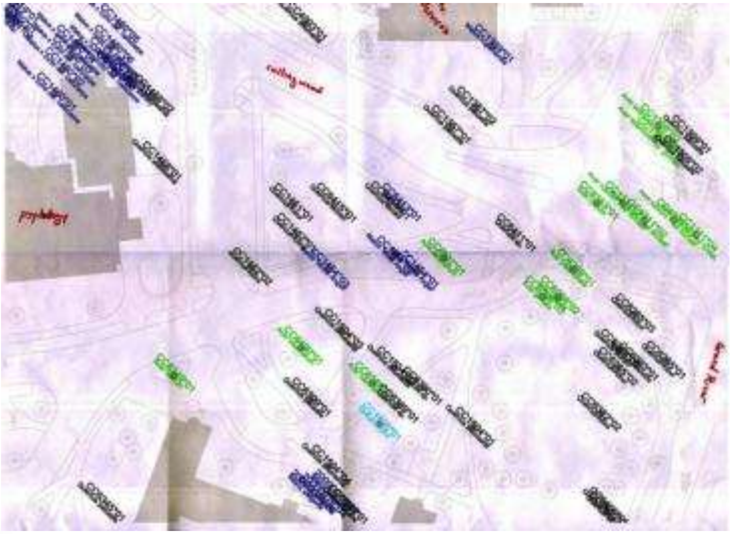
- Students will:
  - Represent, interpret and analyze original data;
  - Communicate findings in written and oral forms; and
  - Participate (as contributor and recipient) in the process of peer review.

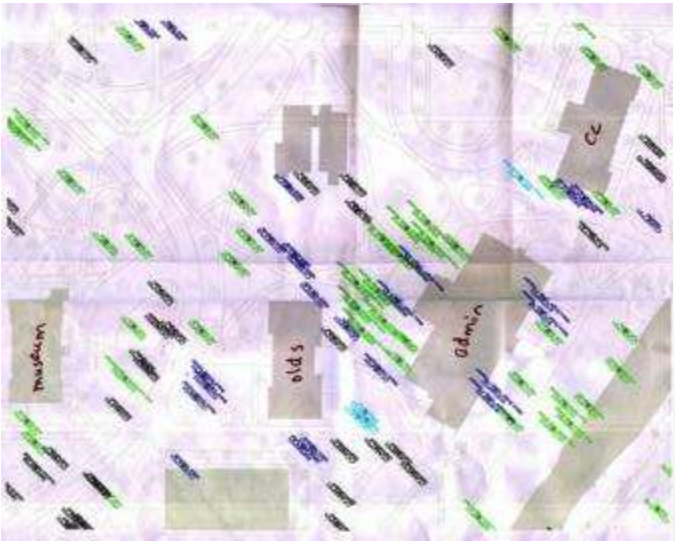
Project Design (Faculty)

- Project timeline
  - 4 weeks – Intro, method development & review
  - 8 weeks – Data collection
  - 1 week – Method review
  - 1 week – Final Poster Session
- Assessment
  - Check points determined
  - Rubrics for each section

Project Design (Faculty)

- Determine "campus" trees
- Narrow down tree genera or species
- Identify trees for the study
- Assign trees to groups
  - Each tree studied by 3 independent groups





Project Structure

- (1) Getting to Know You
- (2) Initial quantitative measures
- (3) Method Design
  - Plan
  - Oral presentation (tools, plan, tables and graphs)
- (4) Peer Review
- (5) Finalized Methods

Project Structure

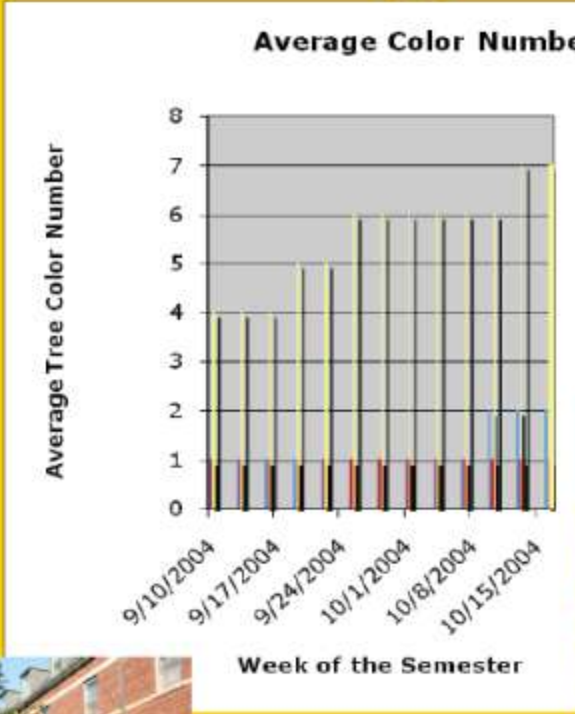
- (6) Data Collection
  - Summary tables & figures
- (7) Peer Review of Methods
  - Review methods for the same tree
  - Compare/contrast with your own
- (8) Final Presentations
  - Method, data, results, evaluation & recommendation

