Climate Change and Vegetation Phenology
Climate Change

- In the Northeastern US mean annual temperature increased 0.7°C over 30 years (0.26°C per decade)
- Expected another 2-6°C over next century (Ollinger, S.V. “Potenail effects of climate change and rising CO2 on ecosystem process in northeastern U.S. forests)
Why does it matter?

- Impacts on plant productivity
- Competition between plant species
- Interaction with other organisms
- Food production
- Shifts in agricultural
- Pest and disease control
- Pollen forecasts
- Carbon balance of terrestrial ecosystems
- Feedback into atmosphere
- Water, energy exchange
- Timing of migrations and breeding
- other ideas?
Phenology is the science that measures the timing of life cycle events in all organisms. Plants tell a story about climate... Listening to the story they tell year after year can tell us about climate change.
Plants provide an excellent context to understand changes in the environment. They are extremely sensitive to:

- temperature change
- precipitation change
- growing degree days
Phenology: A glimpse of ecosystem Impacts

Some potential effects:

- Wildlife populations
- Vegetation health
- Species composition and ranges
- Water availability
- Nutrient cycling and decomposition
- Carbon storage
Measuring Phenology

Field Observations

Satellite Remote Sensing
How do scientists monitor vegetation phenology?

- Intensive Sites
- Spatially Extensive Science Networks
- Spatially Extensive Volunteer & Education Networks
- Remote Sensing and Synoptic (wall-to-wall) Data

Tier 1: Field Based
Tier 2: Satellite Based
Tier 3: NWS Coop, NPS Inv. & Mon., State Ag. Exp. Sta.
Tier 4: Nature Preserves, Campuses, NASA, USGS, NOAA

Decreasing Spatial Coverage → Increasing Process Knowledge → # of Measurements
Measuring Phenology on the ground

Field Observations
Timing of sugar maple leaf drop
Monitored at Proctor Maple Research Center
Hemispherical Photography

Helps us “see” the canopy as a satellite might see it
Hemispherical Imagery

- Scientists spend big bucks to purchase the equipment and software necessary to link ground measurements with satellite imagery.
- Calculate canopy closure, transparency, leaf area index, vegetation indices, gap fraction, etc.
Measuring Phenology

Satellite Remote Sensing

Land surface phenologies in 2000 revealed by three AVHRR biweekly composites.”
From USA National Phenology Network (USANPN)
How do you see phenology from space?

- Chlorophyll, strongly absorbs visible light for photosynthesis.
- Leaf cell structure reflects near-infrared light.
- NDVI exploits these characteristics of vegetation reflectance to quantify how much, how dense and how productive vegetation is.

Normalized Difference Vegetation Index (NDVI)

- Negative values of NDVI correspond to water.
- Values close to zero correspond to barren areas of rock, sand, or snow.
- Low, positive values represent shrub and grassland.
- High values indicate temperate and tropical rainforests.
What would this NDVI curve look like?
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NDVI for Phenological Dates

comparison of NDVI values for different dates

- http://www.seiswaves.com/cappelluti/docs/anims/leicester/
Plotting NDVI
Use of NDVI to identify key phenological dates

Maximum NDVI
Rate of Greenup
Time Integrate d NDVI
End of Season
Rate of Senescence
Duration of Season
Start of Season
How do you determine dates?

Use of NDVI thresholds to identify key phenological dates

Start of the Season

Common Thresholds

0.5 of the Max:Min NDVI ratio to approximate the start and end of the season.
50% Threshold (Seasonal Mid-point)

(White et al., mean day = 124, May 4th)
## Other key phenological dates

<table>
<thead>
<tr>
<th>RSP Data Set</th>
<th>Acronym</th>
<th>Phenological Interpretation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start of Season – Time</td>
<td>SOST</td>
<td>Beginning of measurable photosynthesis in the vegetation canopy</td>
<td>Day of year identified as having a consistent upward trend in time series NDVI</td>
</tr>
<tr>
<td>Start of Season – NDVI</td>
<td>SOSN</td>
<td>Level of photosynthetic activity at the beginning of measurable photosynthesis</td>
<td>NDVI value (or baseline) identified at the day of year identified as a consistent upward trend in time series NDVI</td>
</tr>
<tr>
<td>End of Season – Time</td>
<td>EOST</td>
<td>End of measurable photosynthesis in the vegetation canopy</td>
<td>Day of year identified at the end of a consistent downward trend in time series NDVI</td>
</tr>
<tr>
<td>End of Season – NDVI</td>
<td>EOSN</td>
<td>Level of photosynthetic activity at the end of measurable photosynthesis</td>
<td>NDVI value corresponding with the day of year identified at the end of a consistent downward trend in time series NDVI</td>
</tr>
<tr>
<td>Time of Maximum</td>
<td>MAXT</td>
<td>Time of maximum photosynthesis in the canopy</td>
<td>Day of year corresponding to the maximum NDVI in an annual time series</td>
</tr>
<tr>
<td>Maximum NDVI</td>
<td>MAXN</td>
<td>Maximum level of photosynthetic activity in the canopy</td>
<td>Maximum NDVI in an annual time series</td>
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</tbody>
</table>