Use of CIR aerial photography at Huntsville Botanical Garden

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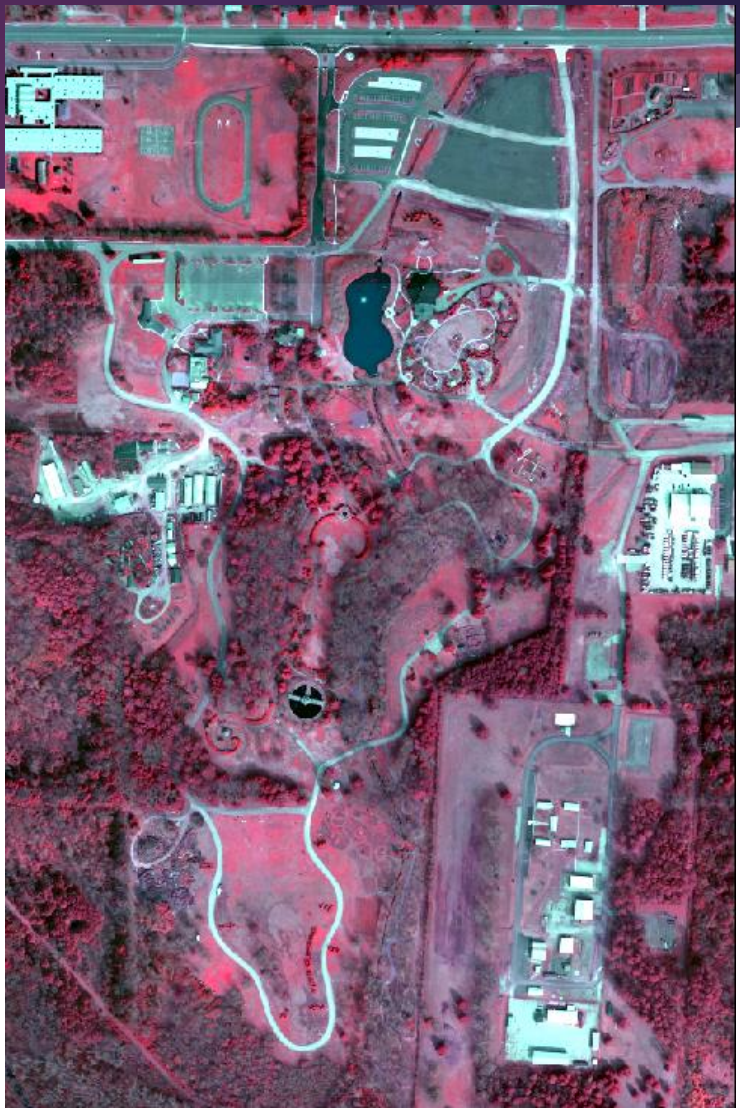
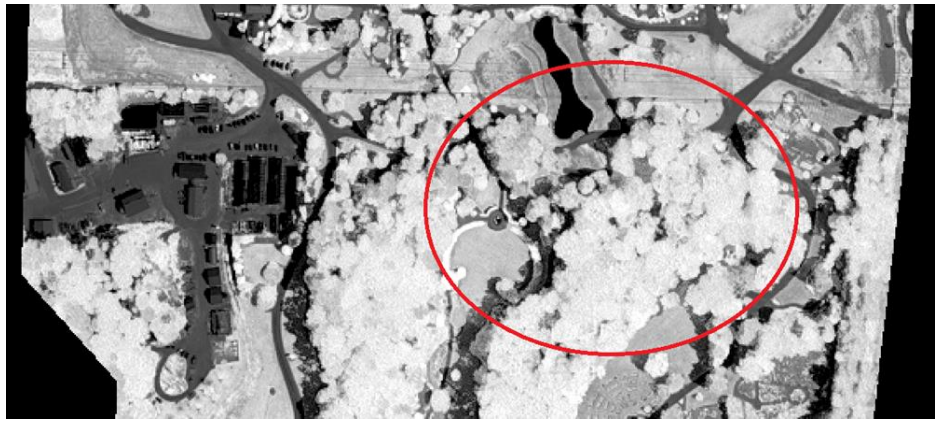
Introduction:

- Mapping and plant collections curation in public gardens are often critically underfunded.
- Efficient methods of mapping changes that take place in vegetation performance is necessary to support the mission.
- Remotely sensed data analysis in a GIS platform is a cost-effective alternative for delineating features, detecting multi-year changes, and broadly assessing the vigor or decline of vegetation over time.



Objectives:

- 1) Delineate features and vegetation types into broad categories via image classification tools in the Spatial Analysis toolbox in ArcMap 10.3.1.
- 2) Apply NDVI and Change Detection to CIR aerial photos with an elapsed time to see if vegetation decline is detectable in areas that were damaged by a storm that felled 17 mature trees in June 2016.