Innovative Methods

- Paint Chips
- Color Wheel
- RGB codes
- Twister spinner
- Tennis ball toss
- Photography
- Digital technology

Final Presentation Examples

Collection Date	Average Tree Color Number Tree 1 (Harriet Beecher Stowe)	Tree 2 (Eleanor Roosevelt)	Tree 3 (Betsy Ross)
September 14	1	1	4
September 17	1	1	4
September 20	1	1	5
September 23	1	1	5
September 26	1	1	6
September 29	1	1	6
October 2	1	1	6
October 5	1	1	6
October 8	1	1	6
October 11	1	1	6
October 14	2	1	7
October 17	2	1	7



Betsy Ross

Eleanor Roosevelt

Harriet Beecher Stowe

TRACKING COLOR CHANGE OVER TIME IN FOUR MAPLE TREES ON BETHEL UNIVERSITY CAMPUS IN THE FALL OF 2010

Introduction and Research Aim:

Phenology is the study of plant and animal life cycle events over time. Phenology detects the way that organisms adapt to underlying changes in the environment. This may provide data for ecosystem and species preservation.

Deciduous trees in temperate climates absorb sugars from their leaves in the autumn and store them in their roots during the winter months. This causes leaves to become dry and brittle and fall from the tree. The process of leaf color change occurs in the fall in temperate climates like Minnesota because the trees cease to replenish their chlorophyll, which is used in photosynthesis. When chlorophyll levels decline, other pigments in the leaves become apparent. The rate of color change is indicative of how quickly a tree is preparing for harsh conditions. Evergreens' leaves are modified into cold-hardy needles, whereas deciduous trees like the four maple trees in this experiment cope with the cold conditions of winter by shedding their leaves.

Our research aim was to track leaf color change in four maple trees on Bethel Campus for seven weeks in September and October. We wanted to determine when and how the colors changed, and if there were any differences among the four trees.

Specimen Description:

The trees we selected for this experiment were the four maple trees on the lowest two tiers of the Hargis park stairs leading up to Royal Stadium on Bethel University Campus. These trees all appear to be planted as landscaping plants. The numbers we assigned to each tree are listed below in **Figure 1.**

Figure 1. *The four Hargis Park Maple Trees*

Acknowledgements: Dr. Sara Wyse

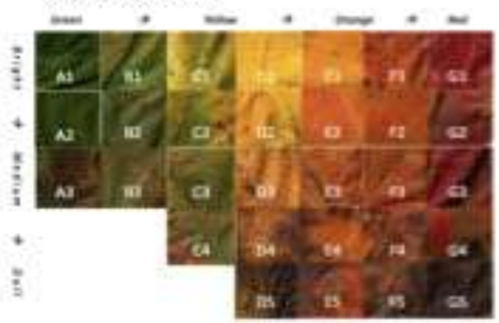
Method for determining leaf color change:

Once a week, beginning September 9, 2010, we went to the Hargis Park steps by the Royal Stadium on Bethel University campus and collected leaves from the four trees (see specimen description) for documentation. First, we took a picture of the trees from the lower level of the steps to use as a point of reference for overall tree color and leaf drop. Then for each tree, we visually estimated the average leaf color and selected two leaves from each tree that were representative of the tree's average color.

Each week, we wrote the tree's number on the back of each leaf with a pen during collection, scanned the leaves in pairs, and labeled the scanned photos with the tree number and the week number. The image of the scan often had a color that was different than the actual leaves, so each scan had to be recolored in iPhoto using tint, temperature, exposure, contrast, and/or saturation to make the scan true to color. All scans and color adjustments were made within one hour of taking the leaf from the tree. These scanned photos were arranged into **Table 1.**

We created a "color square," shown in **Figure 2**, by selecting 30 various hues that we found on our leaf scans. From right to left, we arranged our hues from green to yellow to orange to red. From top to bottom we arranged our hues from bright to dull. Then from right to left, we labeled the squares with letters from A-G, and from top to bottom with numbers from 1-5. There are five 'blank' squares in the bottom left corner because it was difficult to find green and yellow leaves that were also dull. We used our color square to choose the average representative color for each pair of leaves from Table 1. The representative color, labeled with a letter and a number, was taken from the color square and arranged into **Table 2.** Table 2 is a summary of Table 1 in which leaf colors have been quantified. For further research, we recommend using the same color square so that the same numbers are indicative of the same color.

