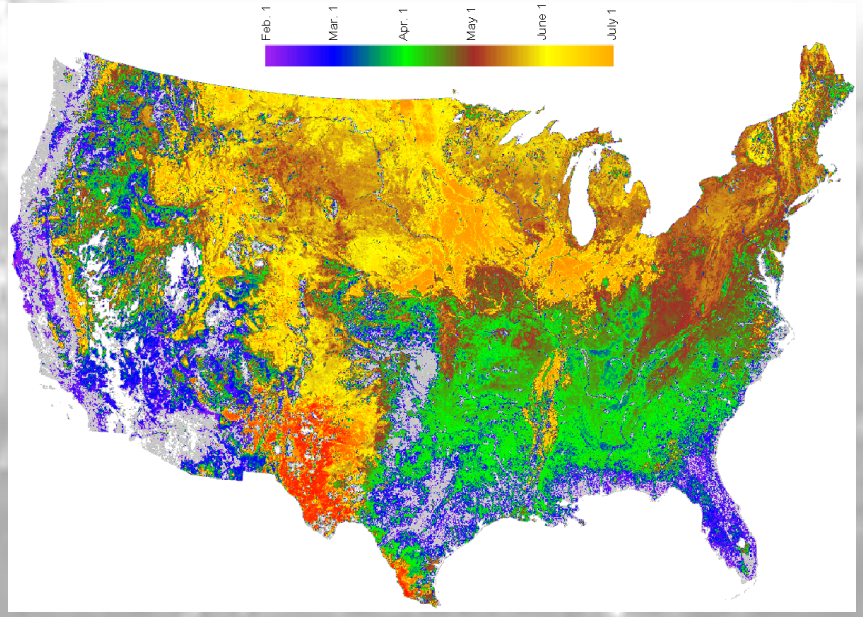
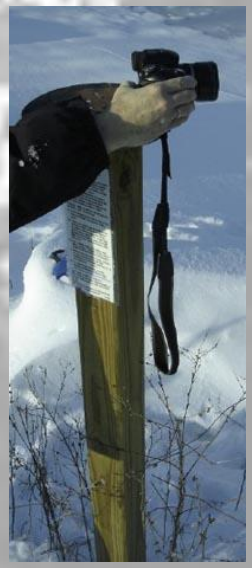
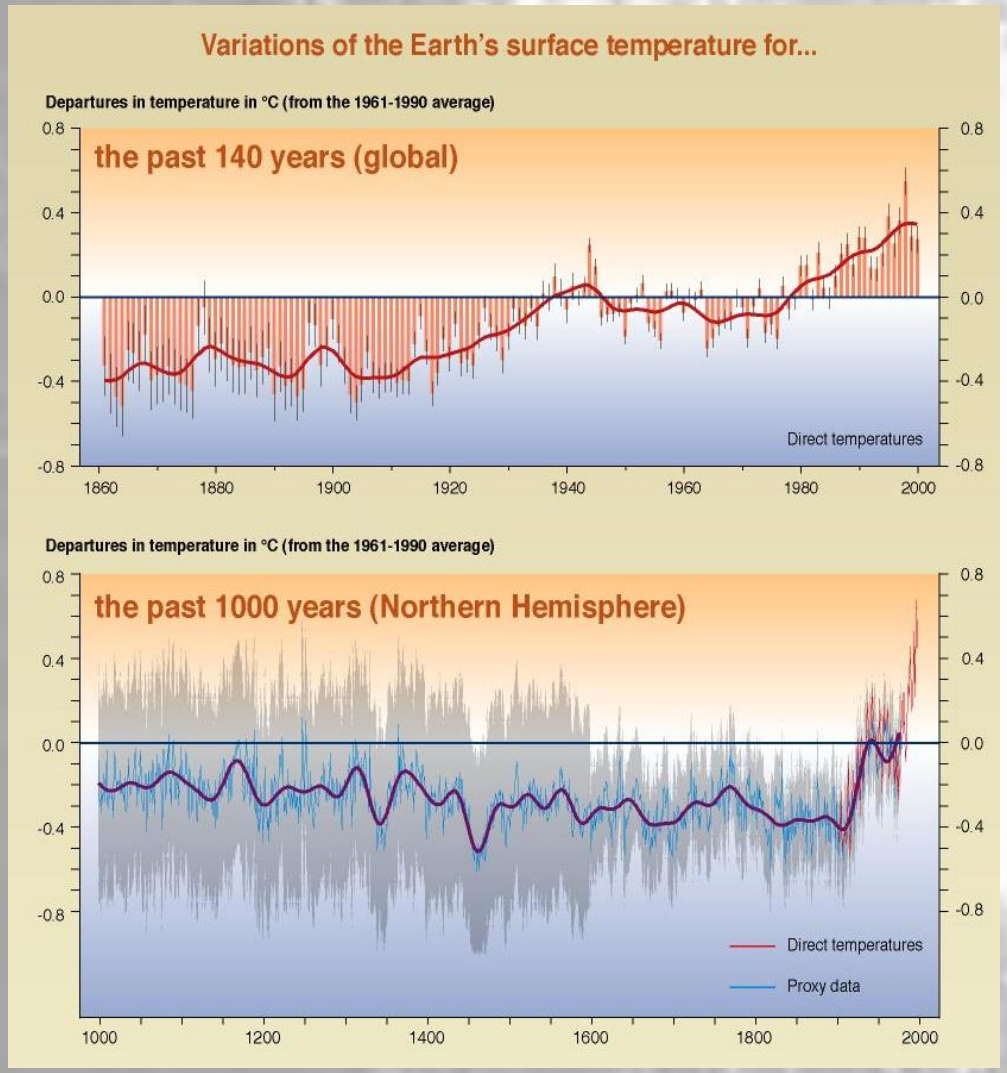
Climate Change and Vegetation Phenology





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……

Earlier Springs

Listening to the story they tell year after year can tell us about climate change

Later Falls

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

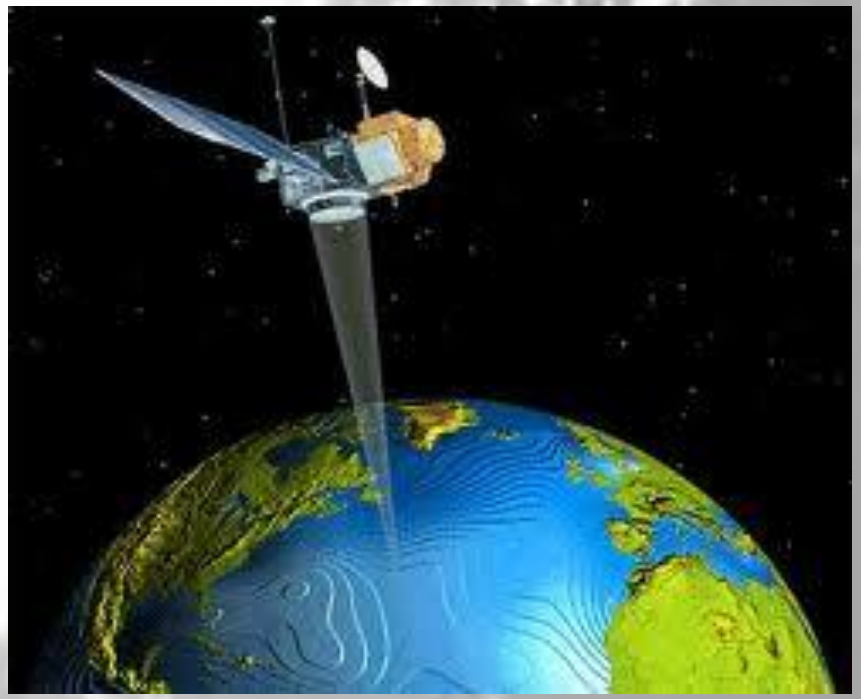
Some potential effects:

