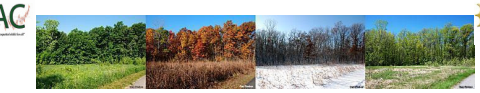
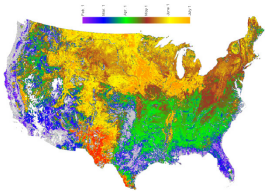
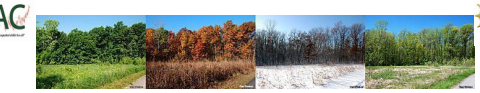


# Climate Change and Vegetationn Phenology

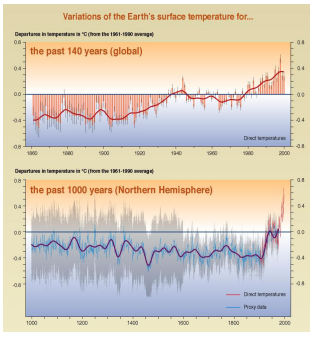



**Introduction to vegetation phenology as a marker of a changing climate**
Temperature metrics are the most obvious way to study weather and climate patterns but it is often the impacts of temperature on our ecosystems that are of concern. Here we explore how a changing climate might impact ecosystem function, with specific focus on vegetation phenology. **(Power Point required)**

a. Explore the range of impacts of a changing climate on ecosystem structure and function.
   - How does temperature impact plants, soils, wildlife, water?
   - Which ecosystem components might be most sensitive to climate change?
   - Which components can respond and adapt most easily?
   - How might these changes in ecosystems impact us?

b. Discuss the use of vegetation phenology as a marker of climate impacts.
   - Why do scientists study phenology?
   - What are some ways to quantify and measure vegetation phenology?
   - How would we expect vegetation phenology to be changing over years?

# 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

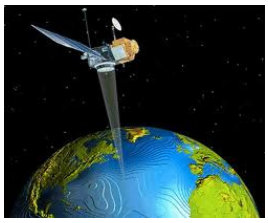
**Some potential effects:**

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

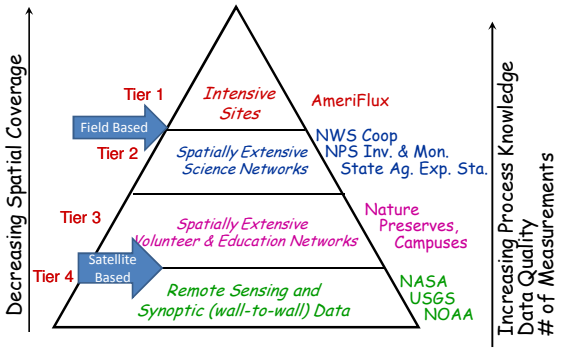
## Measuring Phenology

**Field Observations**

**Satellite Remote Sensing**



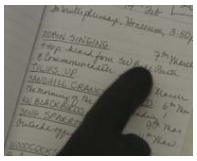
## How do scientists monitor vegetation phenology?

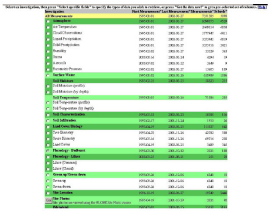



George R. Kish U.S. Geological Survey

## Measuring Phenology on the ground

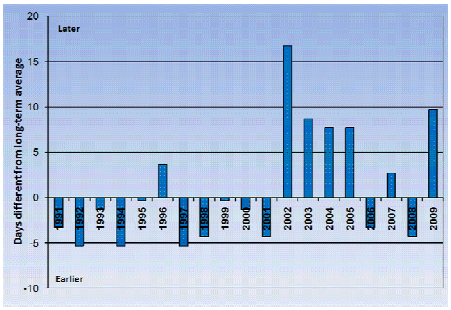
**Field Observations**





## 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

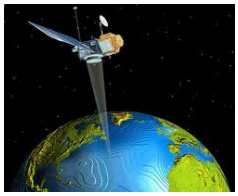
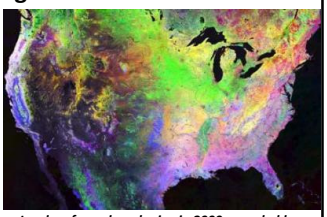
## Hemispherical Imagery

- 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.



