National Aeronautics and Space Administration

Advanced Webinar: Change Detection for Land Cover Mapping

Cindy Schmidt, Amber McCullum

Guest Speaker: Jenny Hewson

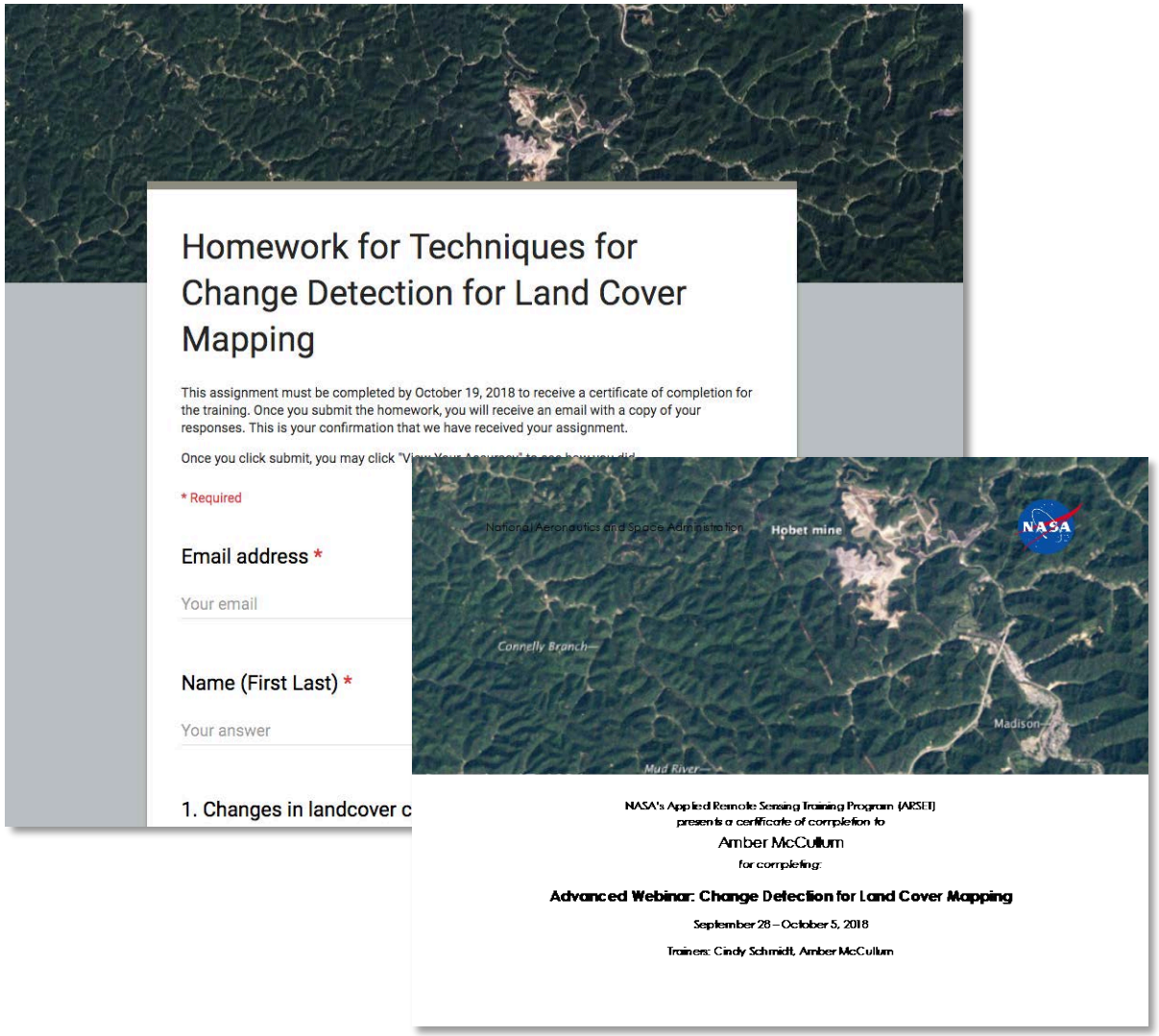
September 28, 2018

Course Structure

- Two, two-hour sessions on Friday, September 28, and Friday, October 5, 2018
- The same content will be presented at two different times each day:
  - Session A: 10:00-12:00 EDT (UTC-4)
  - Session B: 18:00-20:00 EDT (UTC-4)
  - **Please only sign up for and attend one session per week**
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
  - https://arset.gsfc.nasa.gov/land/webinars/adv-change18
  - Q&A: Following each lecture and/or by email
    - cynthia.l.schmidt@nasa.gov, or
    - amberjean.mccullum@nasa.gov