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

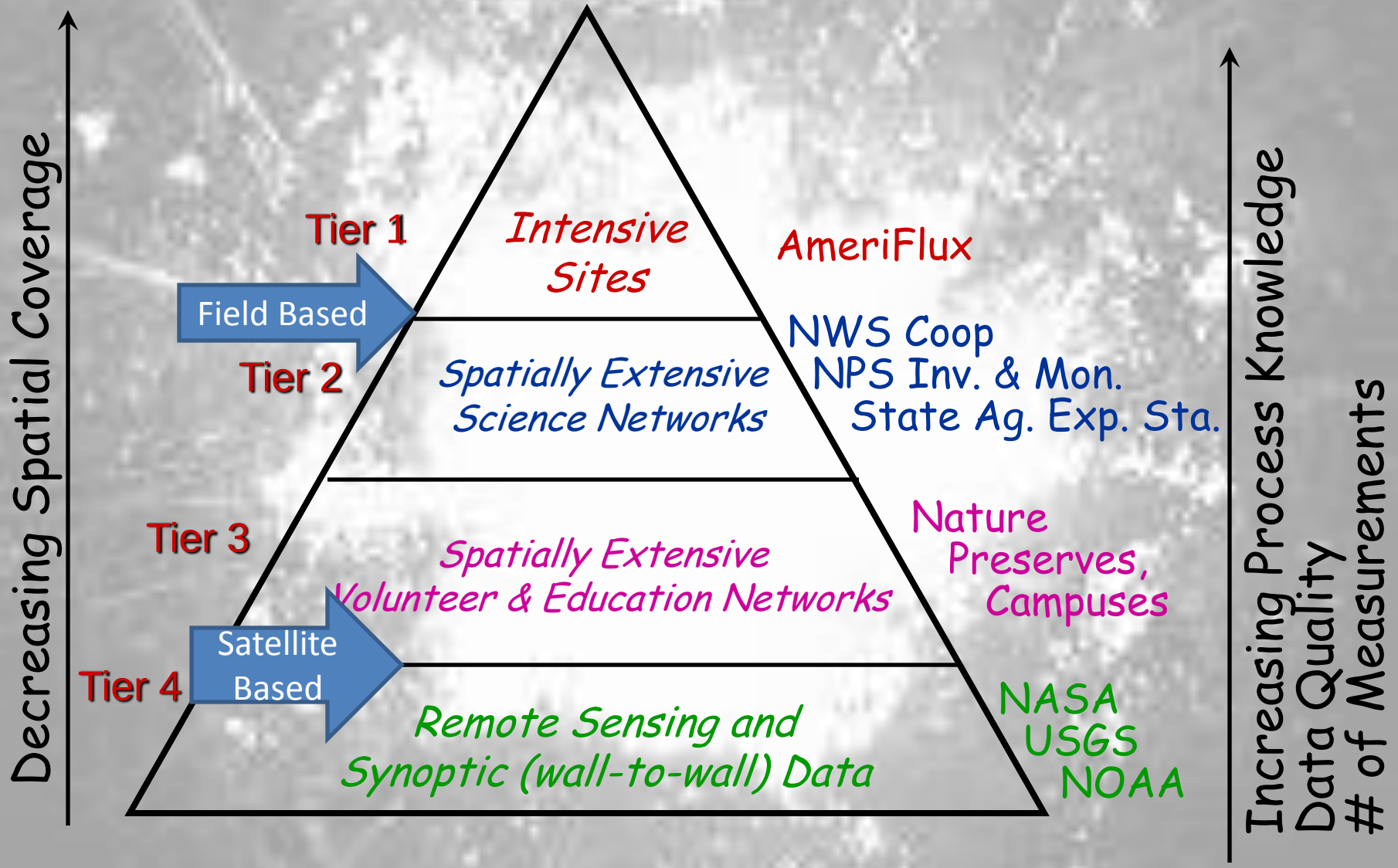
Measuring Phenology

Field Observations

Satellite Remote Sensing

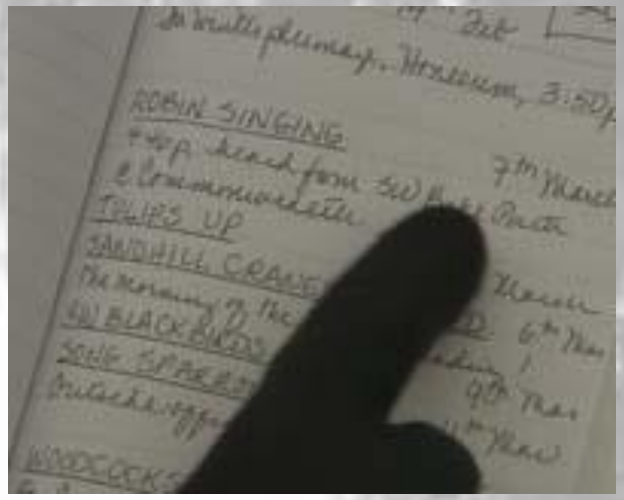


How do scientists monitor vegetation phenology?



Measuring Phenology on the ground

Field Observations

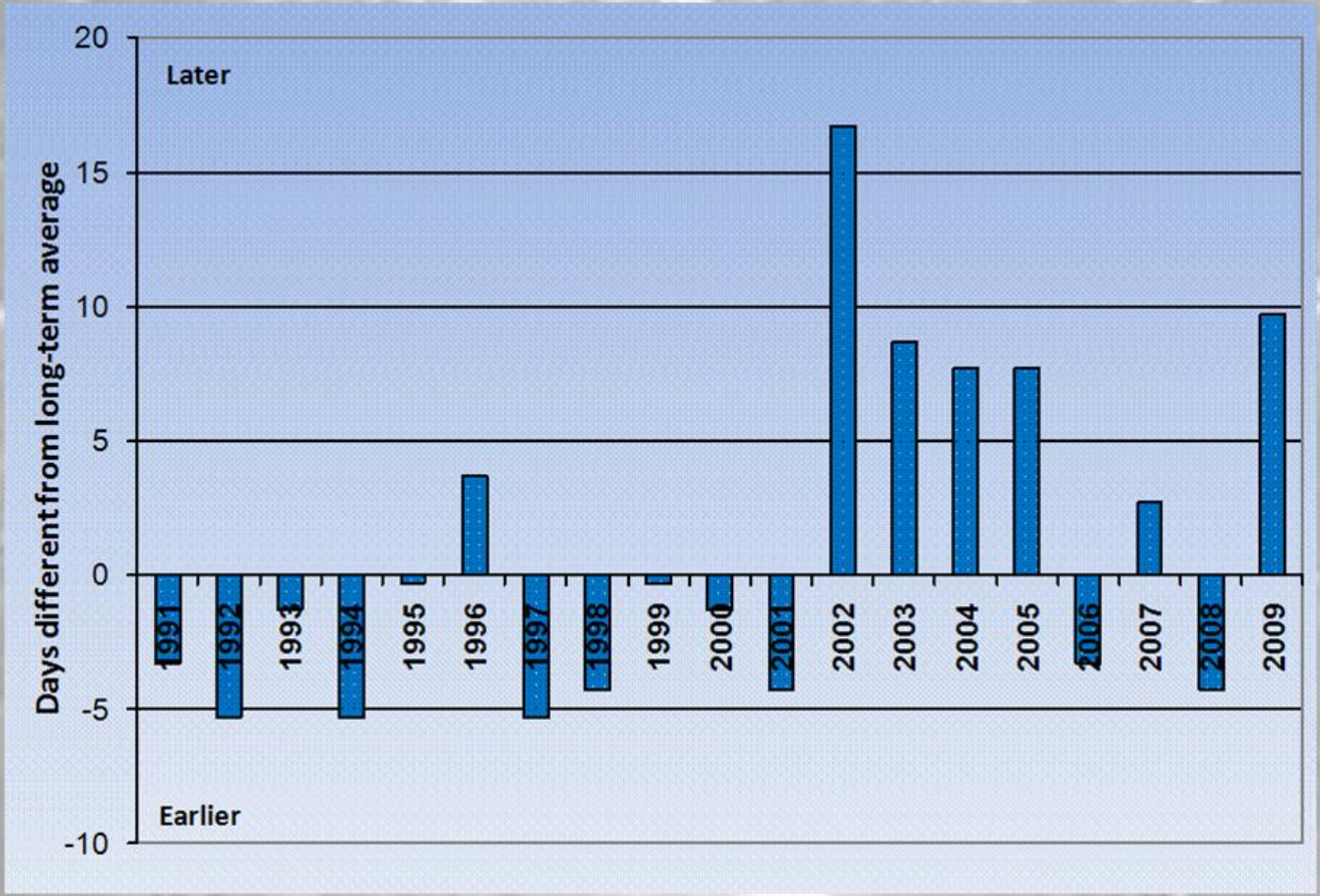


Select an investigation, then press "Select specific fields" to specify the types of data you wish to retrieve, or press "Get the data now!" to get a pre-selected set of columns. Help

Investigation	First Measurement	Last Measurement	Measurements	Schools
All Measurements	1995-01-01	2002-01-27	7351385	5098
Atmosphere	1995-01-01	2002-01-27	6360875	4529
Air Temperature	1995-01-01	2002-01-27	2486014	4050
Cloud Observations	1995-01-01	2002-01-27	1777947	4411
Liquid Precipitation	1995-01-01	2002-01-27	1053441	4019
Solid Precipitation	1995-01-01	2002-01-27	1055716	3421
Humidity	1995-02-02	2002-01-27	53329	363
Ozone	2000-08-16	2002-01-24	4294	19
Aerosols	2000-07-02	2002-01-22	2649	9
Barometric Pressure	1995-02-02	2002-01-27	13685	189
Surface Water	1995-01-03	2002-01-26	628909	1806
Soil Moisture	1995-02-21	2002-01-25	26823	213
Soil Moisture (profile)				
Soil Moisture (by depth)				
Soil Temperature	1997-01-01	2002-01-26	71806	205
Soil Temperature (profile)				
Soil Temperature (by depth)				
Soil Characterization	1998-05-18	2002-01-23	10308	159
Soil Infiltration	1997-02-17	2001-11-24	1910	26
Land Cover/Biology	1995-04-19	2002-01-25	113827	642
Tree Biometry	1995-04-22	2001-11-26	42702	500
Grass Biometry	1995-05-16	2001-11-26	69716	238
Land Cover	1995-04-19	2002-01-25	3409	345
Phenology - Budburst	1998-03-30	2001-10-12	2021	100
Phenology - Lilacs	2000-03-25	2001-06-21	251	20
Lilacs (Common)				
Lilacs (Clonal)				
Green-up/Green-down	1999-09-26	2001-12-06	6048	18
Green-up	1999-09-26	2001-12-06	6048	18
Green-down	1999-09-26	2001-12-06	6048	18
Site Location	1996-10-19	2002-01-27	19749	2446
Go **Site Photos** Site photos are viewed using the GLOBE Site Photo viewer.	1995-04-19	2001-10-20	2031	92
[Meteorological]	1995-05-01	2002-01-25	31652	2164

