The Tecumseh Research and Education Transect (TRET)

PRESENTED BY
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Outline

- Partnering Organizations
- TRET
- The Research
- The Education
- Questions

Sponsoring Organizations

- Margret & H.A. Rey Center
  - www.thereycenter.org
- Plymouth State University's Center for the Environment
  - www.plymouth.edu/cfe

TRET

- A cooperative research and education initiative of the Rey Center and PSU's Center for the Environment
  - Integrates scientific research and place-based education
    - *Research goal* is to contribute to regional efforts to predict the impacts of climate change on northeastern forests.
    - *Educational goal* is to use phenology to inform students and the public about the probable consequences of climate change on the region's forests and to encourage their interest in and support for monitoring the outcome.

The Research

- Background
- Methods
- Results
- Conclusions – Discussion
- Ongoing work

Background: What is Phenology?

- Phenology is the study of recurring plant and animal life cycle events
  - Biodiversity
  - Timing determines growing season length

- "Phenology…is perhaps the simplest process in which to track changes in the ecology of species in response to climate change."
  (IPCC, 2007)

Background: What is Phenology?

- Phenological observations include some of the oldest collected biological recordings

  (Sparks and Carey, 1995; Schwartz, 1999; Badeck *et al.*, 2004).

  - Asia – oldest records
  - Europe – one or more centuries
  - U.S. – older records spotty and discontinuous
- Phenological observations were the pursuit of farmers and naturalists

Background: Temperature

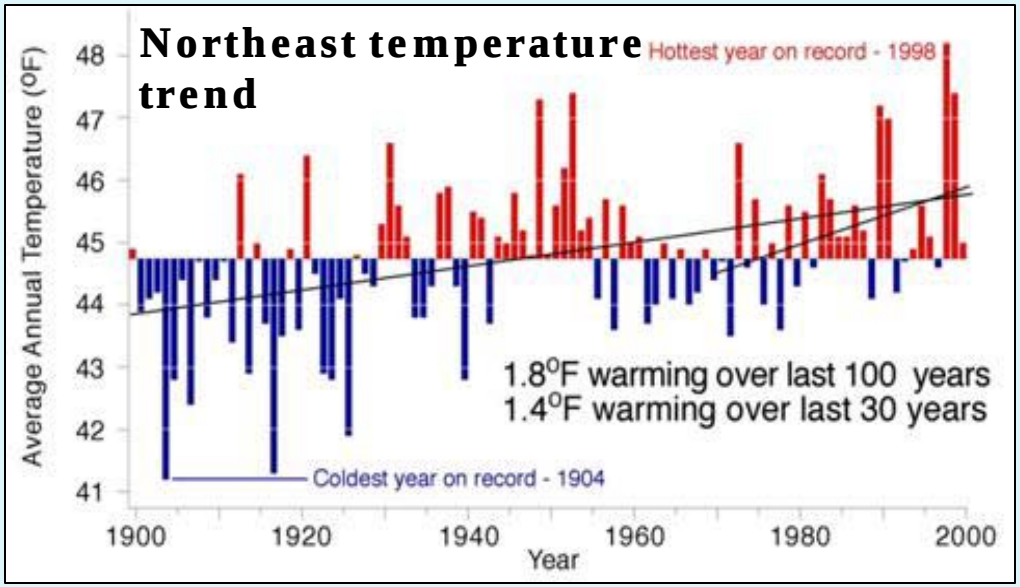
- Temperature has the most influence on the timing of phenophases in plants
  (Lechowicz, 1984)
- In assessing plant phenology, a thermal time approach is often used
  - Assumes that certain phenological events occur when a certain amount of thermal time or accumulated degree-days (ADD) has been reached

Background: Climate Change

- Global climate change will alter phenology because temperature influences the timing of development in plants.