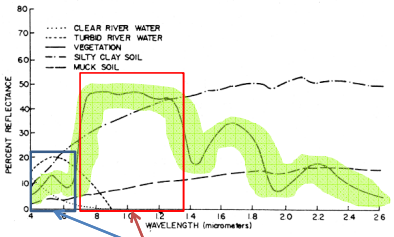
## Measuring Phenology

**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?



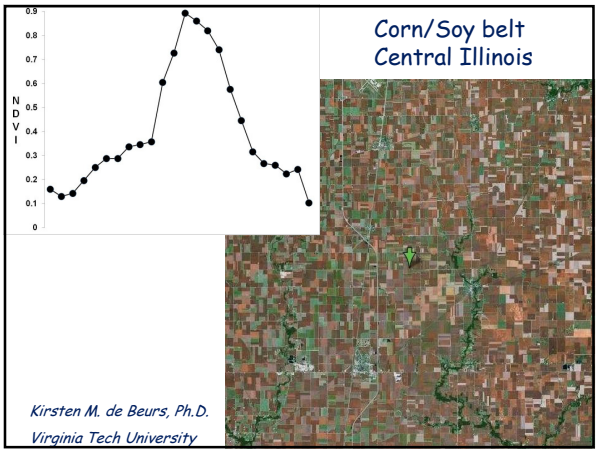

- Chlorophyll, strongly absorbs visible light for photosynthesis.
- Leaf cell structure reflects near-infrared light.
- NDVI exploits these characteristics of vegetation reflectance to quantify how much, how dense and how productive vegetation is.

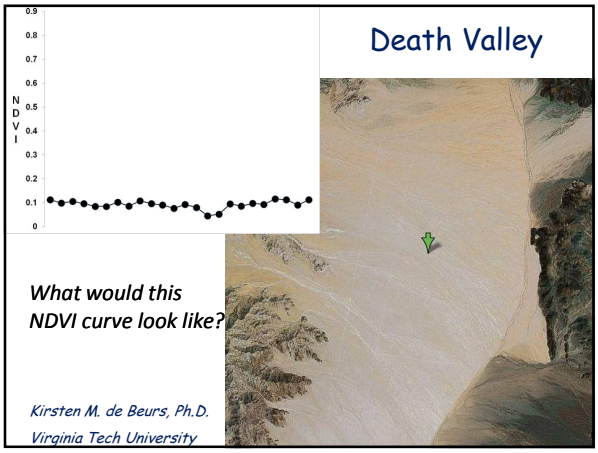
$$\mathrm{NDVI} = \frac{(\mathrm{NIR} - \mathrm{VIS})}{(\mathrm{NIR} + \mathrm{VIS})}$$

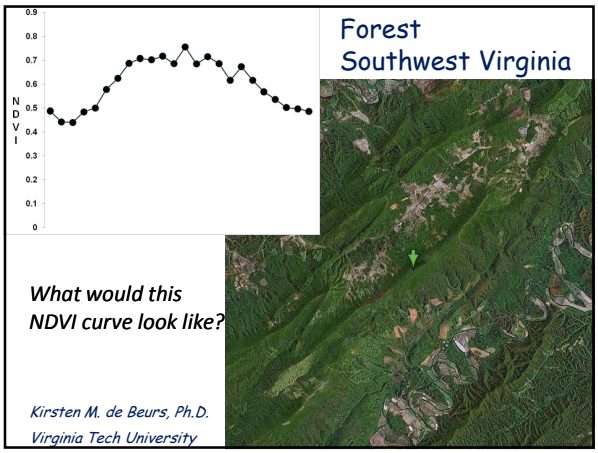
http://www.fao.org/docrep/003/T0446E/T0446E04.htm

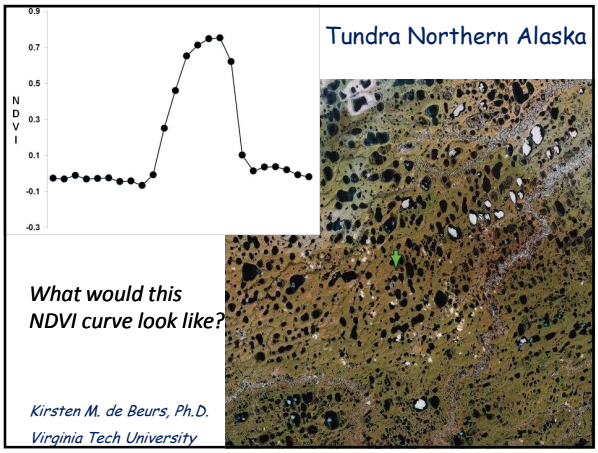
## Normalized Difference Vegetation Index NDVI

- 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.