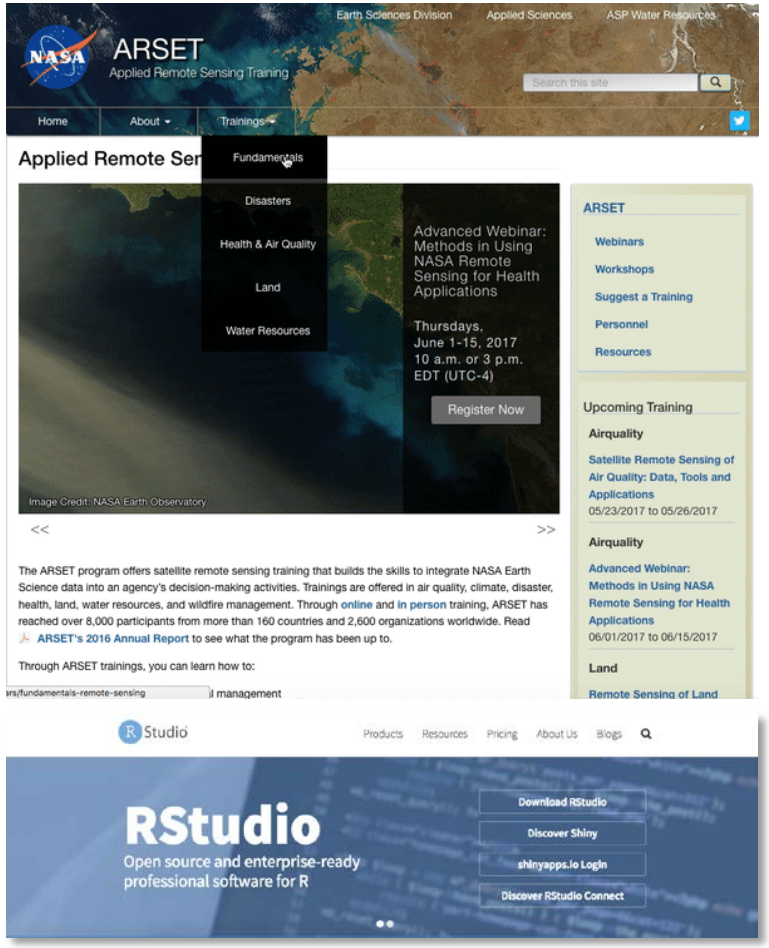
Homework and Certificates

- Homework
  - One homework assignment
  - Answers must be submitted via Google Forms
- Certificate of Completion:
  - Attend both live webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
    - HW Deadline: Oct 19th
  - You will receive certificates approx. two months after the completion of the course from: marines.martins@ssaihq.com