•Global temperature has increased 0.6 to 0.9°C over past 200 years

•Global temperature is projected to increase 1.1 - 6.4°C by the end of the 21st century
(IPCC, 2007)



•Predicted increase of 4°C this century
(NECIA, 2007)

Background: Phenology – Evidence of Change

GLOBAL

Root *et. al.* (2003) – advancement in spring of 5.1 days over 50 years

Parmesan *et.al.* (2003) – advancement in spring of 2.3 days over 17 years

Visser and Both (2005) – advancement in both bird and plant phenology, which is often mismatched

REGIONAL

Fitzjarrald *et al.* (2001) – advancement in spring of 4–6 days in eastern NA over the past 50 years

Several horticultural and agricultural studies – advancement of 2-8 days over last 30 years in northeast (Schwartz & Reiter, 2000; Wolfe et al., 2005)

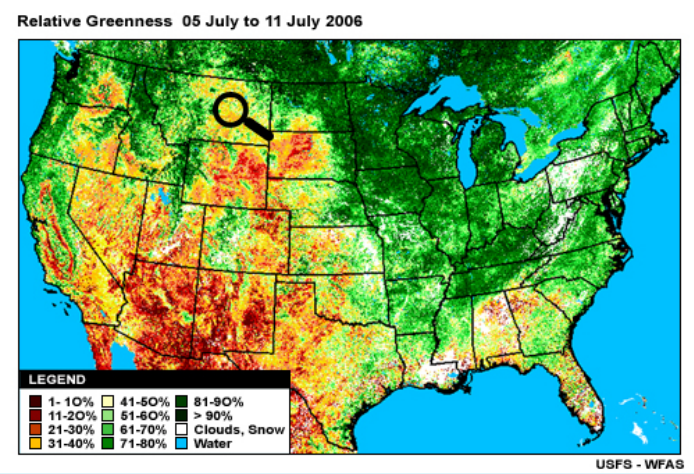
Richardson *et al.* (2006) - advancement in spring of 1-2 days over last 50 years at Hubbard Brook in Thornton, NH

Background: Phenology Research Methods

- The study of phenology is mainly guided by two independent methods:
  - Remote Sensing
  - Ground Observations

Background: Phenology Research Methods

- Remote Sensing
  - Satellite technology
  - Measures greenness – uses reflective/absorption characteristics of plants
    - Start, duration, peak, and end of a growing season
  - Covers large areas at coarse scales



Limitations

- Not as useful in regions with no clear growing season
- Atmospheric interference

Background: Phenology Research Methods

- Ground Observations
  - Provides precise observations on individual plant species
    - Measures the onset and duration of phenophases
  - Species specific – species will vary in their response to climate change
  - Can help account for microclimate and topographical variables that affect phenology

(Source: University of New Brunswick, Forestry and Environmental Management)

Limitation

•Small spatial scale – Does not provide an integrated (forest canopy) response pattern

Background: Phenology Research Methods

- Bridging the gap
  - The development of ground observation protocols specific to validating remote sensing phenology
  - Increase in ground observation networks
    - USA-NPN, Project Budburst, PlantWatch (Canada), Nature's Calendar (UK), Appalachian Mountain Club, Botanical Gardens
  - Increase in research sites monitoring phenology
    - Hubbard Brook, Vermont Monitoring Cooperative, NPS, PSU, Appalachian Mountain Club