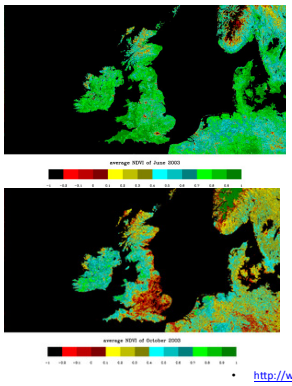





## NDVI for Phenological Dates

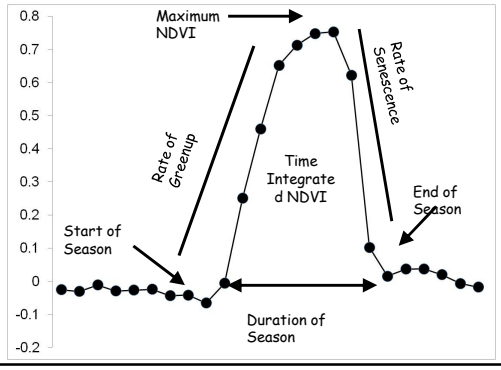


comparison of NDVI values for different dates

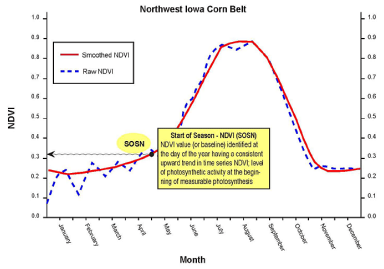
- http://www.seiswaves.com/cappelluti/docs/anims/leicester/

## Plotting NDVI

Use of NDVI to identify key phenological dates




## How do you determine dates?



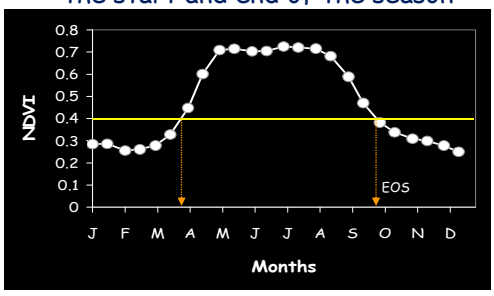

Use of NDVI thresholds to identify key phenological dates

**Start of the Season**

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

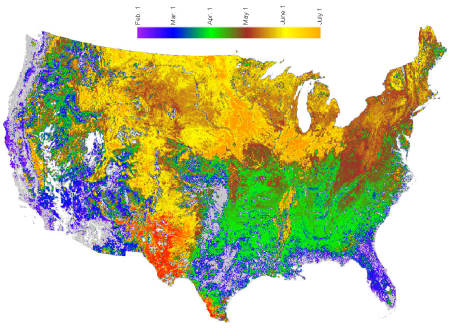
## Common Thresholds

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




*Kirsten M. de Beurs, Ph.D. Virginia Tech University*

## 50% Threshold (Seasonal Mid-point)




## 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

## Satellite Observations….
## what do they mean on the ground?

•How do we know our satellite derived NDVI is accurate?

•How does a given value of NDVI relate to phenology stages on the ground?