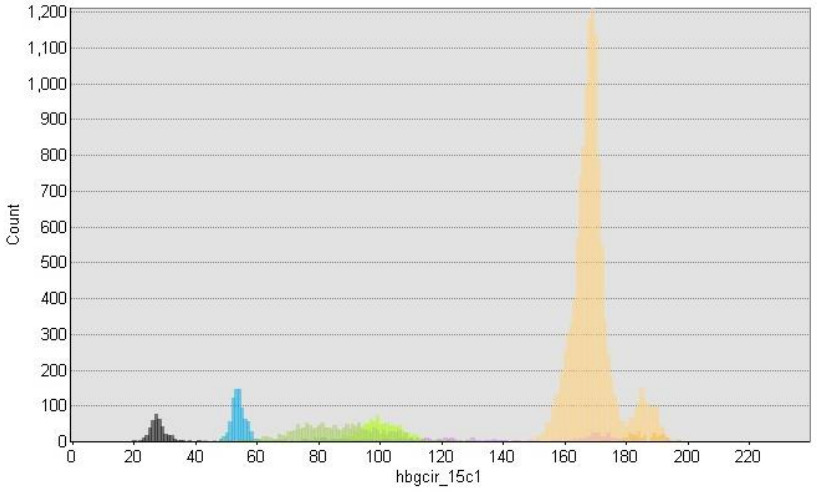


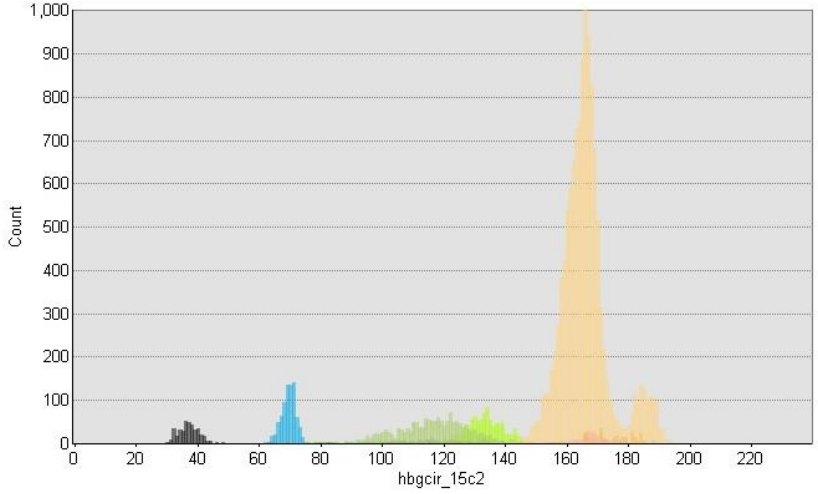
Data:

- 1) A 4 band RBG-CIR NAIP Digital Ortho Photo Image depicting the Huntsville Botanical Garden. (USDA-FSA-APFO Aerial Photography Field Office. Publication Date: 20151125).
- The images were taken in February 2013 and have been orthorectified using 9 control points. This image was used for the supervised classification.
  - Spectral resolution: .48 -.85 µm
  - Radiometric resolution: unsigned 8 bit
  - Spatial resolution: 0.3 meter pixels.
- 2) CIR NAIP Digital Ortho Photo Images depicting the Huntsville Botanical Garden for 2011, 2013, & 2015. (USDA-FSA-APFO Aerial Photography Field Office. Publication Date: 20151125).
- These images were used to produce NDVI surfaces for comparison.
  - Temporal resolution: approximately 2 years (August)
  - Spectral resolution: .48 -.85 µm
  - Radiometric resolution: unsigned 8 bit
  - Spatial resolution: 1 meter pixels.

Methods: Supervised Classification

- The *Maximum Likelihood Classification* Tool in the *Multivariate Toolset* in ArcMap 10.3.1. was used to classify the 1 meter resolution image for 2015 using the *Training Sample Manager* to create the signature files.
- The predefined information classes are shown in the classification scheme on the right.

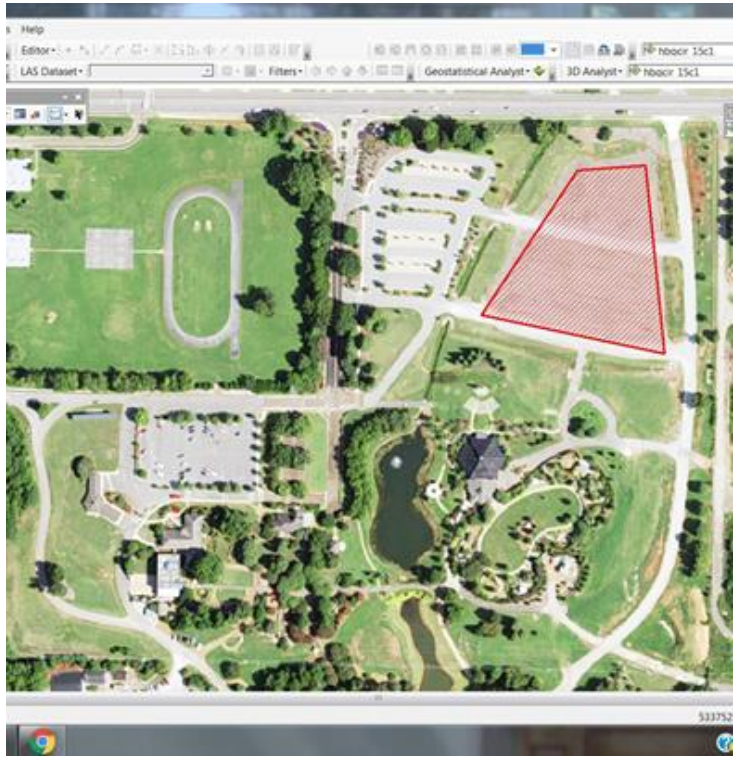




Classification Scheme

1. Paving
2. Buildings
3. Shadows
4. Water
5. Bare Earth
6. Vegetation
   a. Evergreen Trees
   b. Deciduous Trees
   c. Low Vegetation
   d. Lawns