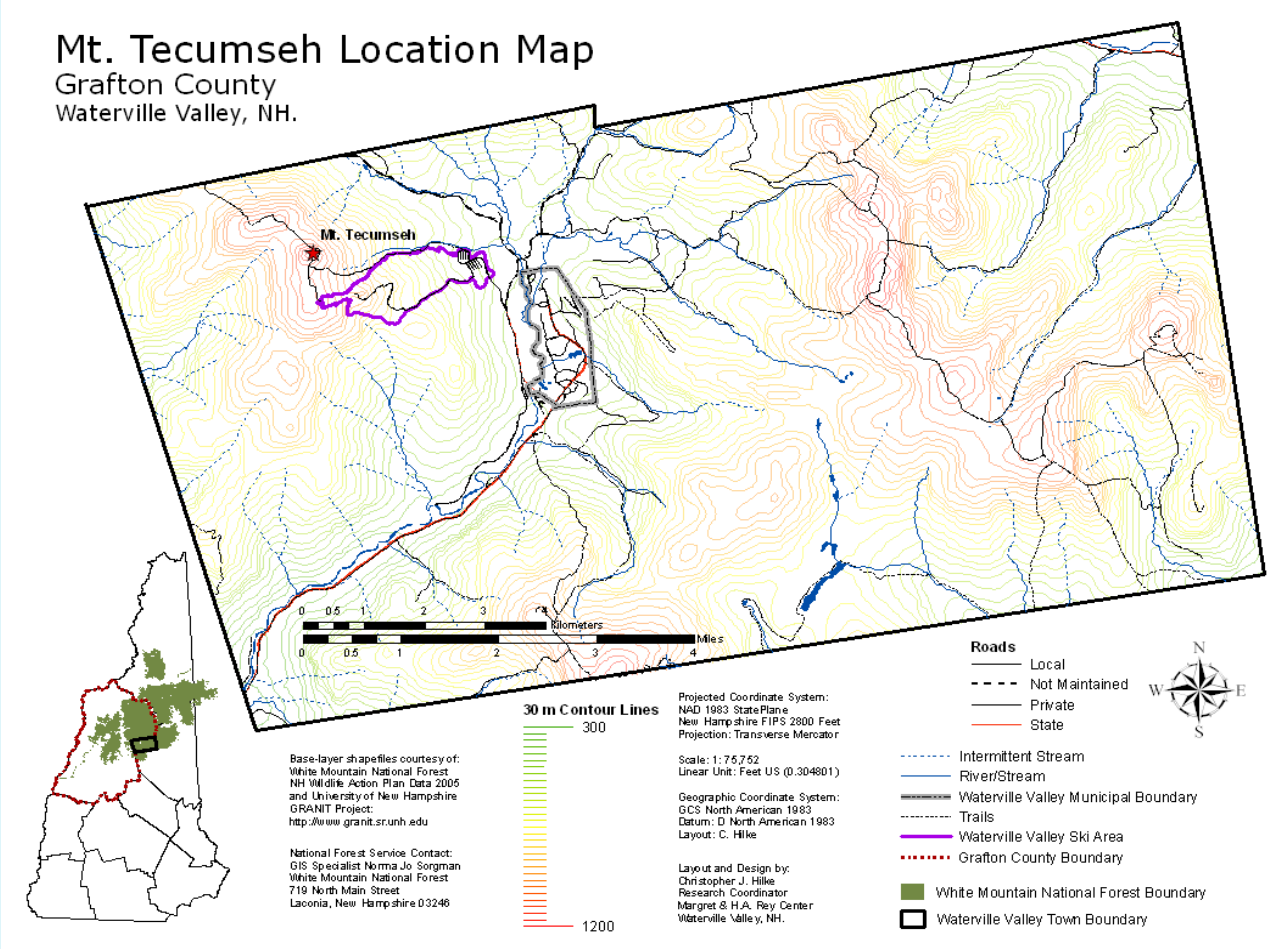
Mount Tecumseh Research Transect

Mountain elev.: 1,220 m

Transect spans: 3.94 km

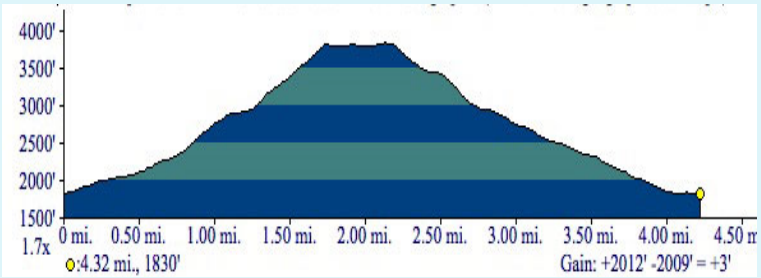
Elev. gain: 569 m

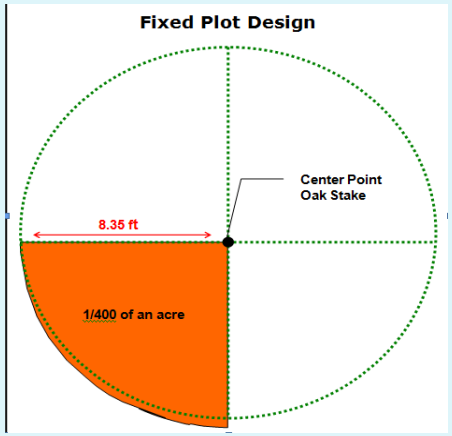
Aspect:
Easterly/southeasterly



Methods: Vegetation Monitored

- 28 Trees
  - 20 Northern hardwoods
    - Species: Sugar Maple, American Beech, Yellow Birch, Paper Birch
  - 8 Conifers
    - Species: Balsam Fir and Red Spruce
  - 6 Circular, herbaceous plots delineated at different elevations
    - 6 Herbaceous species are monitored