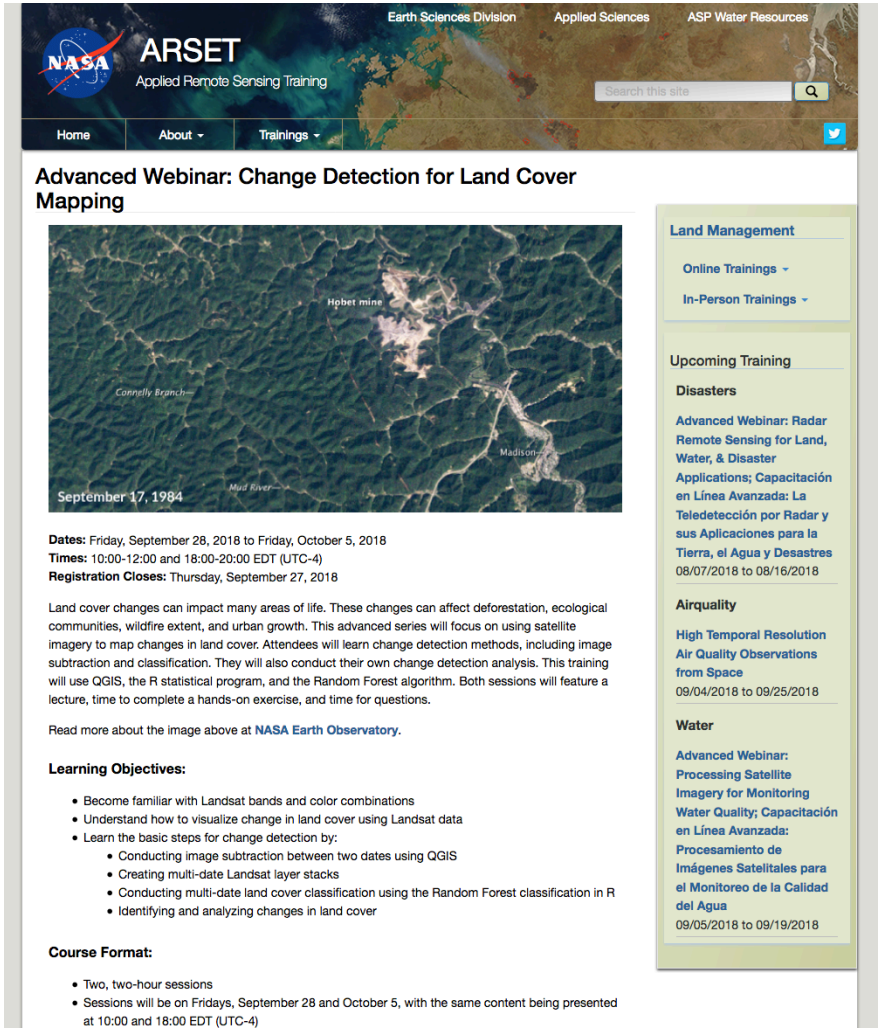
Prerequisites

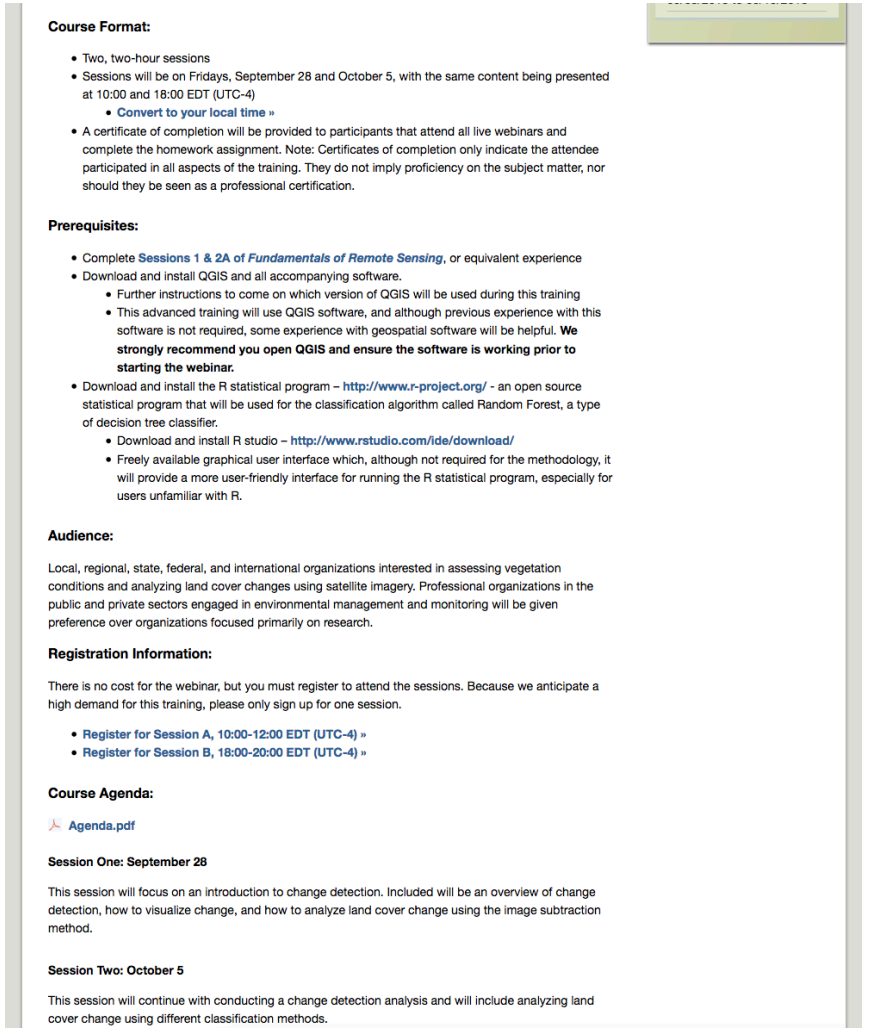
- Fundamentals of Remote Sensing
  - Sessions 1 and 2A (Land)
  - On demand webinar, available anytime
- Advanced Webinar: Land Cover Classification with Satellite Imagery
- Download and install QGIS and all accompanying software Use this exercise for help: Downloading and Installing QGIS
- Download and install the R statistical program
- Download and install R Studio