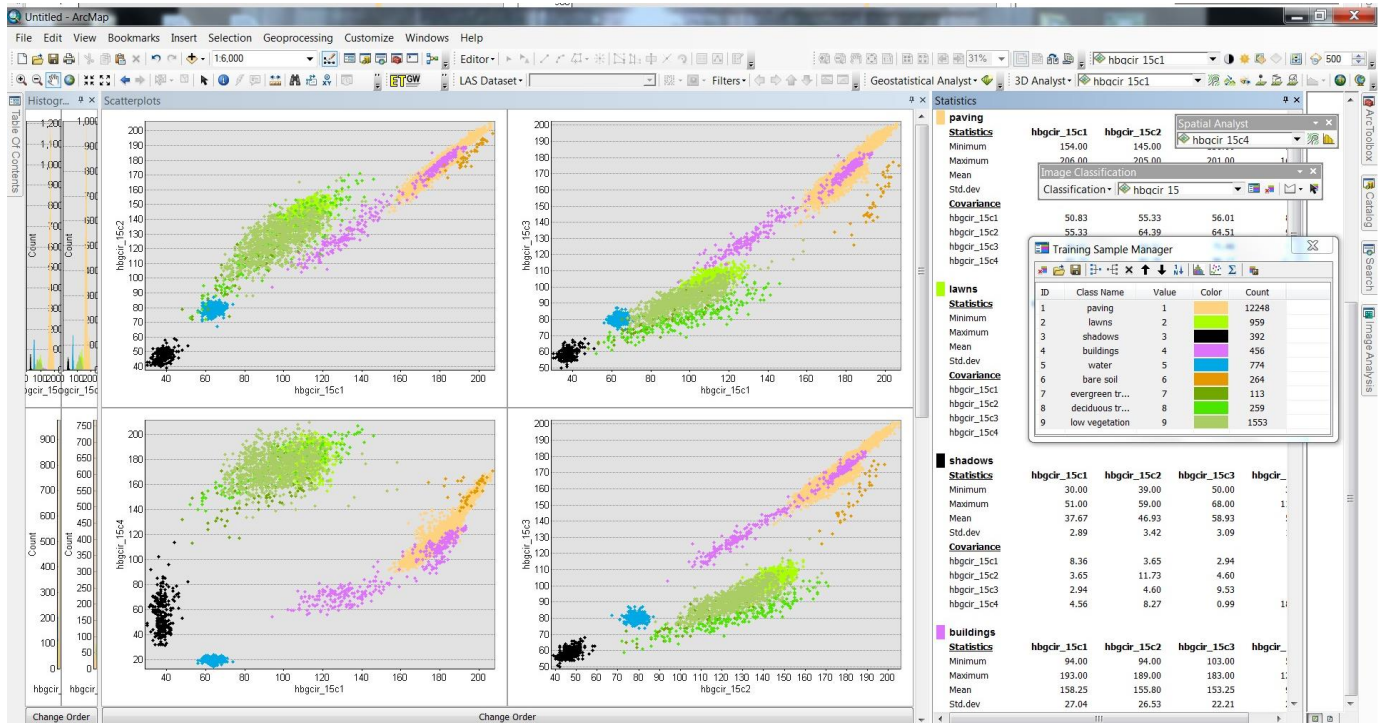
Methods: Supervised Classification



- The polygon drawing tool was used to create a multiband signature file to assign class names to polygon areas.
- 23 signatures were created throughout the image to capture both distinct areas and the variability in those areas across the image.
- The signatures were chosen based on both on personal knowledge of the area and the way pixels appeared in the multiband image.
- The signatures were then assessed to be sure the classes were explicit.

WAIT! It didn't work….

- Several information classes were "spectrally confused"!
- Many attempts were made to separate them using different tools available in the *Training Sample Manager*:



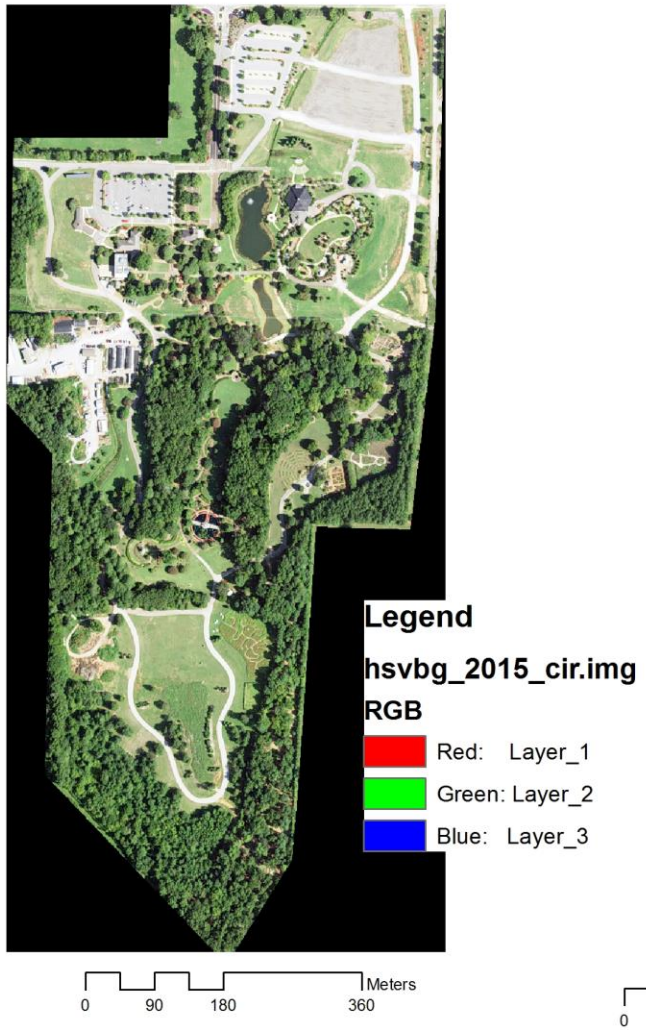
- Histogram comparisons of multiple signatures
- Scatterplots for multiple signatures
- Statistical filtering
- Stretch tool for histogram equalization in bands
- Re-drawing and deletion of signatures in different band combinations

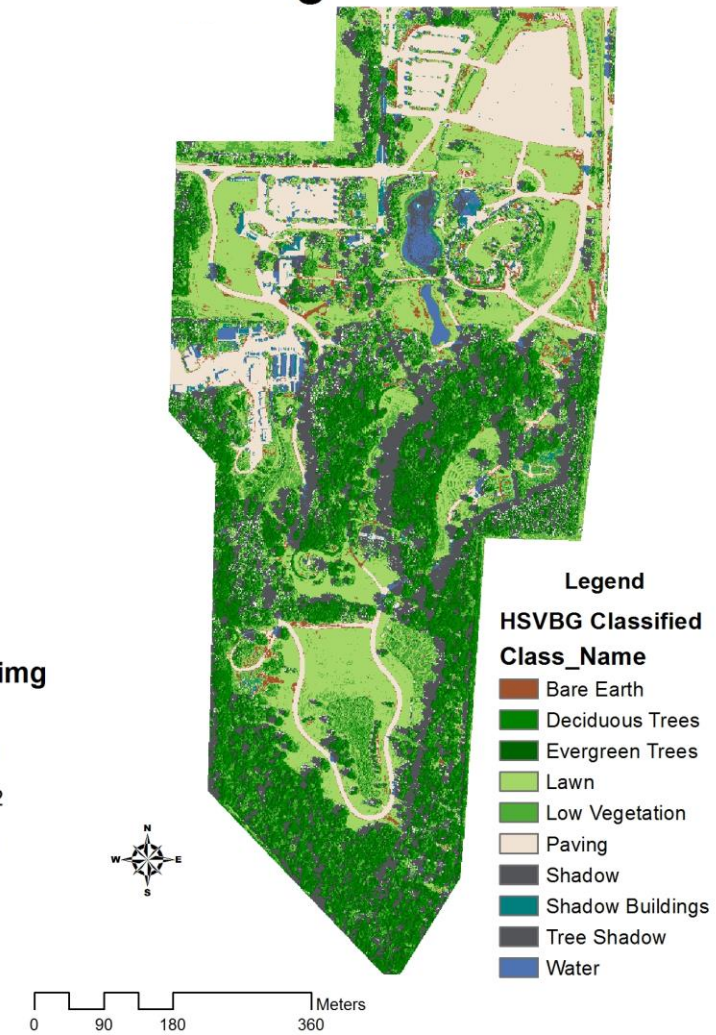
Let’s try this again…

- The image used could not be separated into the classes desired based on their spectral signatures in part because the image was taken during the dormant season.
- Data: 2015 1m resolution image from August 2015.
- 36 new signatures were created for this image.
- The evaluation process resulted in 7 signatures deleted and the rest merged.
- Final result: 10 classes; only 2 classes noticeably overlapping.

Results: Eureka!

Comparison of CIR Aerial Photo to Classified Image





Methods: NDVI
(Normalized Difference Vegetation Index)

- NDVI is a measure of vegetation productivity – healthy vegetation yields a higher pixel value than unhealthy vegetation.