Figure 2. *Color Square*



Results:

Table 1. *Leaf Color Change over Time for Four Maple Trees*

Table 2. *Average Leaf Color Change over Time for Four Maple Trees*

	Sept. 9	Sept. 16	Sept. 23	Sept. 30	Oct. 7	Oct. 14	Oct. 21
Tree 1	A1	A1	A1	B1	C1	D4	E2
Tree 2	A2	A1	B2	C3	C4	D3	F3
Tree 3	A2	A2	A2	C2	C3	E3	D5
Tree 4	A1	A1	A2	B3	F3	F4	D3

Conclusions and Recommendations:

From **Table 1** we observed that leaf color does not appear to flow smoothly from green to yellow to orange to red as expected. Rather, red pigment sometimes appears on an otherwise green leaf (Tree 3, Sept. 23; Tree 2, Oct. 7), and transitions from bright yellow directly to brown were observed (Tree 3 from Oct. 14-21).

From **Table 1** we also observed that at week 5, all four trees still had traces of green chlorophyll, at week 6, only two trees contained traces of green, at week 7, no green traces remained, and by week 8 (October 21, 2010), all four Maple trees were leafless or nearly leafless. In some leaf samples (Tree 4, Oct. 14) nearly every color on our color scale was present on just two leaves. This result was interesting but it made "average color" determination difficult.

From our analysis of **Table 2**, it appears that once the leaf color moved past the green "A" color column, leaf color changed dramatically. Only Tree 1 followed the ABCDE pattern. None of the leaves had an average color in the "G" column of our color square. The date of leaf drop appears to correlate more strongly with the week than with leaf color, as the average leaf color at week 7 was different for each tree.

Due to rapid color change and leaf loss, we recommend that if the experiment were to be performed again, leaf collection should occur at least twice a week to increase precision. We also recommend taking temperature and precipitation data every day.

Overall, as a group we were very pleased with our choice of method. It was not overly complicated, and with the creation of the color square chart, further studies will be even simpler. Ultimately, we would recommend our method to future groups. Our only caution is that a scanner and photo editing software such as iPhoto are absolute necessities with this method. We recommend the use of digital color documentation because leaf pigments can break down and change over time.

Figure 6: Trees 2, 3 and 4 follow a more similar trend of leaf drop as compared to tree 1 which had the most percentage of leaves to start with and had the fastest rate of leaf drop.