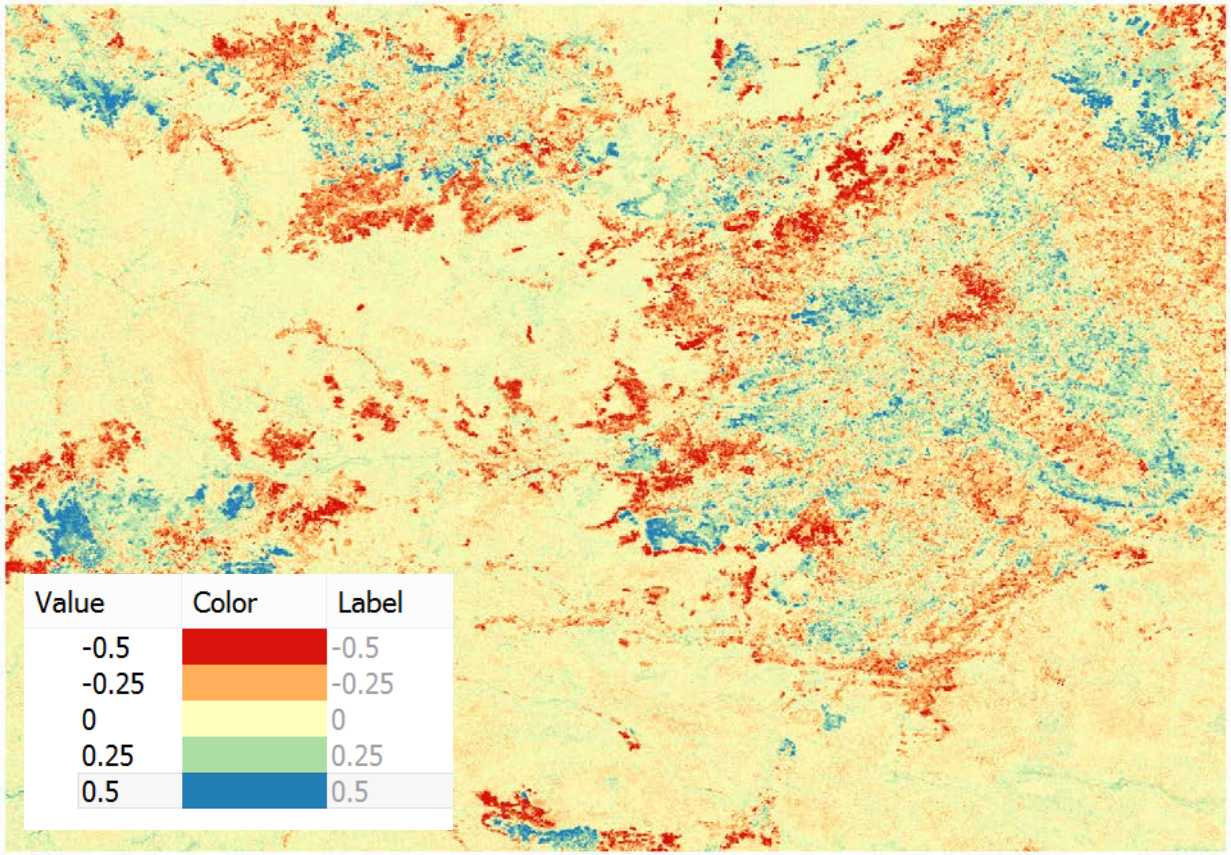
Accessing Course Materials

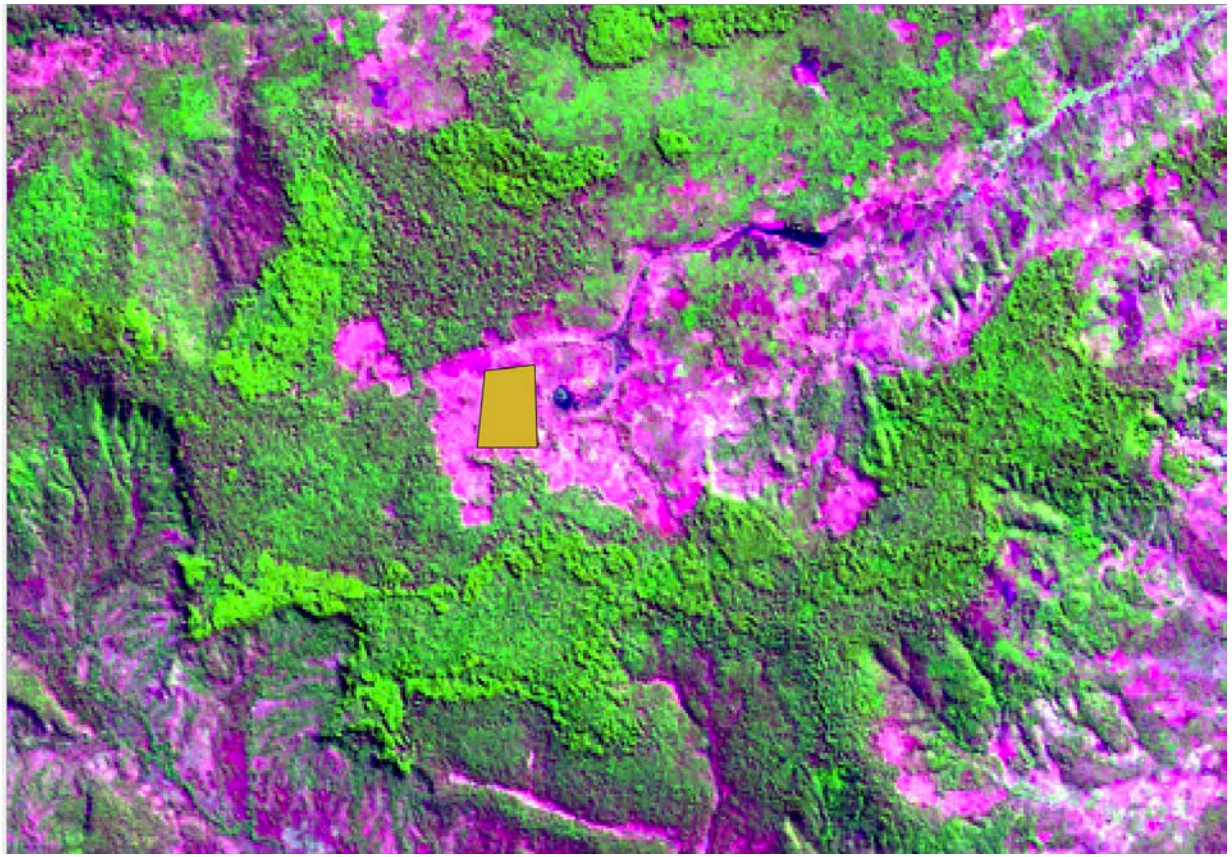
https://arset.gsfc.nasa.gov/land/webinars/adv-change18