Timing of sugar maple leaf drop

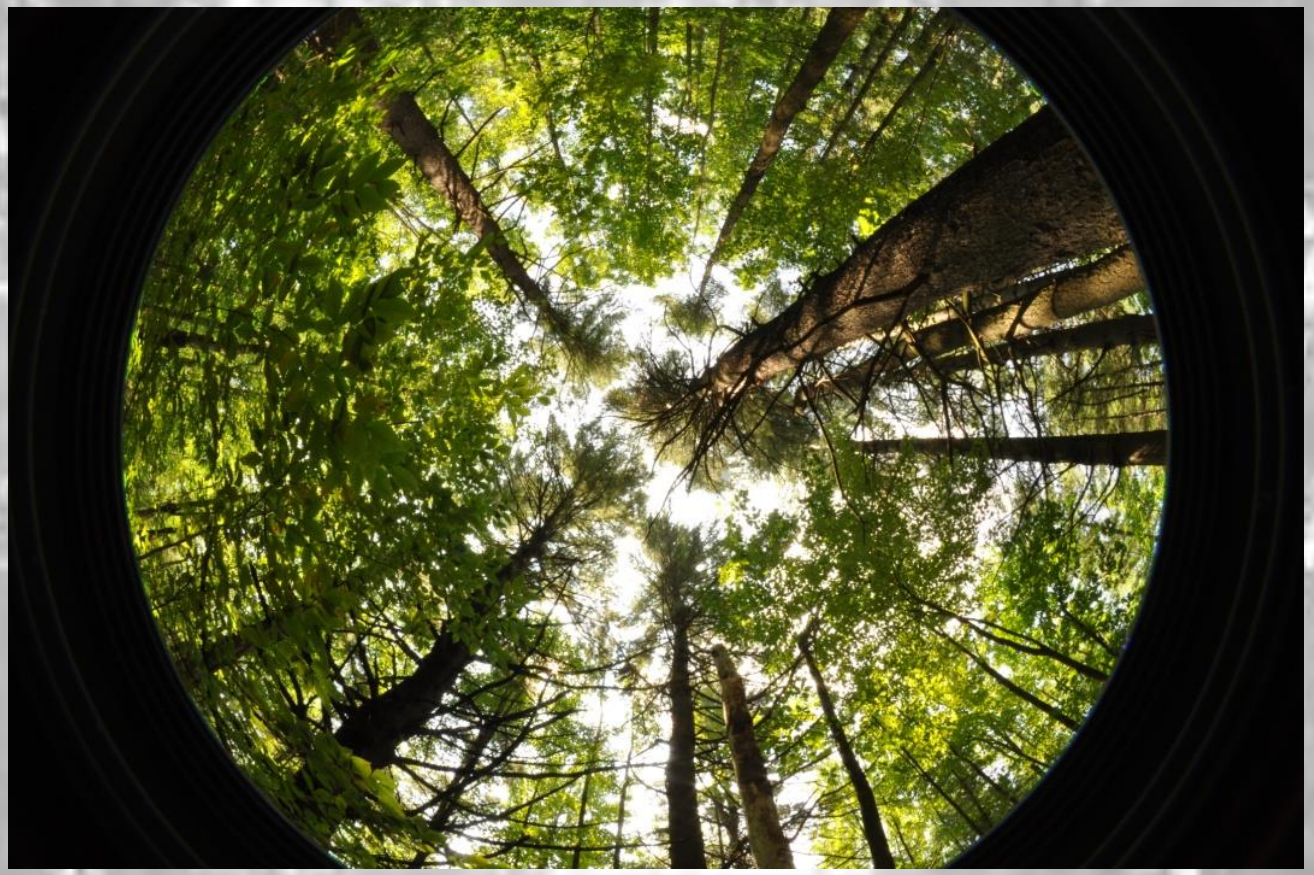
Monitored at Proctor Maple Research Center



Sandra Wilmot Tom Simmons

Vermont Monitoring Cooperative

Hemispherical Photography



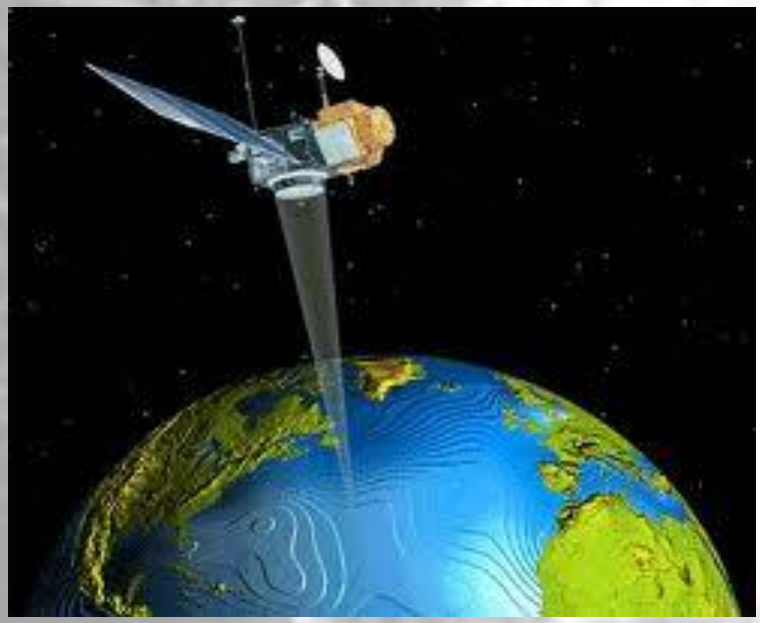
Helps us “see” the canopy as a satellite might see it