Methods: Vegetation Data Collection

- USA-NPN Protocols (2008)
  - Initial through 100%
- 1x – 2x weekly in season

Deciduous Tree Data Collection Sheet Date:

		Physical Characteristics			Leaf Color Change					Leaf Fall				
Tag #	Species Code	Snow on ground	Snow on trees	Visible frost damage	First leaf color	25% leaf color	50% leaf color	75% leaf color	All leaves colored	First leaf fall	25% leaf fall	50% leaf fall	75% leaf fall	All leaves fallen
		fill in Y (yes) or N (no)			* fill in X (did not check); N (not reached); Y (reached); M (missed)									
1	Beal													
2	Fagr													
3	Beal													
4	Fagr													
26	Acsa													
5	Beal													
6	Beal													
27	Fagr													
28	Acsa													
11	Acsa													
29	Fagr													
10	Acsa													
13	Bepa													
14	Beal													
30	Fagr													
31	Acsa													
16	Acru													
18	Beco													
20	Beco													
23	Beco													
32	Beco													

Notes:

Methods: Vegetation Data Collection

- Equipment:
  - Spotting scope in spring (60x)
  - Visual aids
  - Written phenophase descriptions

American Beech

Leaf Color Change

First leaf colored

In at least 3 locations on the plant, the green leaves have begun to change to their late season colors.

25% of leaves colored

For the whole plant, one-quarter (25%) of the leaves (including any that have fallen to the ground) have changed to their late season colors.

Sugar Maple at budburst
(Photo source: University of New Brunswick, Forestry and Environmental Management)

Methods: Temperature Data Collection

- 5 Microclimate dataloggers
  - Air and soil temperature
- Lorenz Weather Station
  - 1148 m
  - Meteorological data
  - Image data

Methods: Data Analysis

- Phenophase events analyzed:
  - Spring – budburst & leaf elongation progression (LE)
  - Autumn – first leaf color & leaf color progression (LC)
    first leaf fall & leaf fall progression (LF)

- Occurrence values compared:
  - Day-of-year (DOY) – day of year of a phenophase occurrence
  - Accumulated degree-days (ADD) – amount of accumulated degree days achieved at phenophase occurrence
    - (Max temp + Min temp)/2 – Base temp = ADD

Research Objectives

- Gather data on the timing of basic phenological stages of trees and plants along an elevation gradient

- Correlate the relationship between the vegetation data and air temperature to determine the threshold temperatures responsible for triggering phenophases (e.g, budburst, first leaf color)