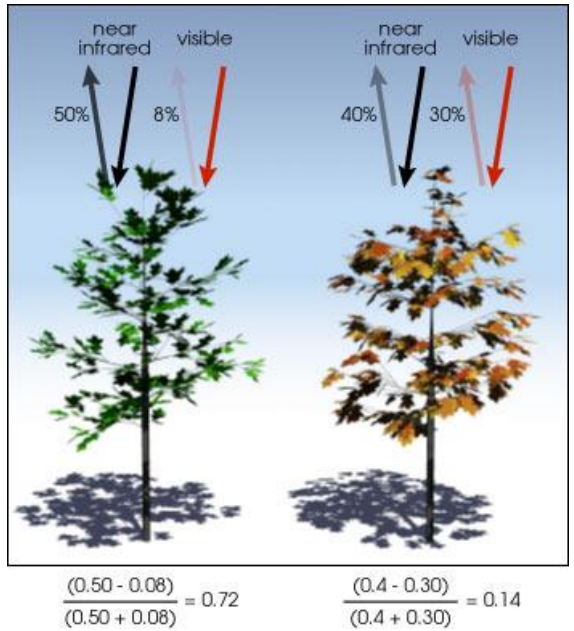
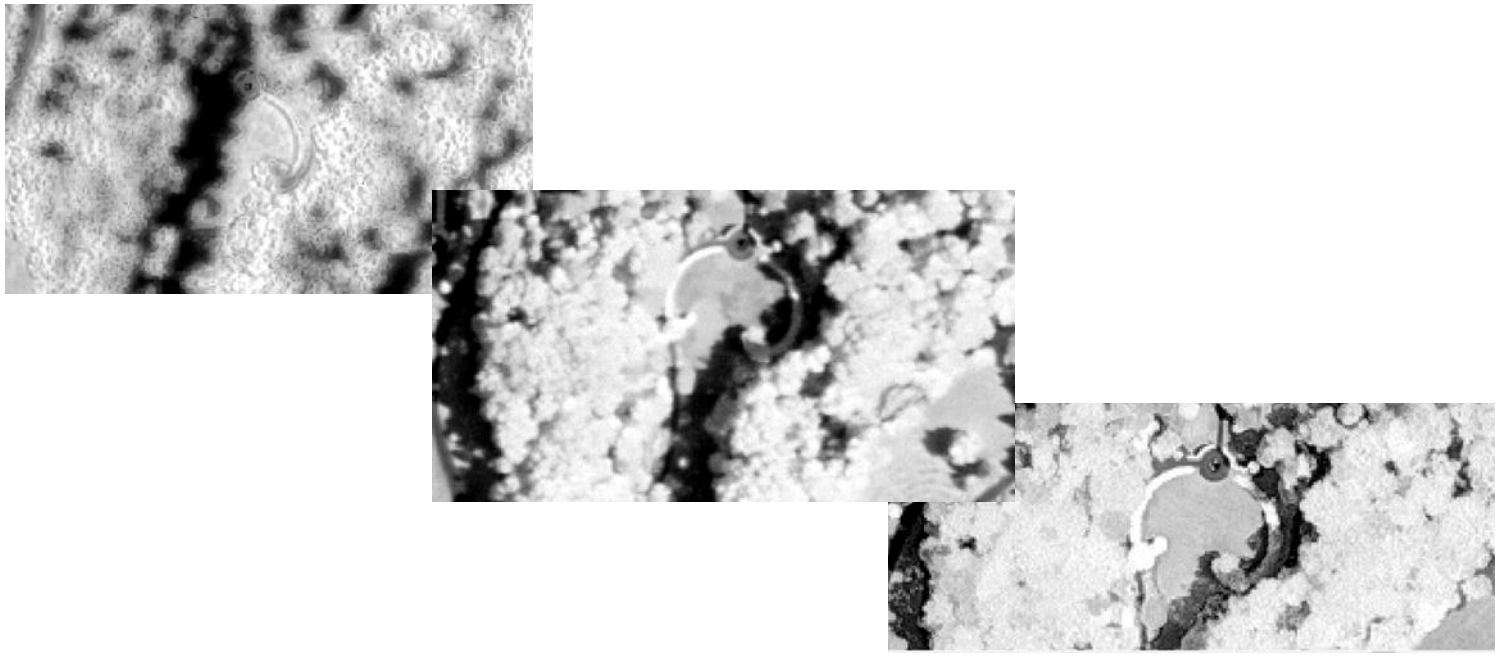


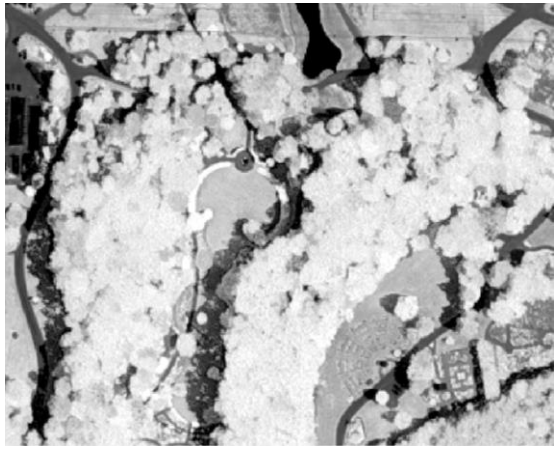
Image Credit:
http://earthobservatory.nasa.gov/Features/MeasuringVegetation



Comparison of 2011, 2013, & 2015 NDVI images

Methods: NDVI
(Normalized Difference Vegetation Index)

- NDVI was generated for the area of interest from the Aug 2013 and Aug 2015 1 m images using the *Image Analysis* window and produces a panchromatic image with the pixel values ranging from 1.0 to -1.0.