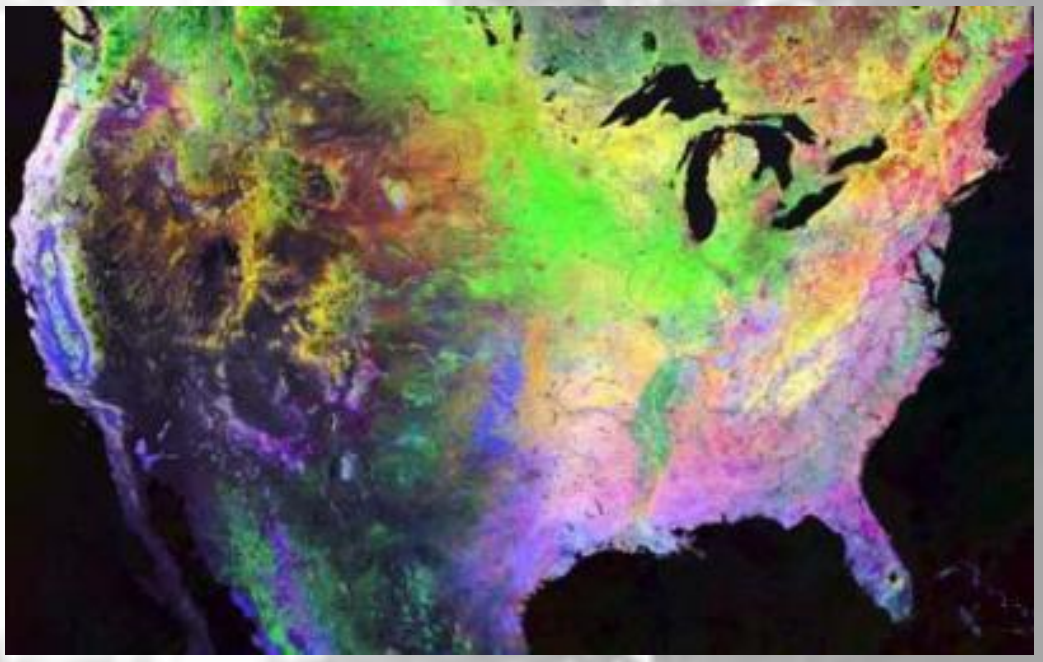
Hemispherical Imagery

- 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

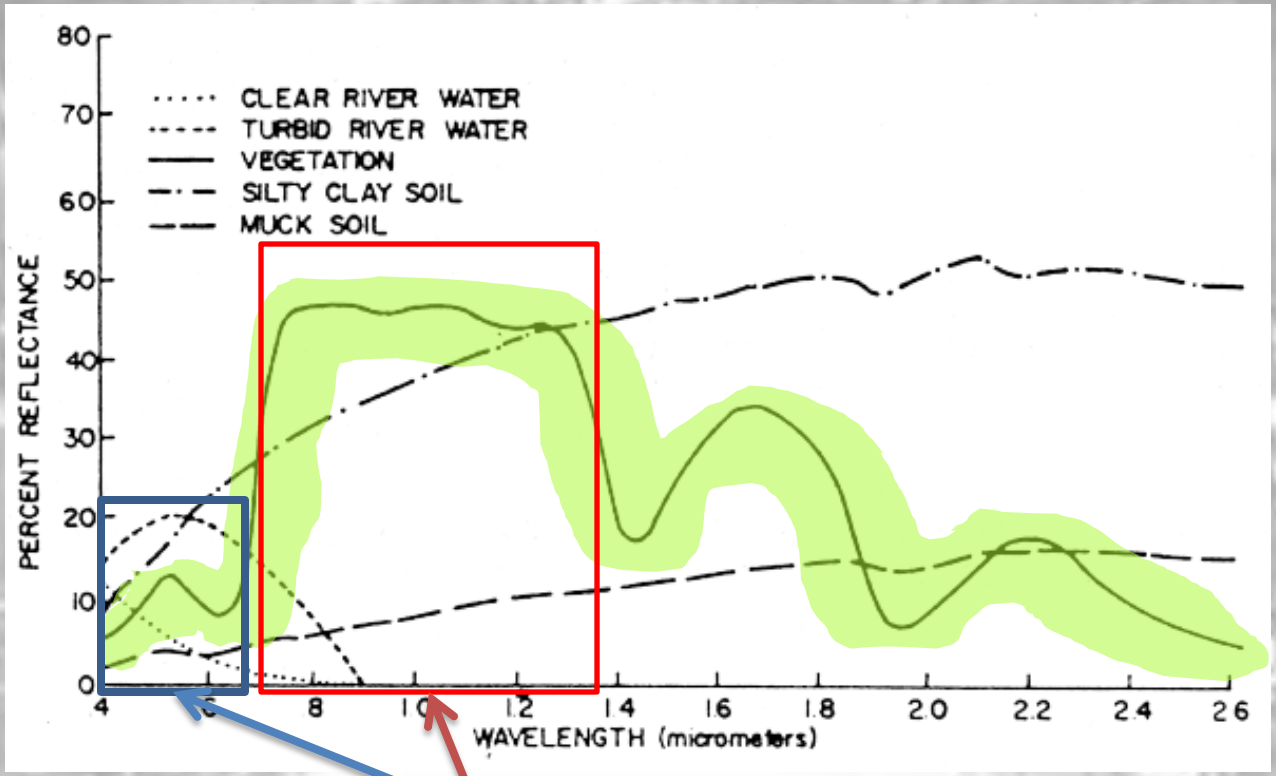
Satellite Remote Sensing





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.

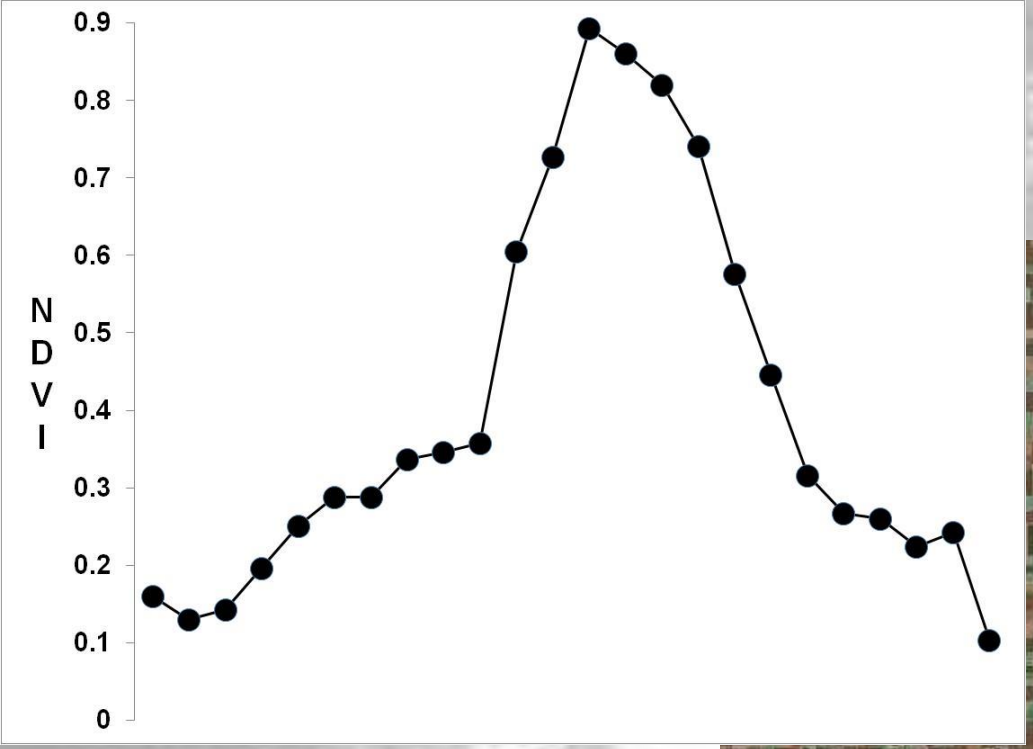
$$NDVI = \frac{(NIR - VIS)}{(NIR + VIS)}$$

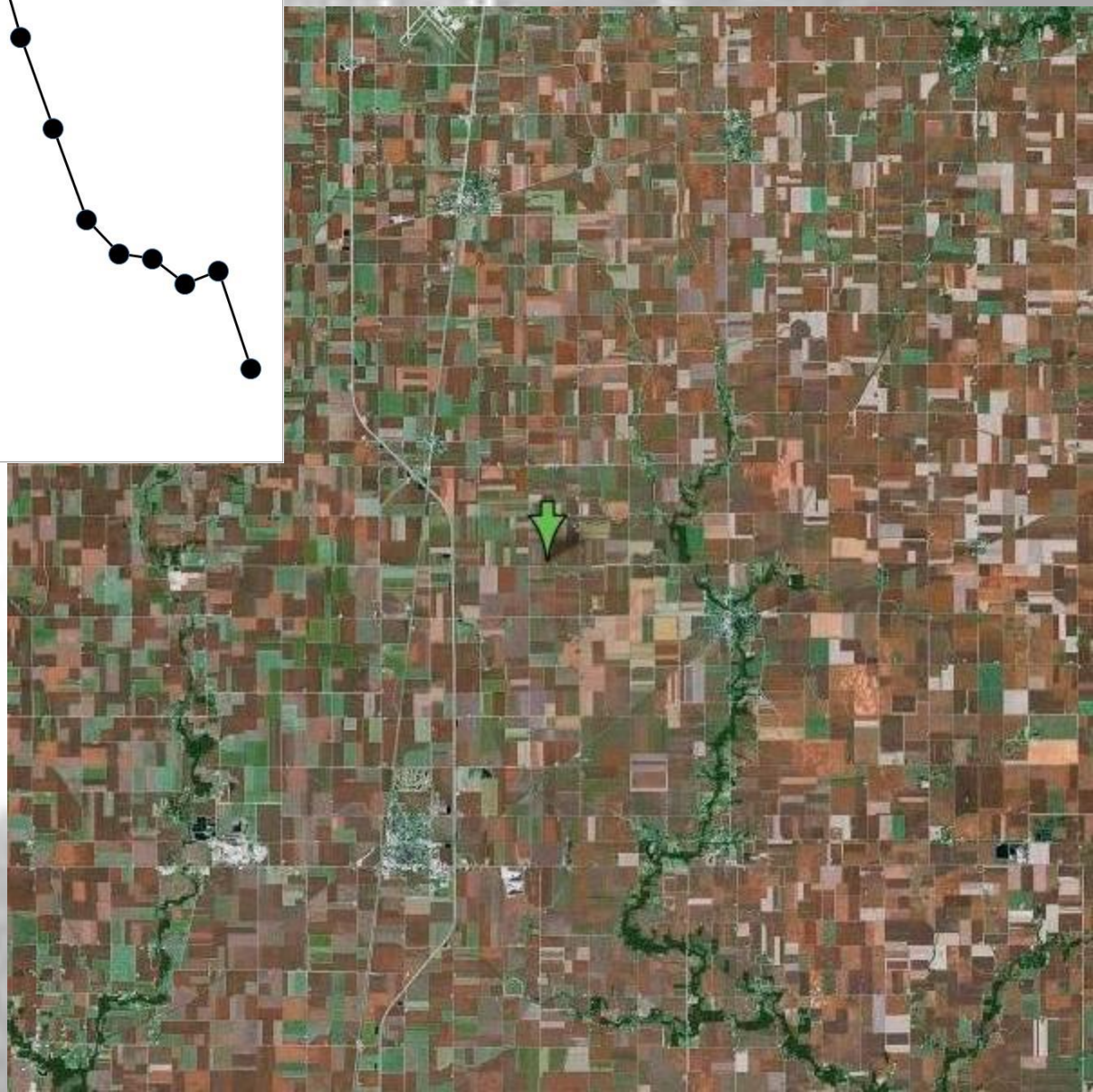
http://www.fao.org/docrep/003/T0446E/T0446E04.htm

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.