Course Outline



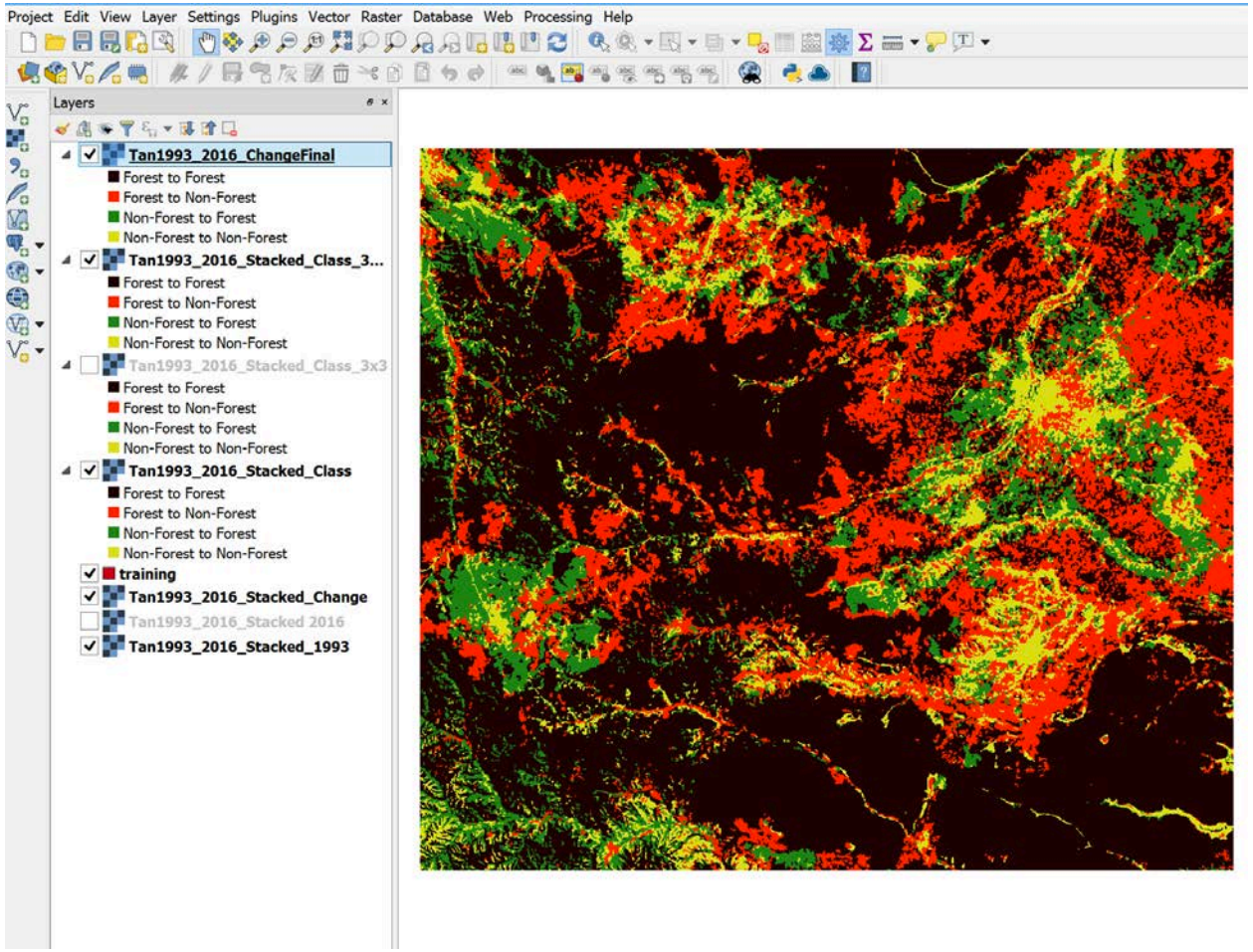


Session 1: Introduction to Change Detection

Session 2: Conducting Change Detection with QGIS & R

Session 2 Agenda

- Supervised Classification Review
- Methodology for Two-Date classification and change detection
  - Image preparation
  - Developing training sites
  - The Random Forest Algorithm
  - Classification refinement
  - Image post-processing
- Exercise 2



Guest Speaker: Jenny Hewson, Conservation International

Supervised Classification

Image Classification

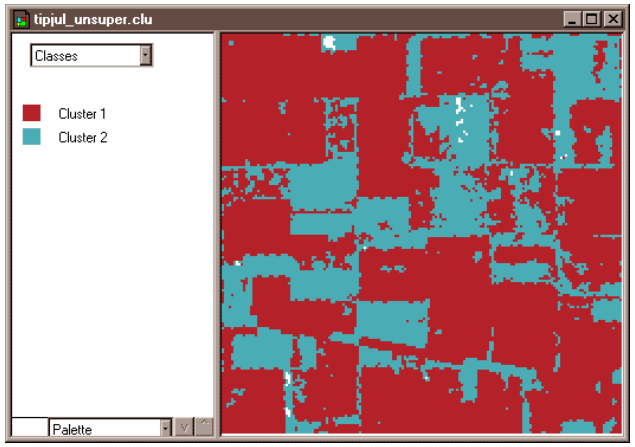
Methods

Supervised

- Uses expert-defined areas of known vegetation types (training areas) to tune parameters of classification algorithms
- Algorithm then automatically identifies and labels areas similar to the training data

Unsupervised

- Uses classification algorithms to assign pixels into one of a number of user-specified class groupings
- Interpreters assign each of the groupings of pixels a value corresponding to a land cover class