**Ground-based observations help scientists validate estimates of growing seasons.**

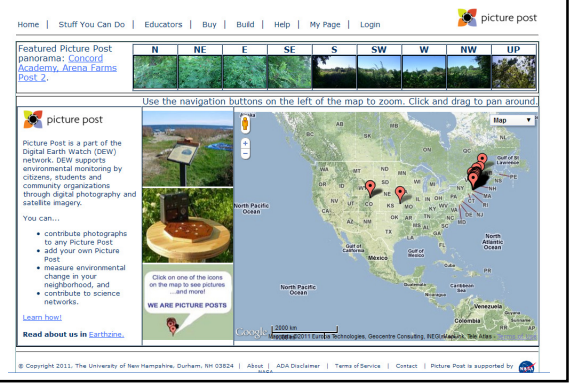
GROUNDTRUTH

**Processing and analysis of digital photographs**

The analysis of digital images and remotely sensed data is central to contemporary monitoring of our planet. Because these data are often collected by satellites, or other sophisticated monitoring equipment, they are usually presented to students in an intangible manner that doesn't engage them in the collection or analysis. The Picture Post Learning Progression introduces you to a new research tool that standardizes the collection digital images through a series of protocols that allows the data to be compared over time, or with that from other sites. In addition to its own investigative value, the Picture Post is a bridge to understanding the fundamental aspects of collecting images and analyzing them digitally.
**(PicturePost Learning Progression required)**

## Picture Post

**http://picturepost.unh.edu/**

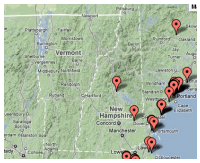



## What is a Picturepost

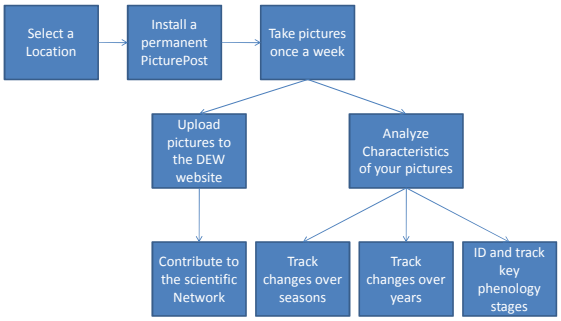

A stable permanent platform
in an ecological important location
where you take
photographs
over time

## What you can do with Picturepost

- Contribute photographs to the scientific network
- Track changes in your site over time
- Link your findings to satellite imagery of your area




## The Picture Post Process




a. Using a standardized protocol, set up a Picture Post to use as the foundation for ongoing monitoring of a specific location, as well as for comparison to other sites throughout the state, region and country. **(PicturePost Guide Required)**
   - Why is following a protocol important in setting up the Picture Post?
   - What are some considerations that we should take into account when choosing a location for our Picture Post?

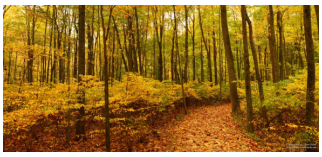
## What you need



- A permanent plot to visit
- Digital Camera
- Camera Mounting Block and post
- Compass
- Computer (for image upload)
- Downloaded freeware
- A group committed to taking regular photos of their site

## The Picture Post Process

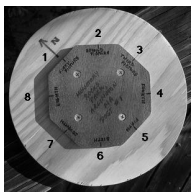
Select a Location



- Choose an easily accessible location
- Include vegetation in each canopy level
- Include a landmark feature for reference


## The Picture Post Process

Install a permanent PicturePost



b. Use the Picture Post, in conjunction with a digital camera, to collect a series of digital images. Images are uploaded to a nationwide, online database for comparison and contribution to scientific efforts. **(PicturePost Guide Required)**

- What are some considerations when using an instrument such as a digital camera to collect data for analysis?
- What types of information might a digital image contain, that would be useful in monitoring an ecosystem, particularly in relationship to climate change?

## The Picture Post Process

Take pictures once a week

During a most of the year, take photographs once a week. To study the seasonal cycles, take photographs once a day during spring "green up" and autumn "green down."

- Record the time and date of your photos
- Take 8 photos of the landscape (clockwise starting N) and one of the sky

## The Picture Post Process

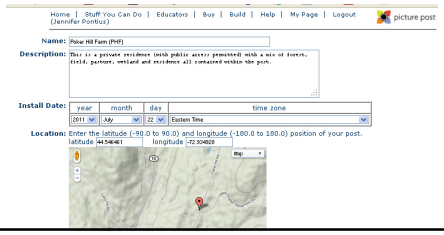
Take pictures once a week

## The Picture Post Process

Upload pictures to the DEW website

Contribute to the scientific Network

1. Register and Log in to the site
2. Create your Picture Post location within the database
   http://picturepost.unh.edu/help_addpost.jsp