Corn/Soy belt
Central Illinois





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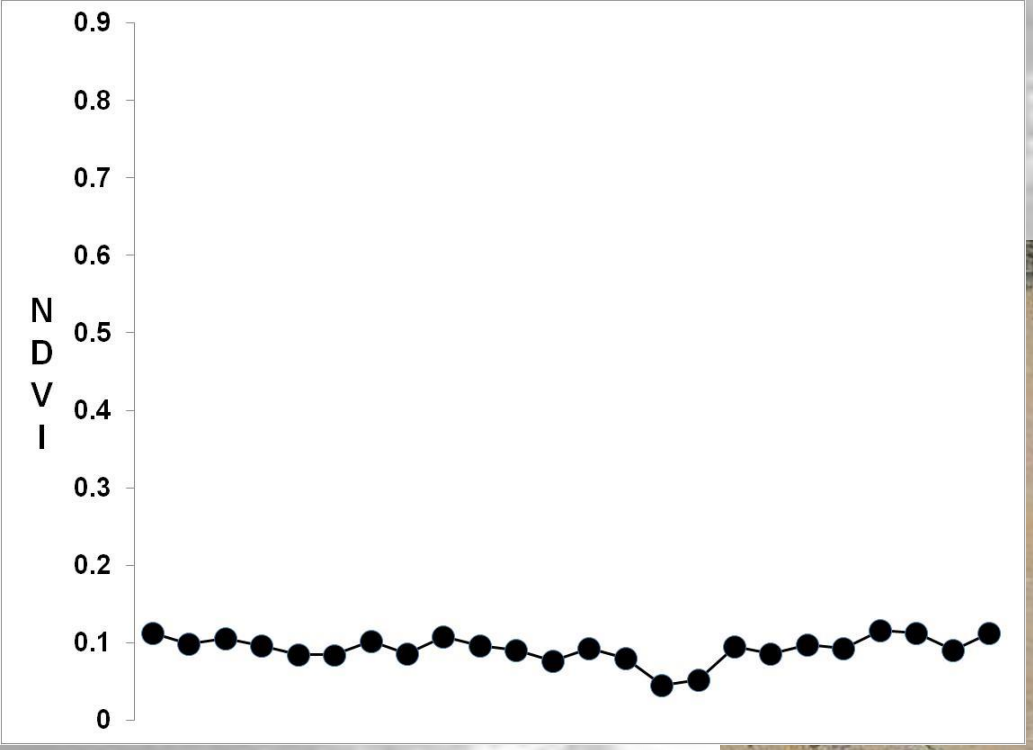
Virginia Tech University

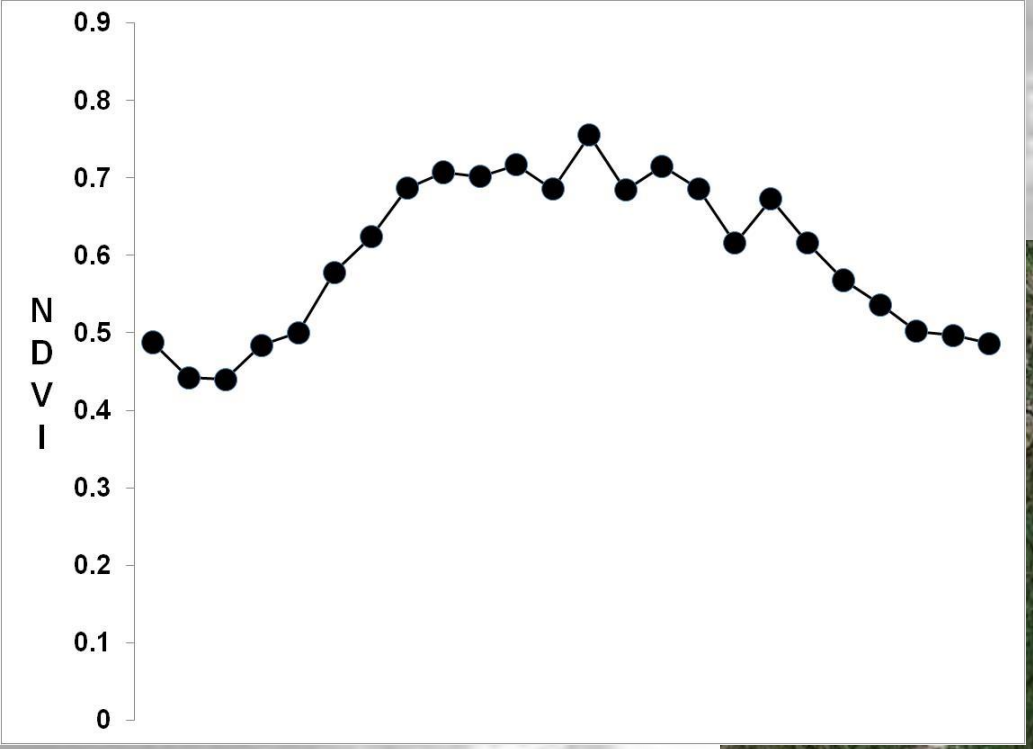
Death Valley



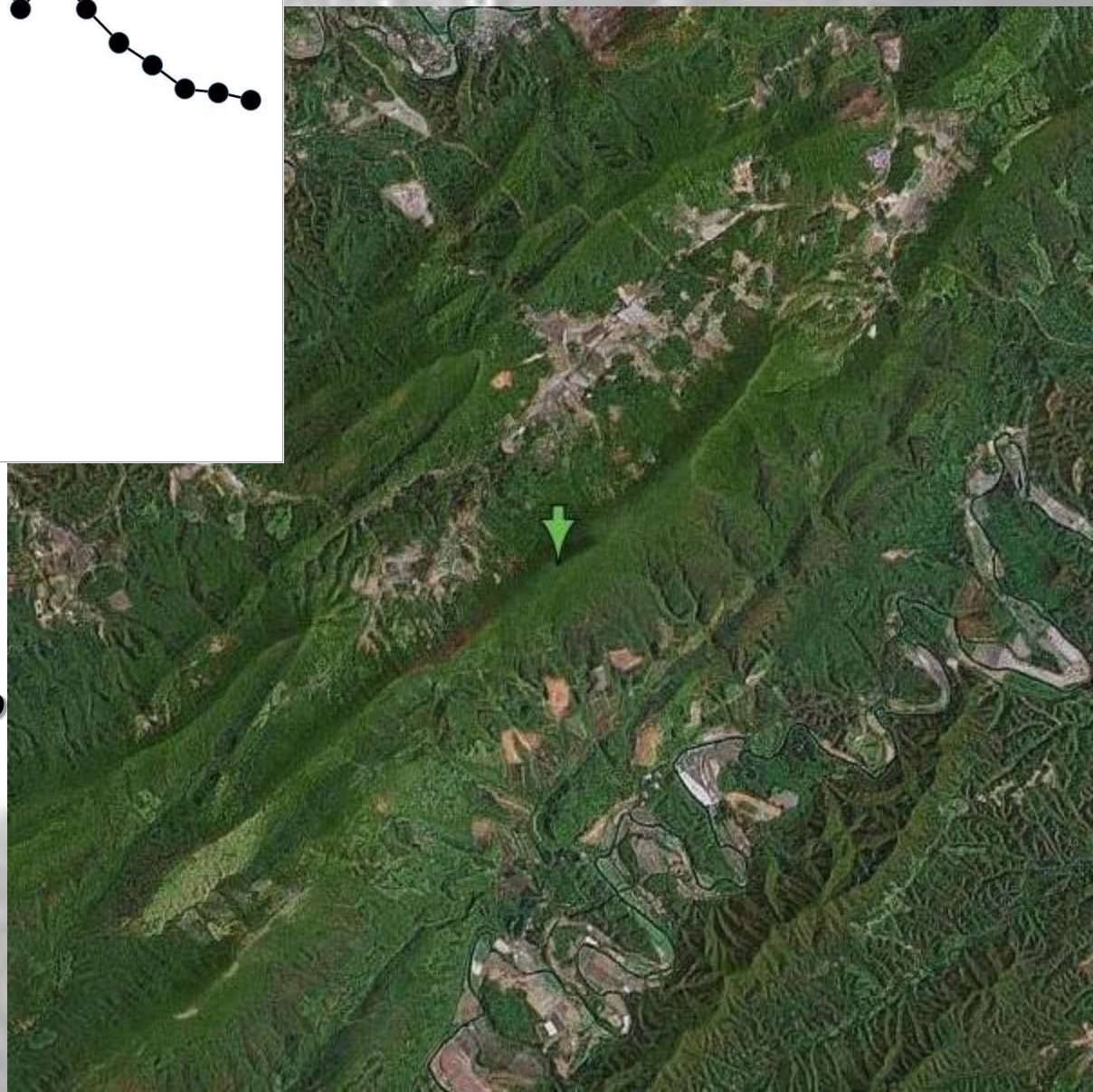
What would this NDVI curve look like?