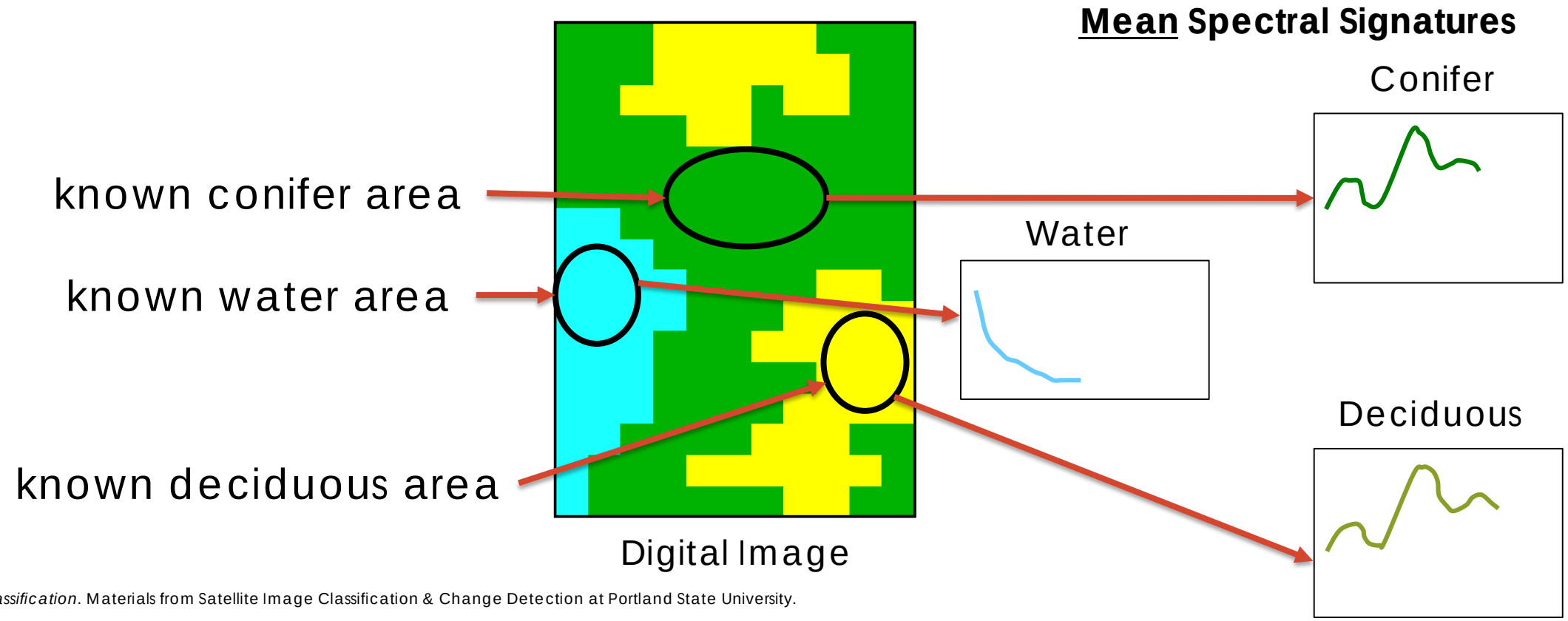


Credit: David DiBiase, Penn State Department of Geography

Image Classification

Supervised Method

Supervised classification requires the analyst to select training areas where they know what is on the ground, and then digitize a polygon within that area

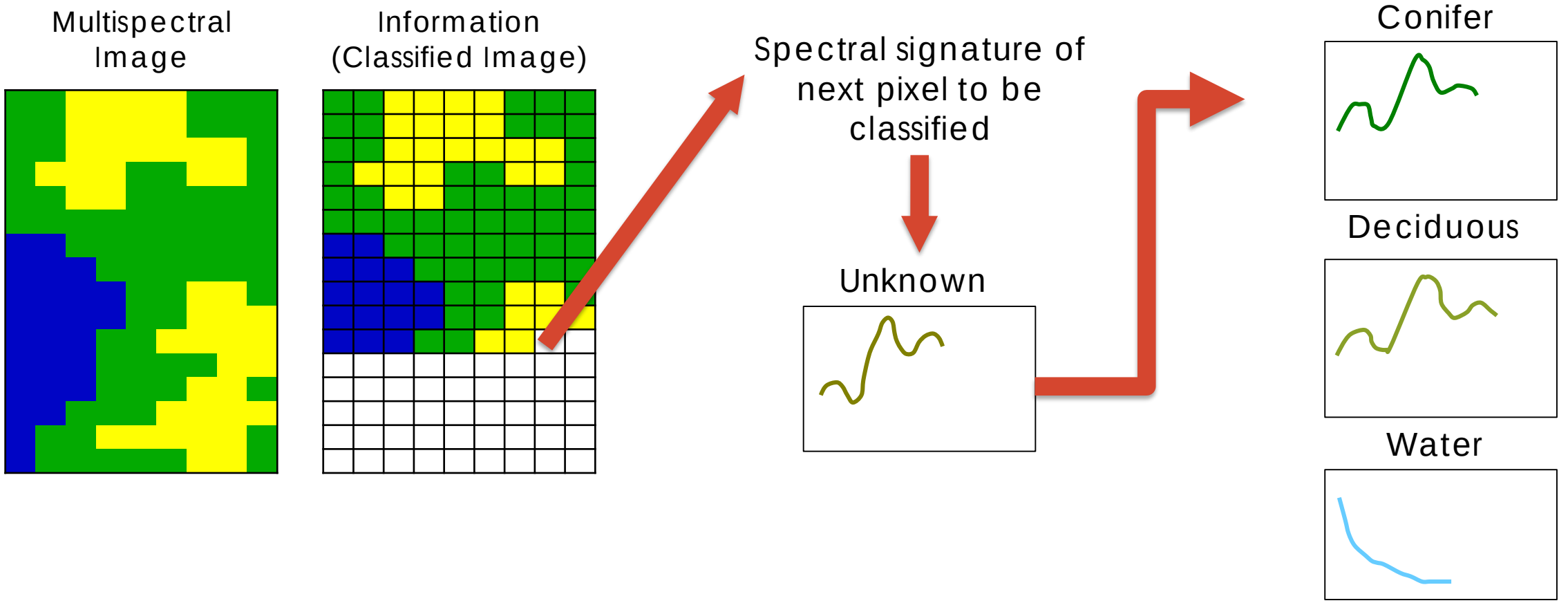


Sutton, L. *Image Classification*. Materials from Satellite Image Classification & Change Detection at Portland State University.