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

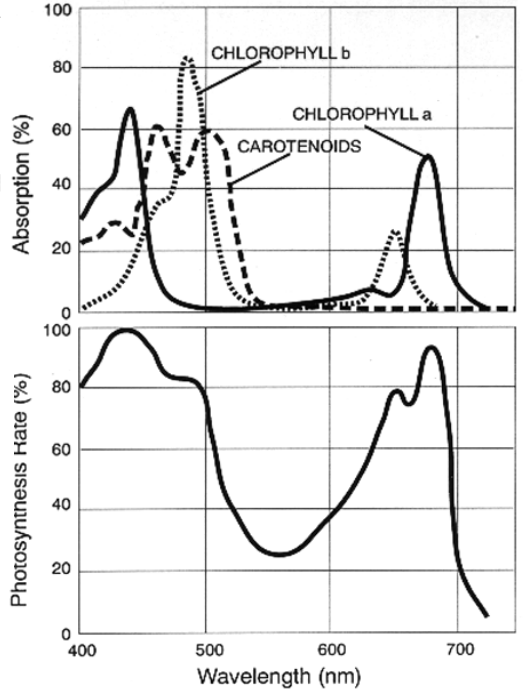
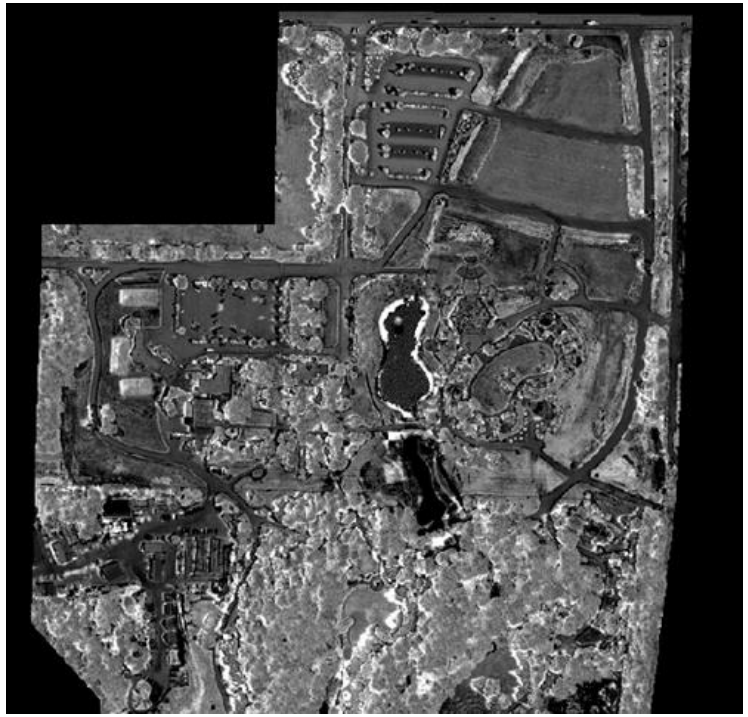
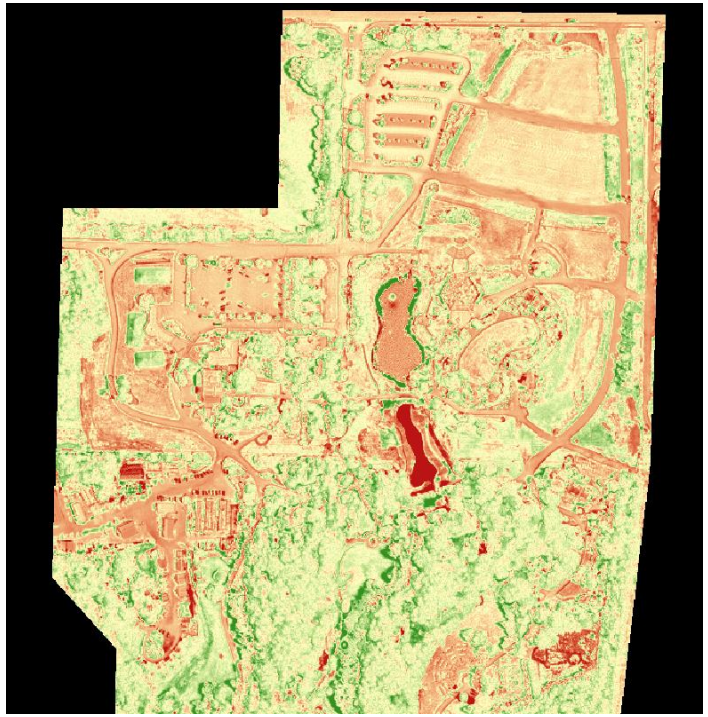


Image credit: By John Whitmarsh and Govindjee.
http://www.life.uiuc.edu/govindjee/paper/gov.html
from "Concepts in Photobiology: Photosynthesis and Photomorphogenesis"

Methods: Change Detection

- Change detection of the 2013 & 2015 NDVI images was taken using the *difference* tool in the *Image Analysis* window to determine if declines in vegetation productivity / reflectance were detectable over that period.