Kirsten M. de Beurs, Ph.D.

Virginia Tech University



Forest
Southwest Virginia



What would this NDVI curve look like?

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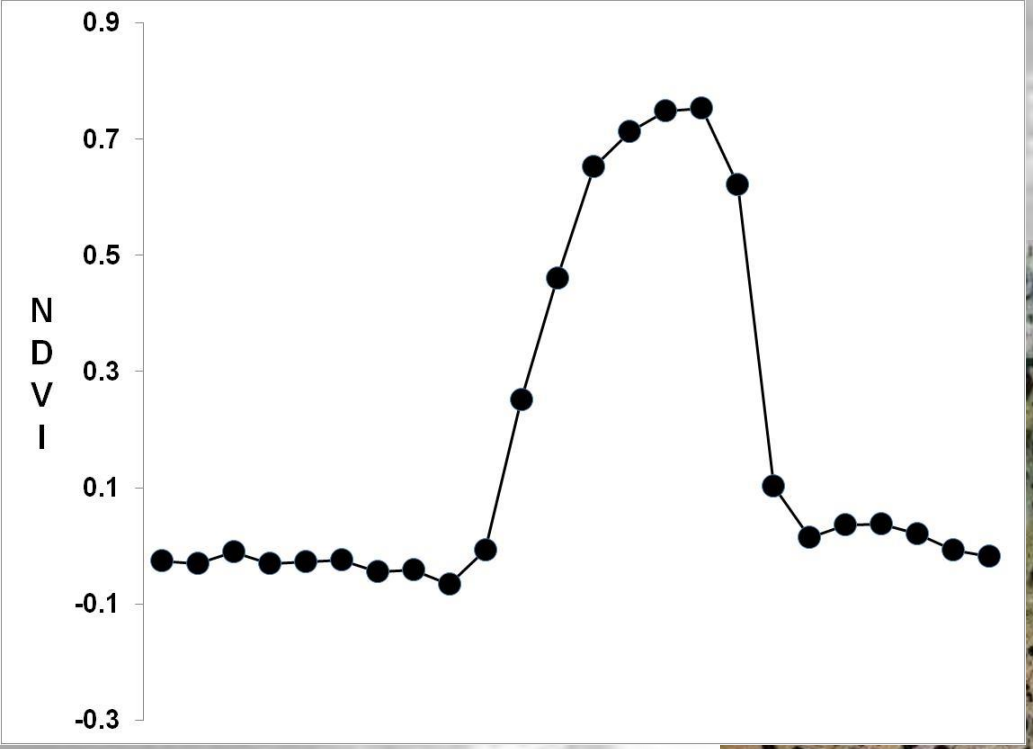
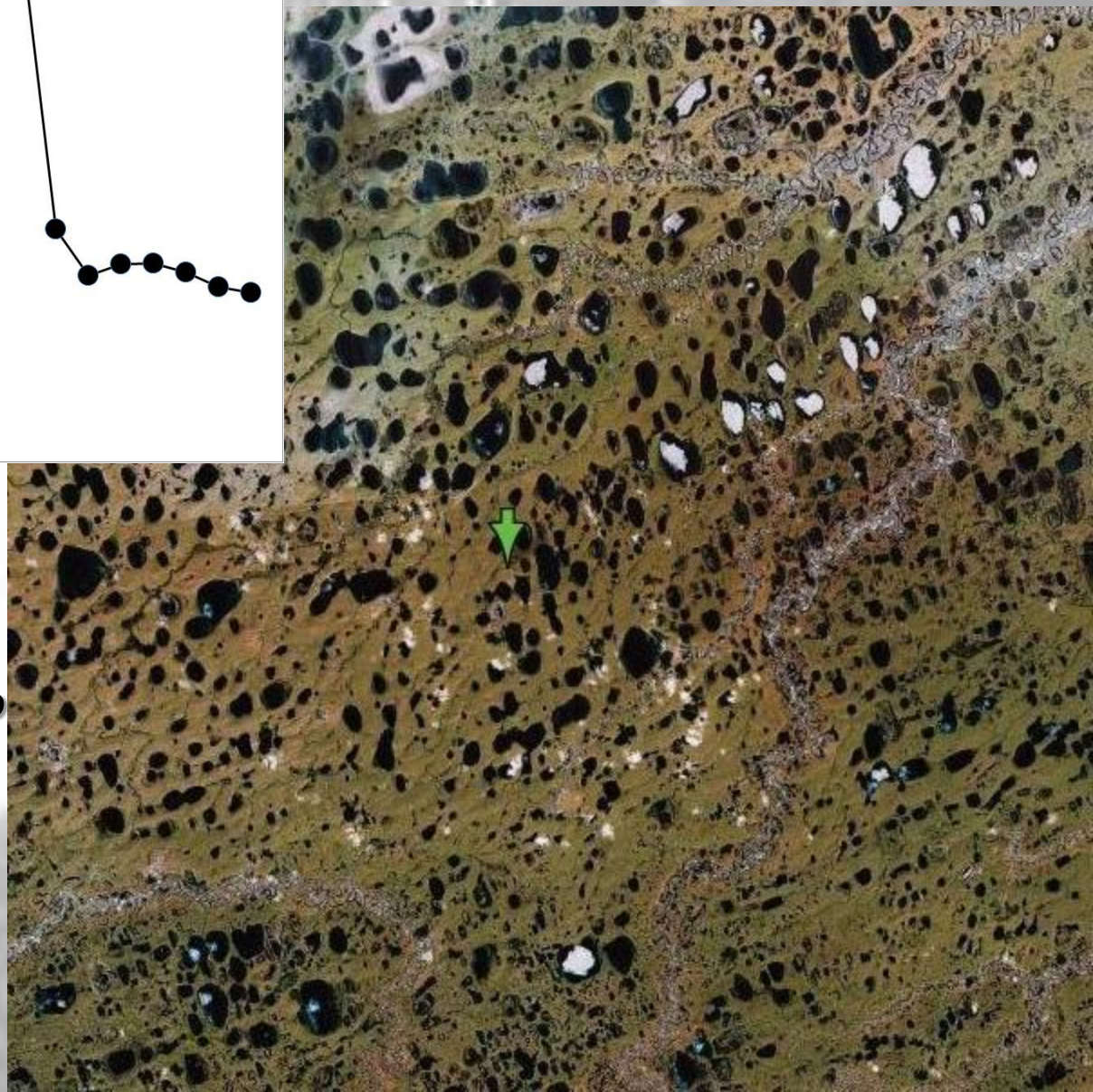
Tundra Northern Alaska





What would this NDVI curve look like?

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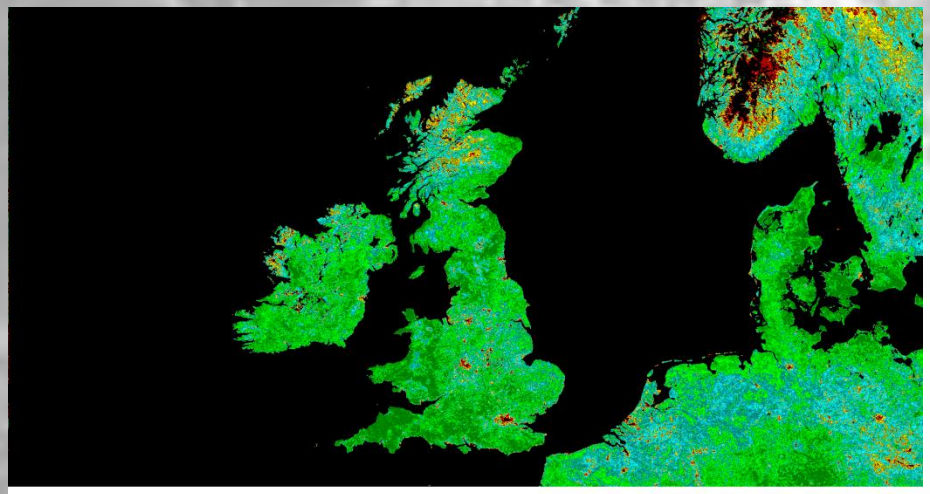
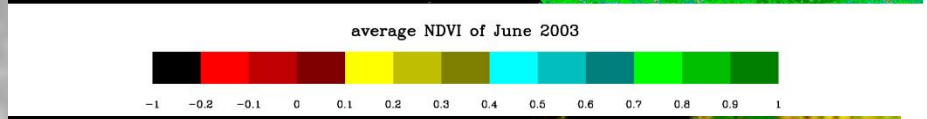
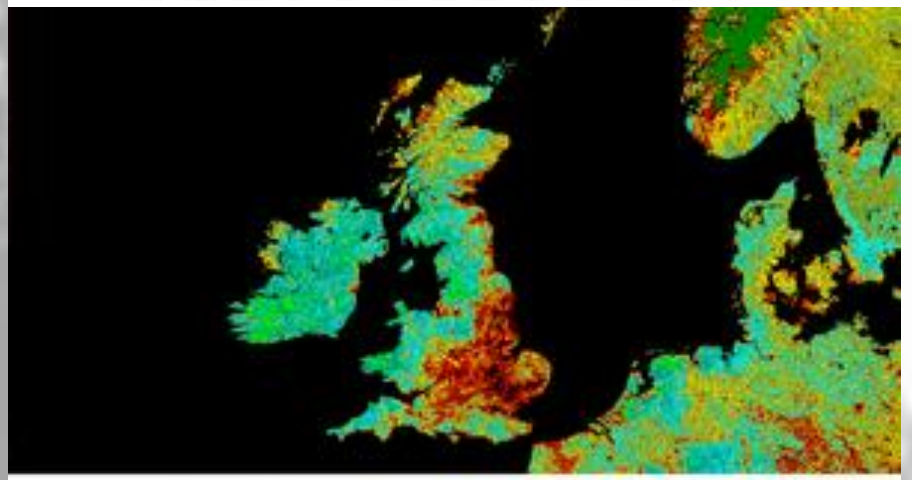
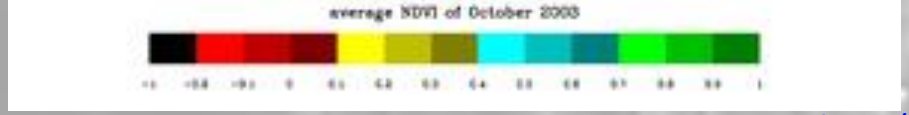
NDVI for Phenological Dates