Image Classification

Supervised Method

The spectral signature of each pixel gets matched with the training signatures and the image is classified accordingly

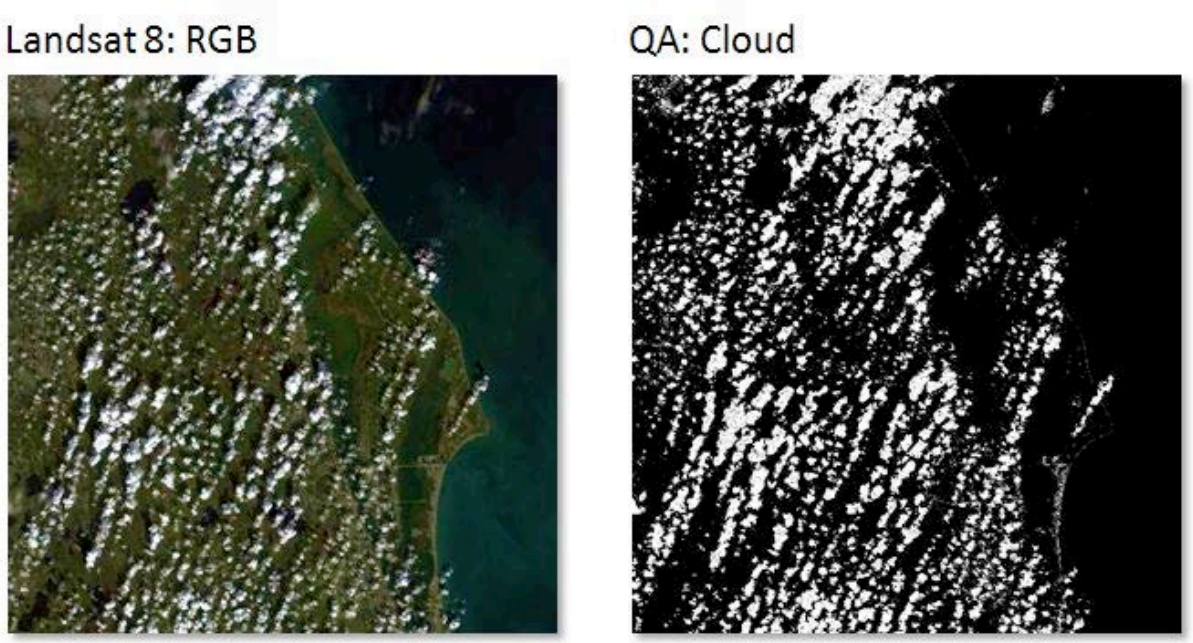


Two-Date Supervised Classification and Change Detection

Methodology

Cloud Masking

- Cloudy pixels affect the ability of optical satellites to “see” land surface
- Cloudy pixels can be incorrectly classified in imagery, affecting the accuracy
- Cloud masking removes cloudy pixels
- Landsat Surface Reflectance Products have a cloud mask layer
  - Pixels are identified as clouds based on their reflectance values
- The user can use this cloud mask layer to remove clouds in each image

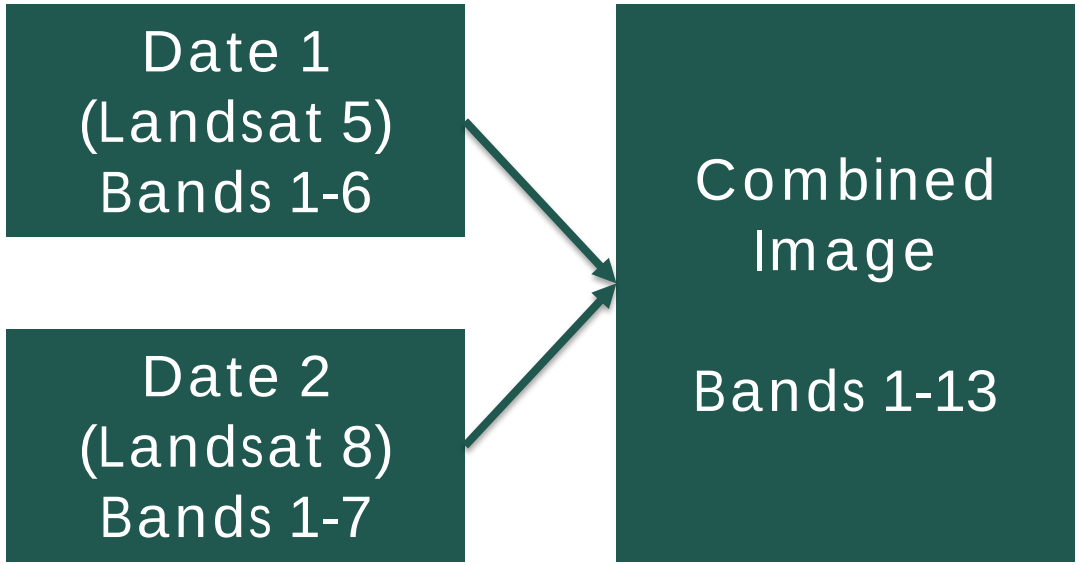


This example illustrates QA output for a subset Landsat 8 scene of Lake Tahoe acquired on April 12, 2014

Image Credit: HySpeed Computing

Band Stacking of Two Dates

- The next step is to stack the two multi-band images into one image
- Assume Date 1 is Landsat 5 and Date 2 is Landsat 8
- Direct change classification minimizes classification errors



Bands Date 1	Name	Bands Date 2
	Blue 1	7
1	Blue 2	8
2	Green	9
3	Red	10
4	NIR	11
5	SWIR 1	12
6	SWIR 2	13