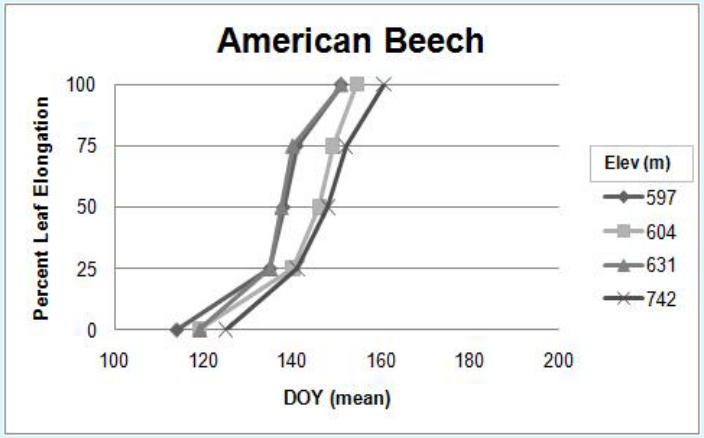
Research Questions

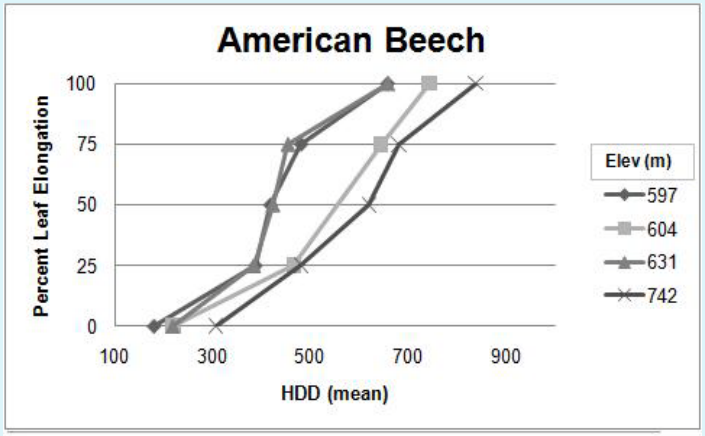
- Is there evidence of variation in the phenology of trees relative to either temperature or day-of-year?
- Is there evidence of trends in the variation of the phenology of trees relative to their location along an elevation gradient?
- Is the phenology of trees representative of regional phenological trends?

Results: General Species Patterns

Spring – Leaf Elongation

- % LE/DOY
  - Lowest tree first to budburst and highest last – same progression for 100% LE
  - Elevation pattern not held with middle trees
- % LE/ADD
  - Same pattern in progression but not as tight



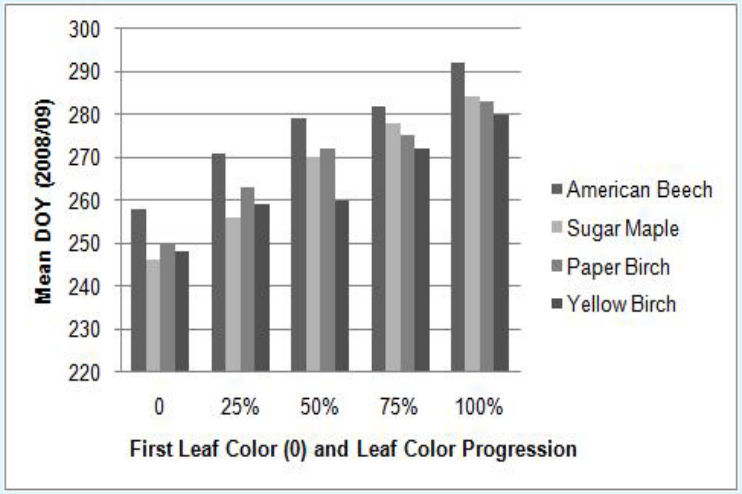


Results: Comparison Among Species

DOY

- **First LC:** sugar maple, yellow birch, paper birch, and American beech

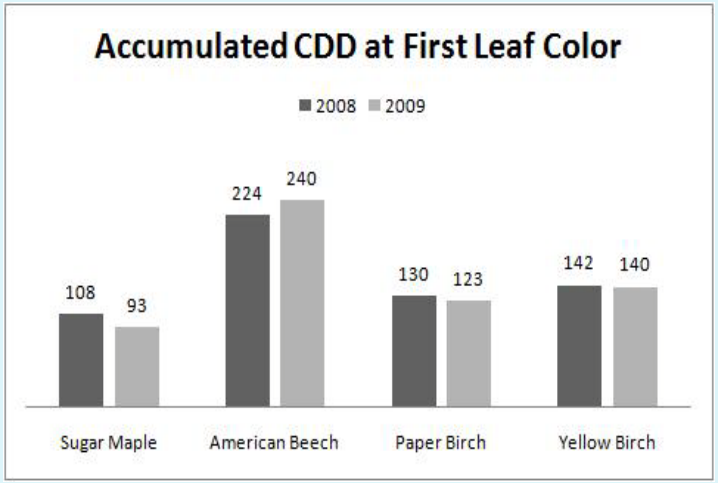
- **100% LC:** yellow birch, paper birch, sugar maple, and American beech