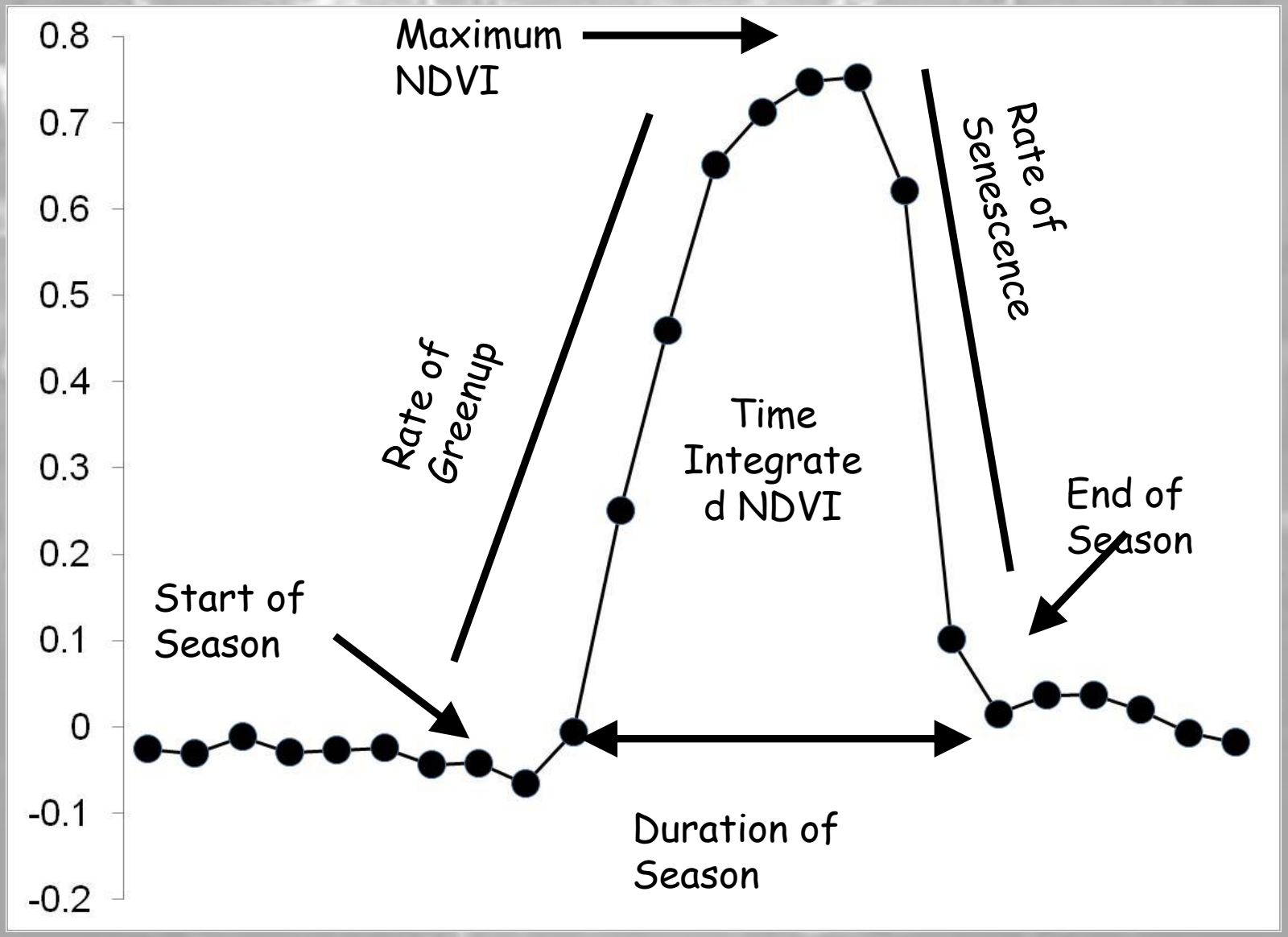


comparison of NDVI values for different dates

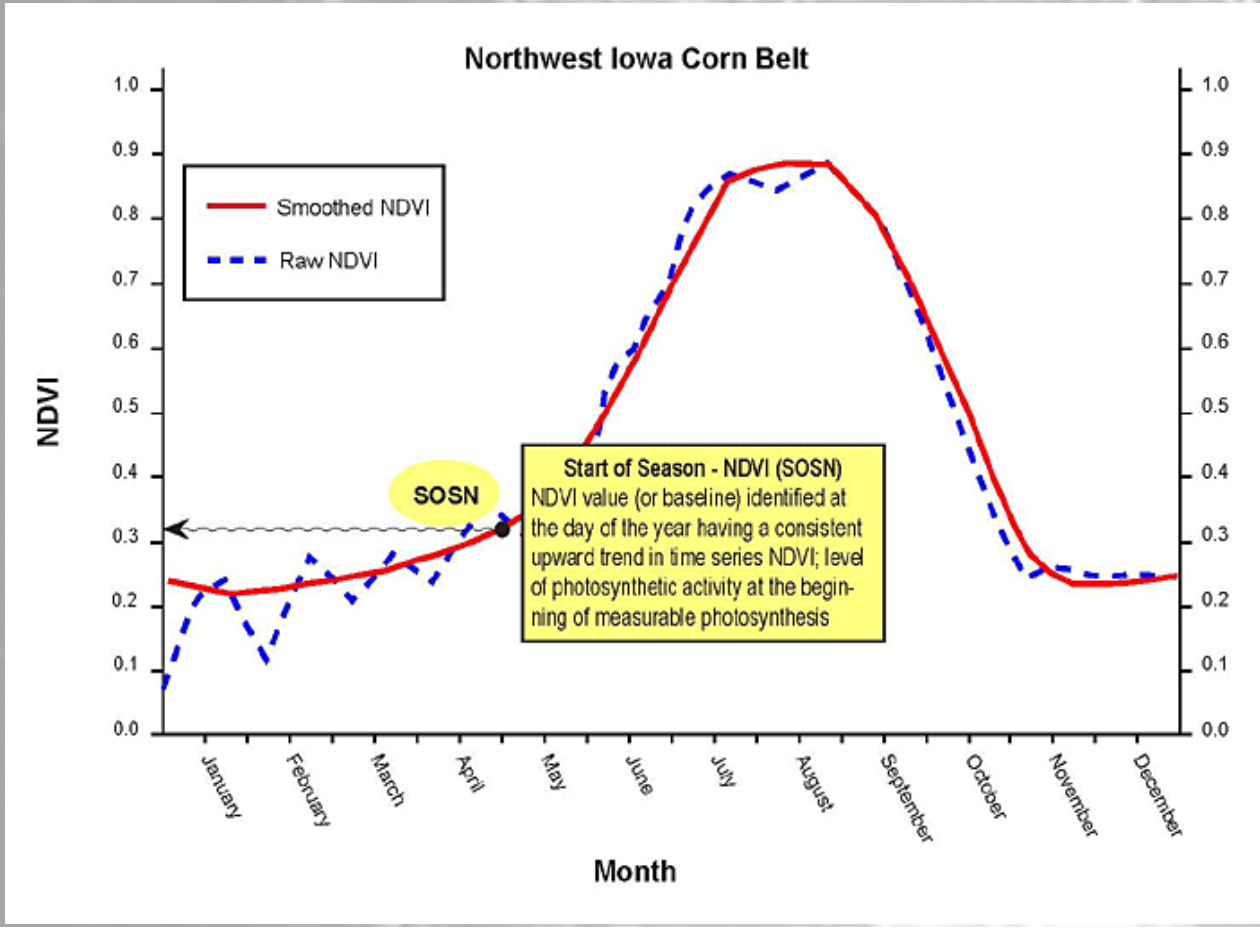
- http://www.seiswaves.com/cappelluti/docs/anims/leicester/

Plotting NDVI

Use of NDVI to identify key phenological dates



How do you determine dates?