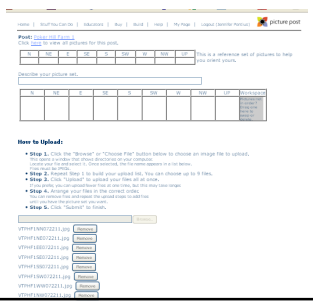



## The Picture Post Process

Upload pictures to the DEW website

Contribute to the scientific Network

Upload your photos on your "My Page"
**http://mvh.sr.unh.edu/mvhtools/uploading_photos.htm**



c. Create hemispherical mosaics and time series animations of your site to visualize changes in phenology over time. **(PicturePost Guide and Panorama software Required)**

- Which portions of your study site change the most? Which change the least?
- Which are the first to "green up"
- Do you see changes not related to vegetation? What is causing these differences? Where could there be error in our measurements?

## Download the Panorama Software

Visualize changes over time

Panarama Factory Software

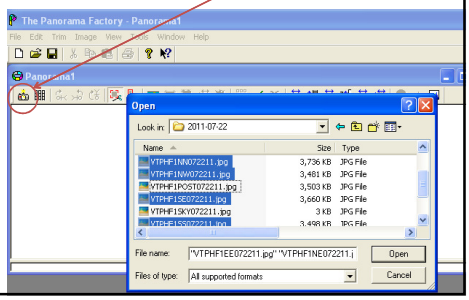

http://www.foto-freeware.de/panoramafactory.php

## Panorama Software

Visualize changes over time

Panarama Factory Software

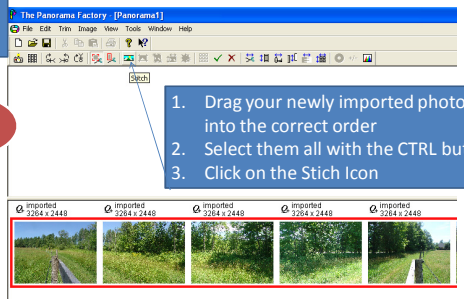
Upload your photos into the Panorama Factory by clicking on the Camera Icon




## Panorama Software

Visualize changes over time

Panarama Factory Software

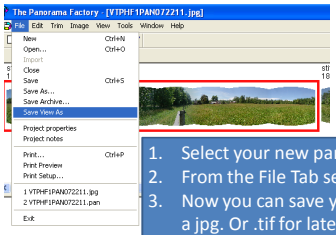



1. Drag your newly imported photos into the correct order
2. Select them all with the CTRL button
3. Click on the Stich Icon

## Panorama Software

Visualize changes over time

Panarama Factory Software




1. Select your new panorama
2. From the File Tab select Save View As
3. Now you can save your panorama as a jpg. Or .tif for later analysis or stacking.

Animate Your Images

## More Visualization Tools

Visualize changes over time

Panarama Factory Software

Animate Your Images

Make your own Picture Story using Windows Movie Maker or Apple's QuickTime Pro

**d.** Identify a specific portion of one of the images for more in-depth analysis relating to phenology. **(PicturePost Guide and ADI software required)**

- Why did you select this specific portion of the image? What species or landscape feature is it focused on?
- How do different vegetation types differ in their greenness?
- How does the temporal scale (length of time for which you have data) of your observations affect what you can infer from the data?

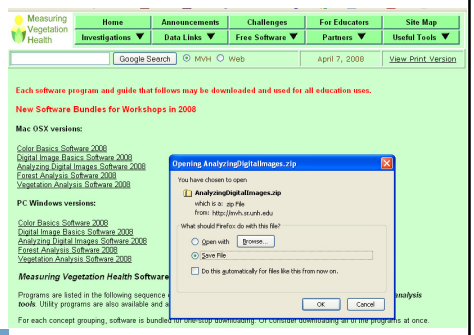
e. Graph your greenness index over time to determine the start and end of the growing season at your site. **(Greenness Activity Guide and spreadsheet software required)**

- What are some different ways to determine when a growing season starts?
- How do greenness curves differ between eco-regions?
- How does the start and end of the growing season this year compare to previous years?