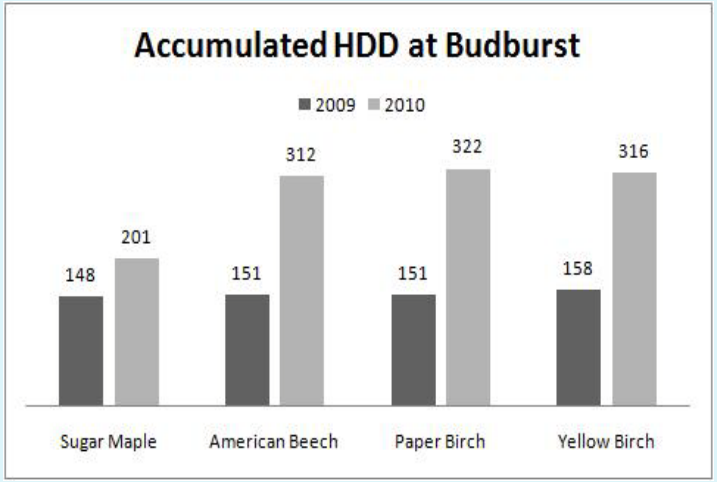


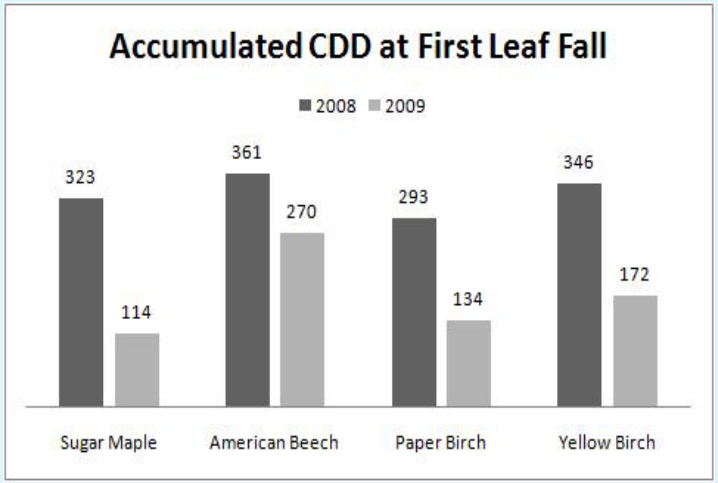
Results: Threshold Temperatures

Year-to-Year Differences in ADD

- Mean ADD were calculated using two years of spring and autumn temperature values.
- A significantly warmer spring resulted in much higher ADD in 2010







Discussion & Conclusions: Elevation Trends

Elevation Trends:

- Spring comes later and autumn sooner at higher elevations on Mount Tecumseh.
- This trend in phenology is in accord with a noted delay in spring and the advance in autumn calculated along the elevation gradient.
  - On Mount Tecumseh we calculated a delay in spring of 0.93 days/30 m in elevation gain and a delay in autumn (1.46 days/30 m in elevation loss).
- Mid-elevation trees did not always follow this trend.

Discussion & Conclusions: Species Variations

- Recent phenological studies of northern hardwood trees and their phenology have indicated variation in the timing of phenological events across species.
  - Hubbard Brook Experimental Forest, Thornton, NH (1989 – 2002) (Richardson, et al., 2006)
  - Vermont Monitoring Cooperative, Mount Mansfield, VT (1992 – 1995) (Wilmot, et al. 1995)

Discussion & Conclusions: Species Variations

Species Trends – Regional Variations:

- Results on Mount Tecumseh confirmed the order of progression of spring and autumn phenology for several northern hardwood tree species as evidenced at Hubbard Brook.
- There is a marked advance in spring phenology and a delay in autumn, evidenced by comparison between Mounts Tecumseh and Mansfield.

Ongoing Work

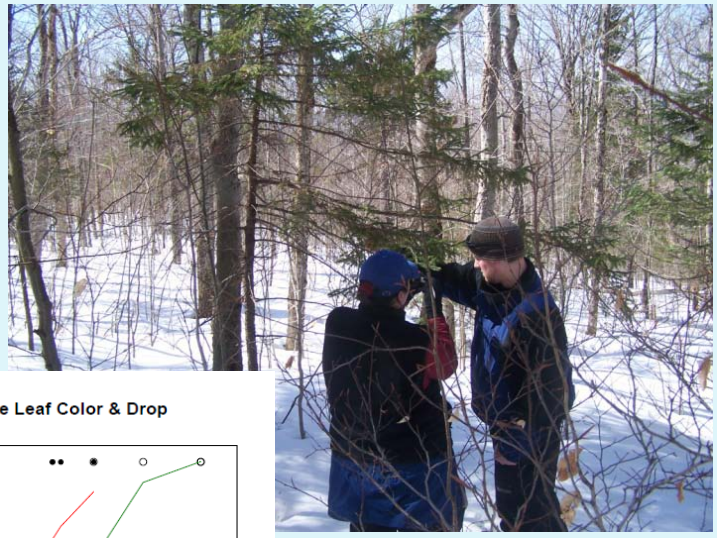
- Fourth year of observation
- Analyze affects of other factors that influence phenology (microclimates, age, species origin, temperature gradients)
- Continue analysis of data in context of other regional phenology datasets
- Develop validation methods to test accuracy of observer records