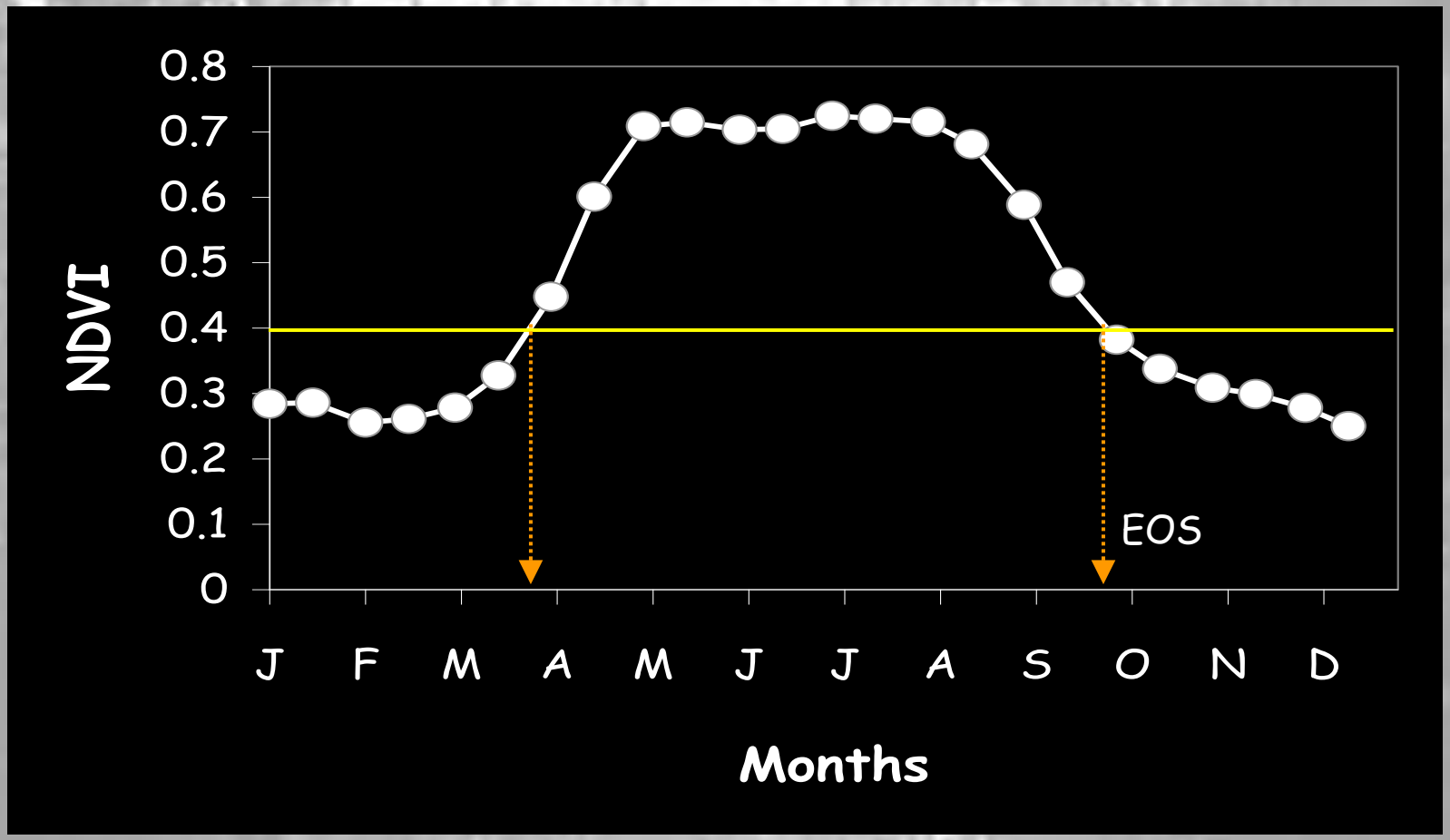
Use of NDVI thresholds to identify key phenological dates

Start of the Season

http://phenology.cr.usgs.gov/methods_metrics.php

Common Thresholds

0.5 of the Max:Min NDVI ratio to approximate the start and end of the season



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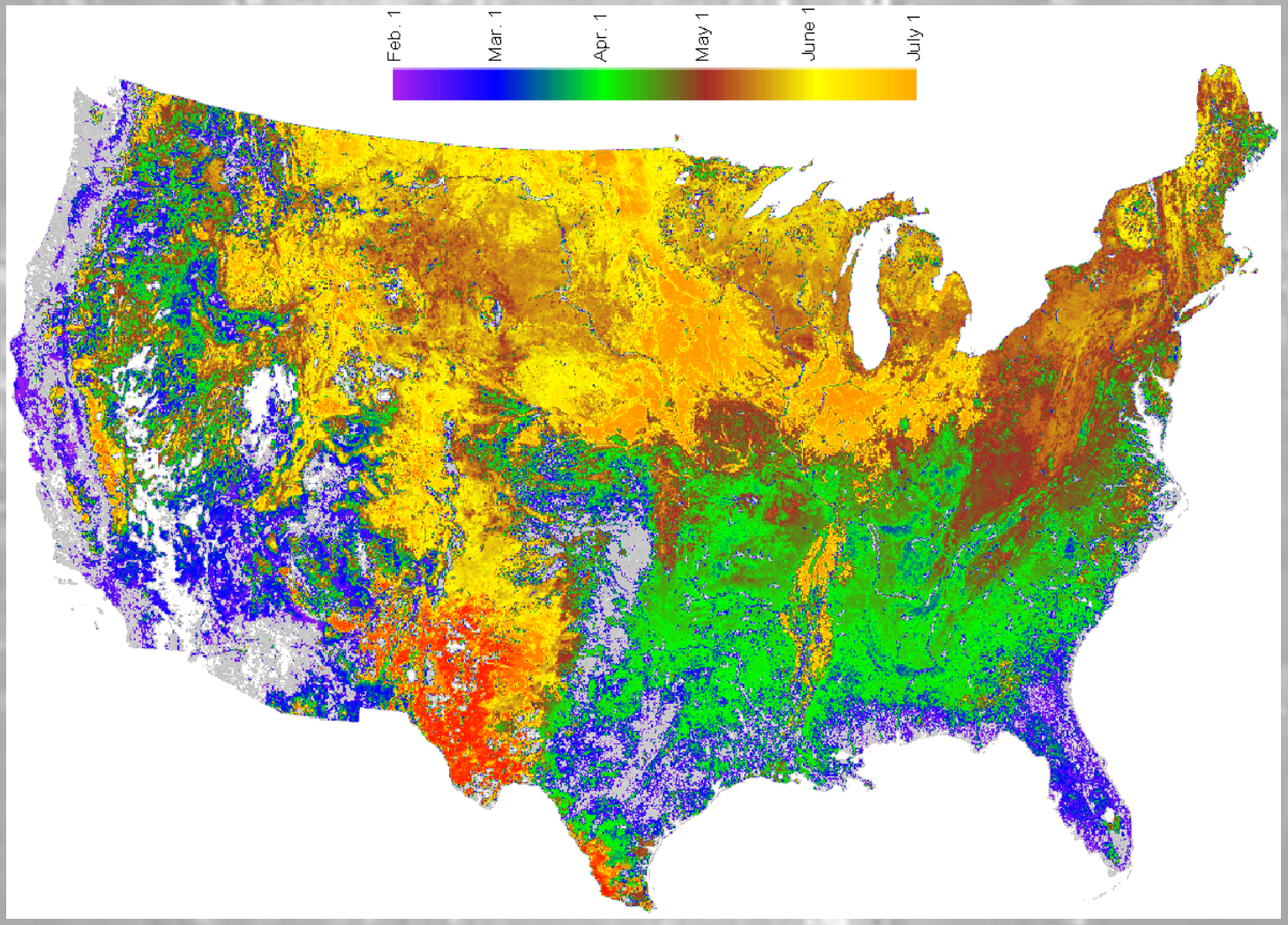
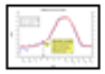
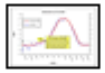
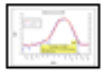
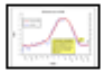
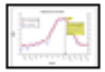
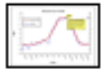
50% Threshold (Seasonal Mid-point)



(White et al., mean day = 124, May 4th)

Other key phenological dates

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

http://phenology.cr.usgs.gov/methods_metrics.php