# Download the ADI Software

Quantify Canopy Characteristics

Analyzing Digital Images Software



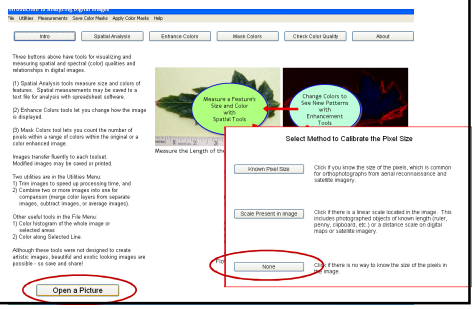

http://mvh.sr.unh.edu/software/software.htm

# Analyzing your imagery

Quantify Canopy Characteristics

Analyzing Digital Images Software

Open the Analyzing Digital Imagery Program
Click Open a Picture and browse to your image
Select NONE for the Calibration Method

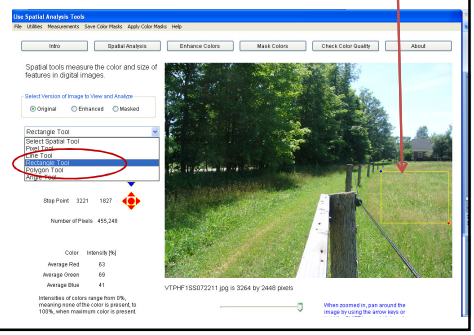



# Analyzing your imagery

Quantify Canopy Characteristics

Analyzing Digital Images Software

Select the Rectangle Tool to isolate an area of vegetation in your image

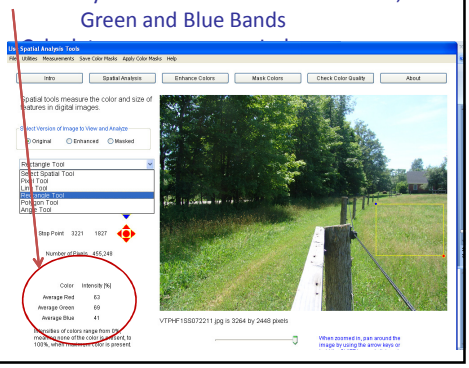


# Analyzing your imagery

Quantify Canopy Characteristics

Analyzing Digital Images Software

Record your color intensities for the Red, Green and Blue Bands




# Analyzing your imagery

Quantify Canopy Characteristics

Analyzing Digital Images Software

Calculate your greenness Index as:

$$Greenness\ Index = \frac{Green}{Red + Blue + Green}$$

| Color | Intensity [%] |
|---|---|
| Average Red | 63 |
| Average Green | 69 |
| Average Blue | 41 |

Intensities of colors range from 0%, meaning none of the color is present, to 100%, when maximum color is present.

$$\frac{69}{(63+69+41)} = 0.398$$

# Analyzing your imagery

Quantify Canopy Characteristics

Analyzing Digital Images Software

Investigate how grass compares to trees or how shadow compared to sunlit areas

$$\frac{18}{(11+18+12)} = 0.439$$

$$\frac{45}{(32+45+22)} = 0.455$$

# Analyzing your imagery

## Track changes over time

Quantify Canopy Characteristics

Analyzing Digital Images Software

**Measuring Greenness Index - Activity Worksheet**

1. What feature of the image did you choose to measure? Why did you choose that feature?

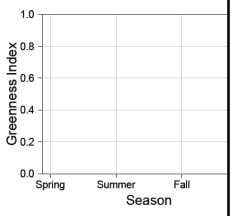
**Greenness Index Data Table**

| Picture Date | Red Intensity | Green Intensity | Blue Intensity | Greenness Index |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |

2. Once you have recorded the red, green, and blue intensities for all pictures, use the space below to calculate the greenness index for each date, and record the values in your table. Greenness index is calculated by using the equation below.

$$Greenness\ Index = \frac{Green}{Red + Blue + Green}$$

3. Make a graph of the Greenness Index over time using the template prov




f. Compare your picture post images to corresponding MODIS images
**(PicturePost guide and link to GLOBE carbon cycle website required)**

- How do Picture Post images compare to corresponding MODIS images, and what potential variables might affect the correlation between these two data sources?
- Use the tool to explore the relationship between albedo and greenness, and what the high and low values on the graphs look like in the images. How might this tool be valuable in studying biomes, tree species distribution and their response to climate change?