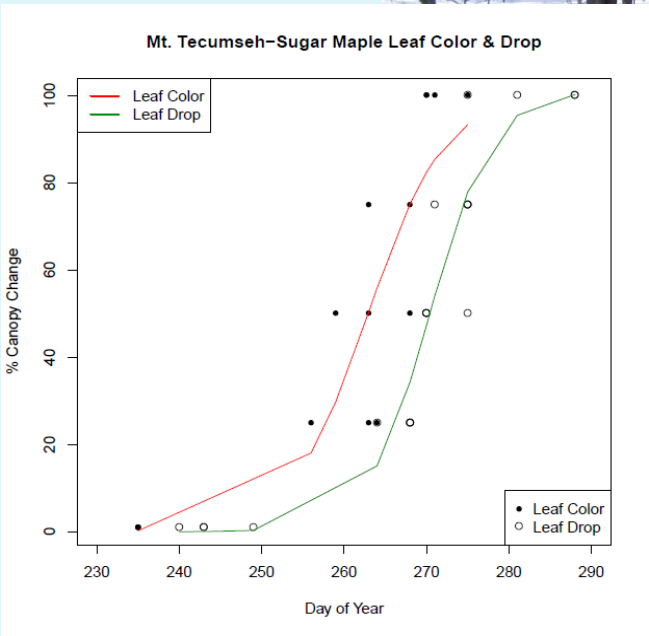
The Education

- Graduate student research
- Applied education and internship opportunities
- In the classroom
- Informal public education and citizen science

The Education

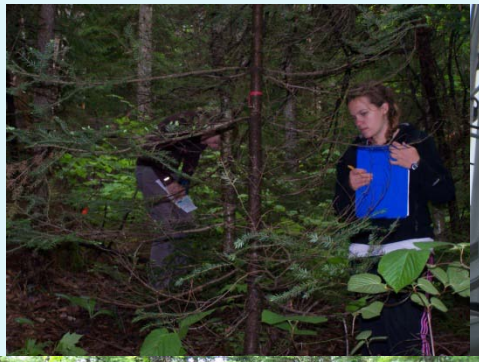
- Graduate student research
  - Establishing protocols
  - Establishing baselines
  - Modeling phenology

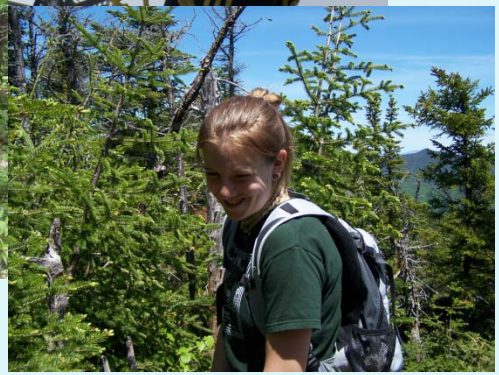




The Education

- Applied education and internship opportunities
  - Field methods and observations (11 undergraduate students)
  - Weather station operations (3 graduate students)
- Projects
  - Digital botanical library
  - Weather data display
  - Mountain weather curriculum
  - Symposium presentations





The Education

- In the classroom
  - Phenology and Climate Curriculum
    - Middle school to high school students
      - Basic principles that cause the physical change of forest vegetation due to seasonality
      - Use of real-time data to create and comprehend visual graphs and charts
      - Basic principles of scientific inquiry and the formation of a testable scientific question
    - Provides teacher training and support for continued observations in-field or on school grounds
    - Coos County Outreach Initiative support for North Country implementation

The Education

- Informal public education and citizen science
  - Tecumseh Overnights
    - Place-based environmental education
      - Citizen science
      - Mountain ecology
      - Climate change
      - Astronomy




Ongoing Work

- Continue to create opportunities for graduate and undergraduate students
- Expand the implementation of the Phenology and Climate curriculum in the classroom and in the field
- Develop a citizen science program to support the long-term collection of phenology data

Acknowledgements

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Questions?