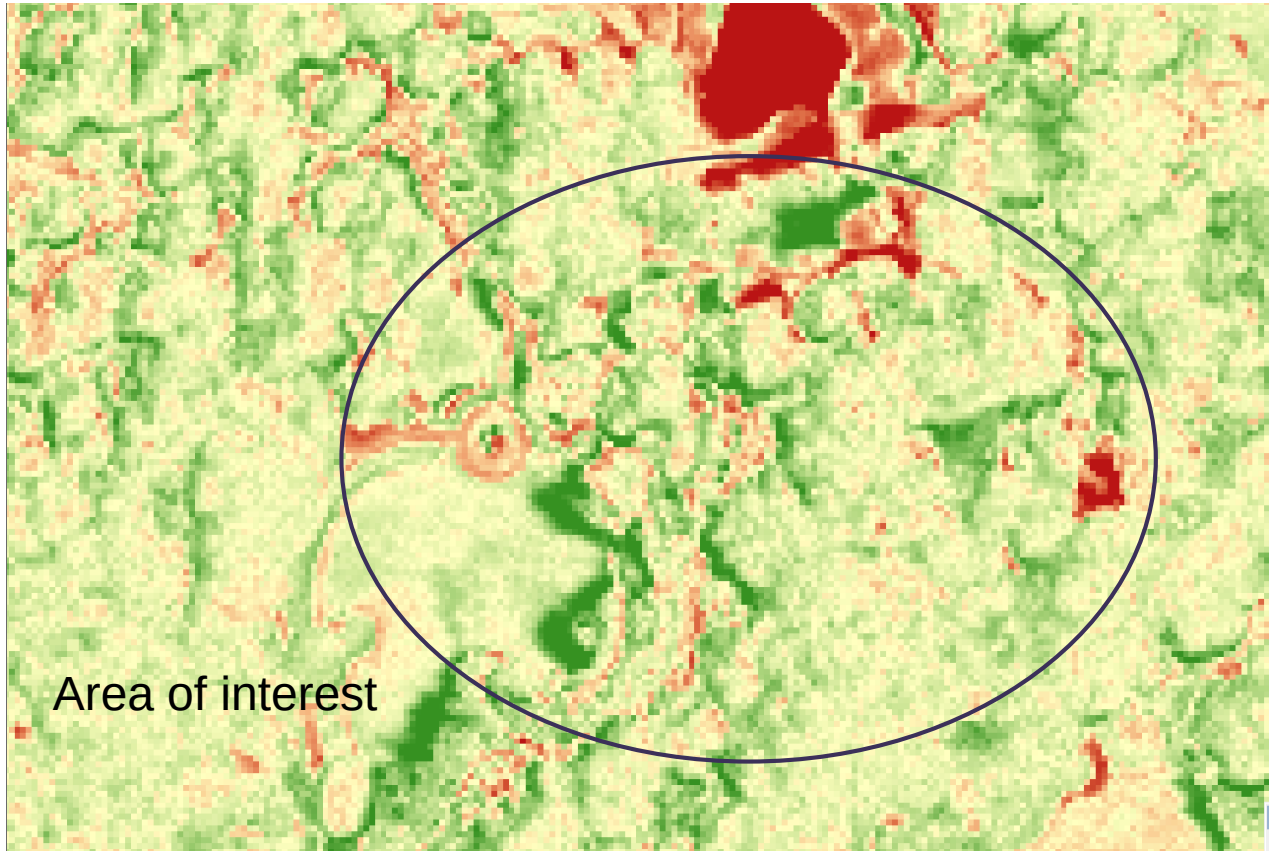




Difference 2013 & 2015 NDVI images

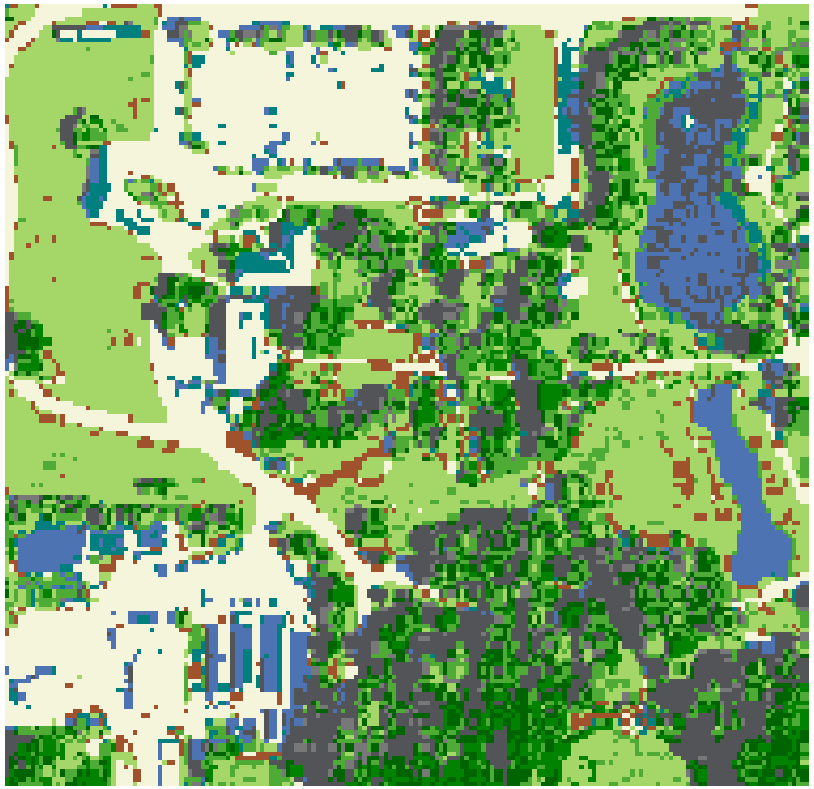
Results: NDVI & Change Detection

- This produces a per-pixel change raster with continuous values based off of the input rasters. Green = increased vegetation , red = decreased, tan = no change.
- The very dark red pixels indicate big man-made changes.
- The differences raster produced was visually inspected to see whether the areas identified are correlated with storm damage that occurred in mid-2016.