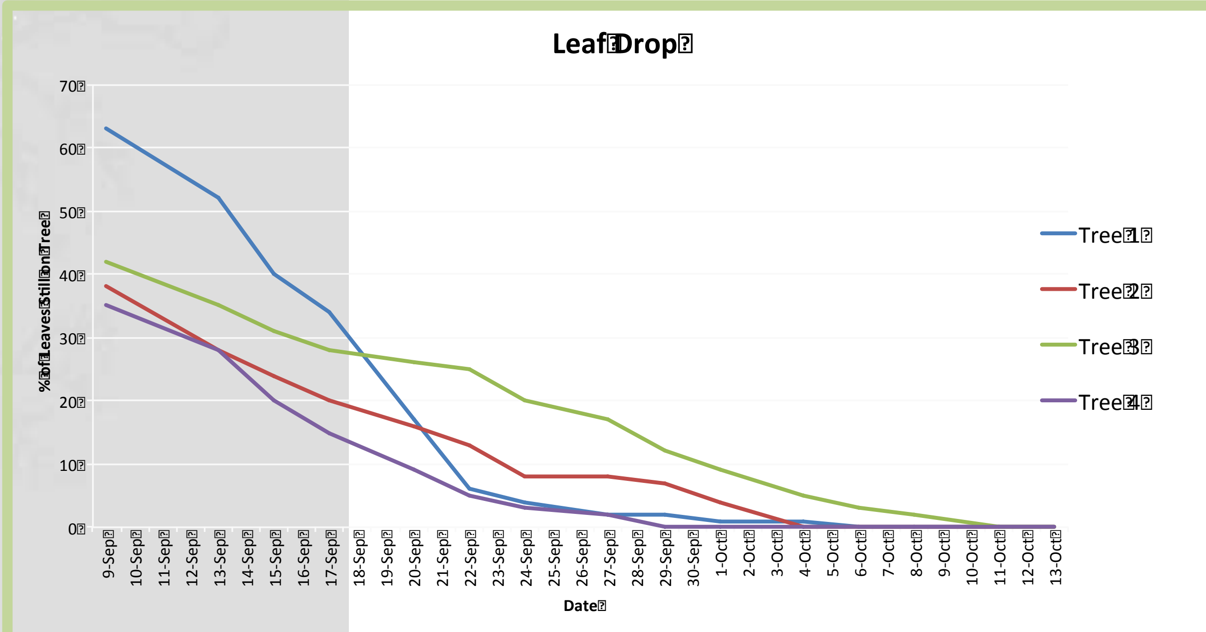
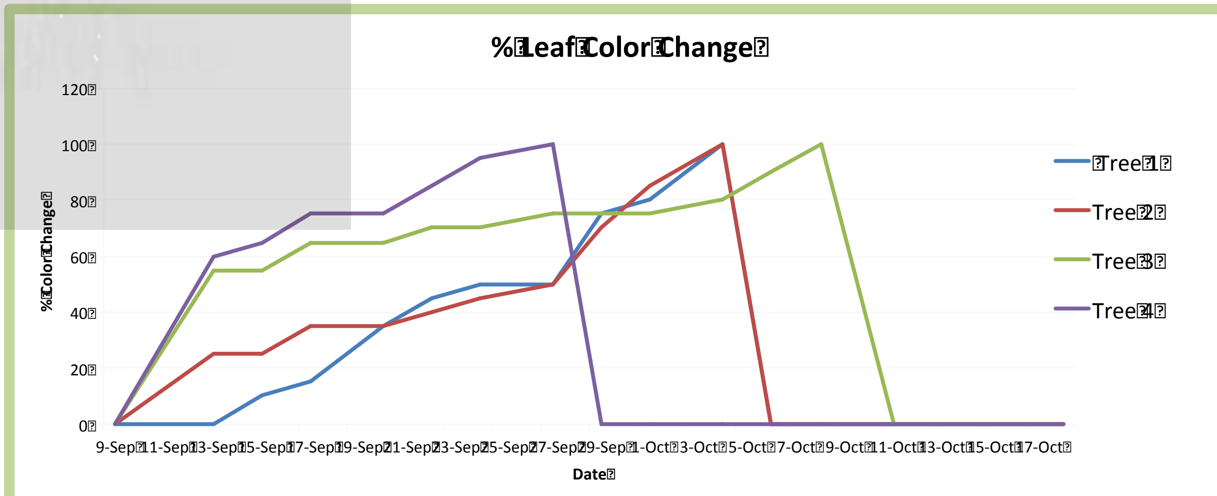


Figure 7: Even though tree 3 and tree 4 very fairly close to each other, tree 4 had the quickest leaf color change and took a significantly shorter time to change color than tree 3. Whereas, trees 1 and 2 have very similar rates of color change.



Critique of Methods

Our Method vs. Best Method – Quality of Data

- Team 3D Dinosaurs > Team Ice Cream
  - Following Team 3D Dino's method would produce more accurate results, as leaf loss on a windy day would be taken into account differently than it would be by our method.
    - Theirs: Strong wind last night = less leaves; Ours: Oh, there's suddenly no leaves on our tree this morning.

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Recommendation for Method

For the Fall of 2009 the best method to use would be the aspects of our method. The one thing we would change would be to find a branch and counting the number of leaves on a specific branch, once a week and then multiplying the number of leaves by the number of branches for each week. This is very tedious, but it is a more accurate way in representing the percentage of leaf fall for each tree.

Common Challenges

- Wind storm blowing all leaves off the tree
- Cloudy vs. sunny days for data collection
- Grounds crew pruned off sampling branches
- Grounds crew cleaned up leaves
- Grounds crew removed tree entirely!

Variations

- Spring
  - Bud Break
  - Greening of grass
  - Spring ephemerals
  - Bird songs/sightings
  - Frog choruses
  - Insect emergence (aquatic, terrestrial)
- Smaller schools – fewer tree species, choose tree locations strategically
- Cellular & Molecular Scale
  - Flagella motion

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Q & A