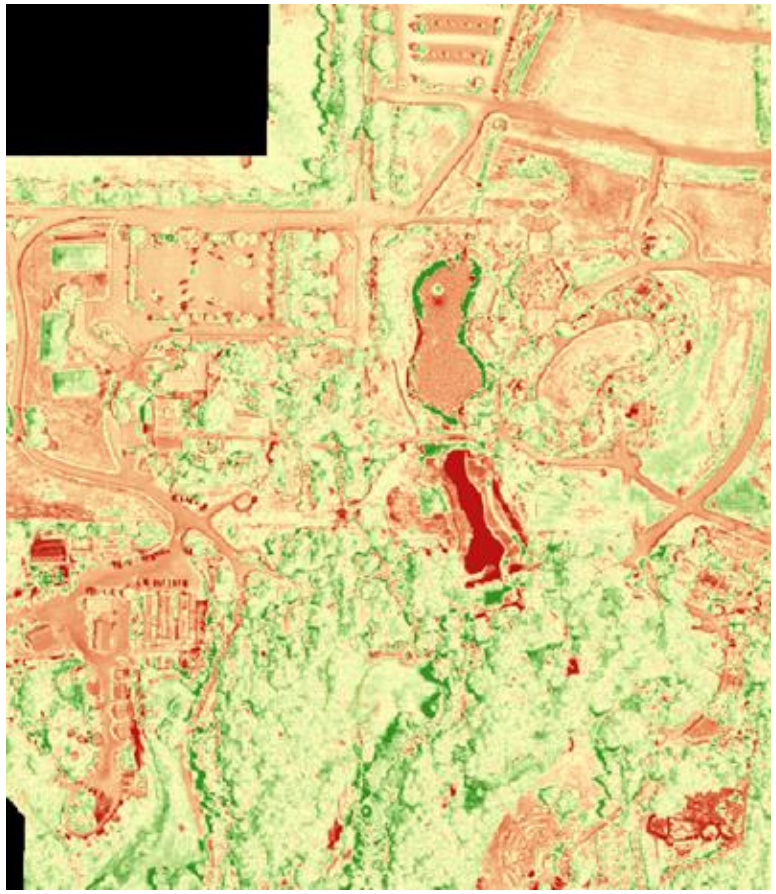
Discussion: Classification

- Timing and season of the aerial photo dramatically affects its usefulness in classification and NDVI.
- Depending on the spectral qualities present in the photo, a hybrid supervised/unsupervised classification would probably yield as good or better results with less effort.
- A classified image is useful in quickly delineating simple classes, but fails when attempting to extract features that are easily confused i.e. nursery weed fabric & shallow water with pond dye.
- Higher spatial resolution is not always better.



Discussion: NDVI / Change Detection

- The elapsed time between images used was very good at highlighting big man-made changes, but not enough to detect tree decline.
- It is possible that using the *slice* tool on the change detection image could make visible more subtle changes within the data.
- It is also possible that the trees felled in the storm were victims of strait-line winds, and no decline is present.
- It would be interesting to see if duplication of this analysis on images with greater elapsed time would yield more noticeable vegetation effects.



References

- Lambert, Jonas, Christophe Drenou, Jean-Philippe Denux, Gérard Balent, and Véronique Cheret. n.d. “Monitoring Forest Decline through Remote Sensing Time Series Analysis.” doi:10.1080/15481603.2013.820070.
- Lévesque, Josée, and Douglas J King. 2003. “Spatial Analysis of Radiometric Fractions from High-Resolution Multispectral Imagery for Modelling Individual Tree Crown and Forest Canopy Structure and Health.” *Remote Sensing of Environment* 84: 589-604
- Peters A Waltershea E Ji L Vliia A Hayes M. 2002. “Drought Monitoring with NDVI-Based Standardized Vegetation Index” *Photogrammetric Engineering & Remote Sensing* 68: 71- 75. doi: 0099-1112/02/6800-07
- Vogelmann, J., Tolk, B., & Zhu, Z. 2009. “Monitoring Forest Changes in the Southwestern United States Using Multitemporal Landsat Data.” *Remote Sensing of Environment* 113: 1739–48. doi::10.1016/j.rse.2009.04.014.
- Wang, Junming, Theodore W Sammis, Vincent P Gutschick, Mekonnen Gebremichael, Sam O Dennis, and Robert E Harrison. 2010. “Review of Satellite Remote Sensing Use in Forest Health Studies.” *The Open Geography Journal* 3: 28–42.
- Xiao, Qingfu, and E Gregory Mcpherson. 2005. “Tree Health Mapping with Multispectral Remote Sensing Data at UC Davis, California.” *Urban Ecosystems* 8: 349–61.

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Thank You

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Questions?