Bands in new combined stack

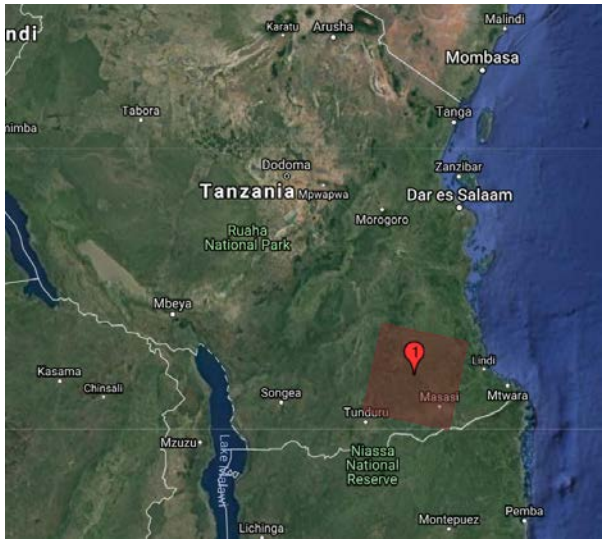
Image Enhancement

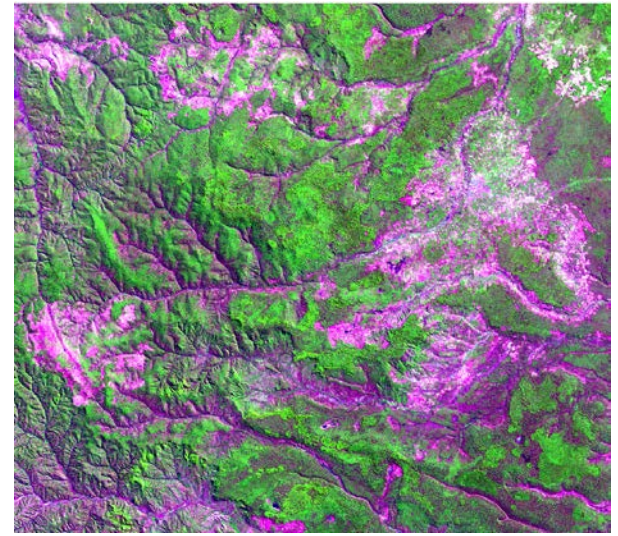
- Makes the image easier to interpret
  - Stretching
    - Ex: adjust the minimum and maximum values OR use the standard deviation of the pixels to make the image look brighter
  - Band Combinations
    - Ex: False color can be used to make vegetation red to stand out in the image

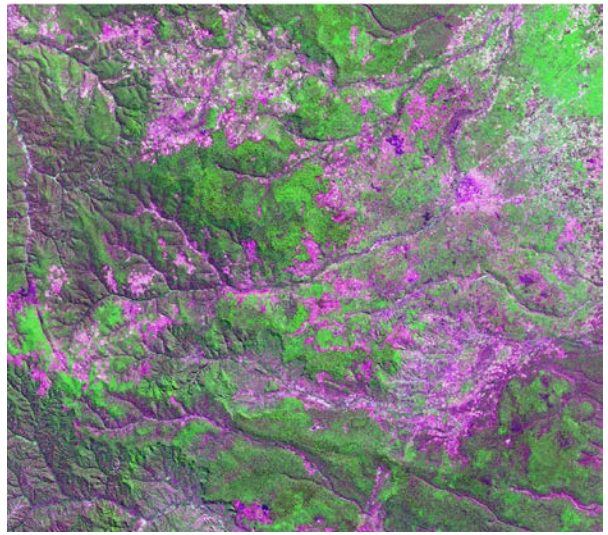
		Landsat 7 Landsat 5	Landsat 8
	Color Infrared:	4, 3, 2	5,4,3
	Natural Color:	3, 2, 1	4,3,2
	False Color:	5,4,3	6,5,4
	False Color:	7,5,3	7,6,4
	False Color:	7,4,2	7,5,3

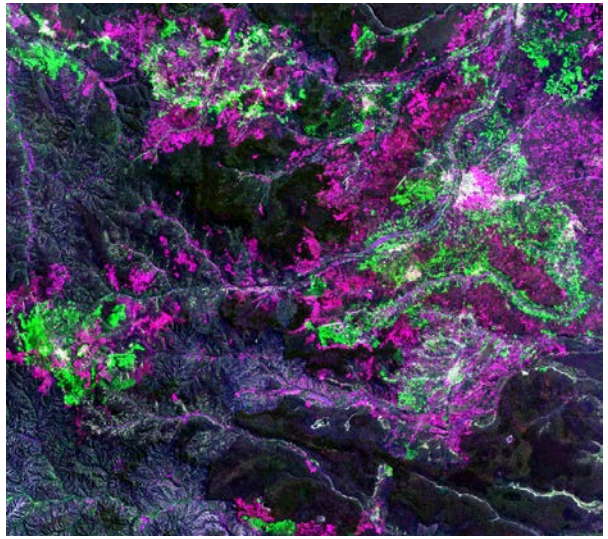
Multi-Date Image Enhancement

- Instead of 7 bands, you have 13 bands
- Highlights changes between two dates
- Example: Multi-temporal false color composite:
  - Red band: Band 12 (SWIR1 – date 2)
  - Green band: Band 5 (SWIR1- date 1)
  - Blue Band: Band 8 (Blue – date 2)



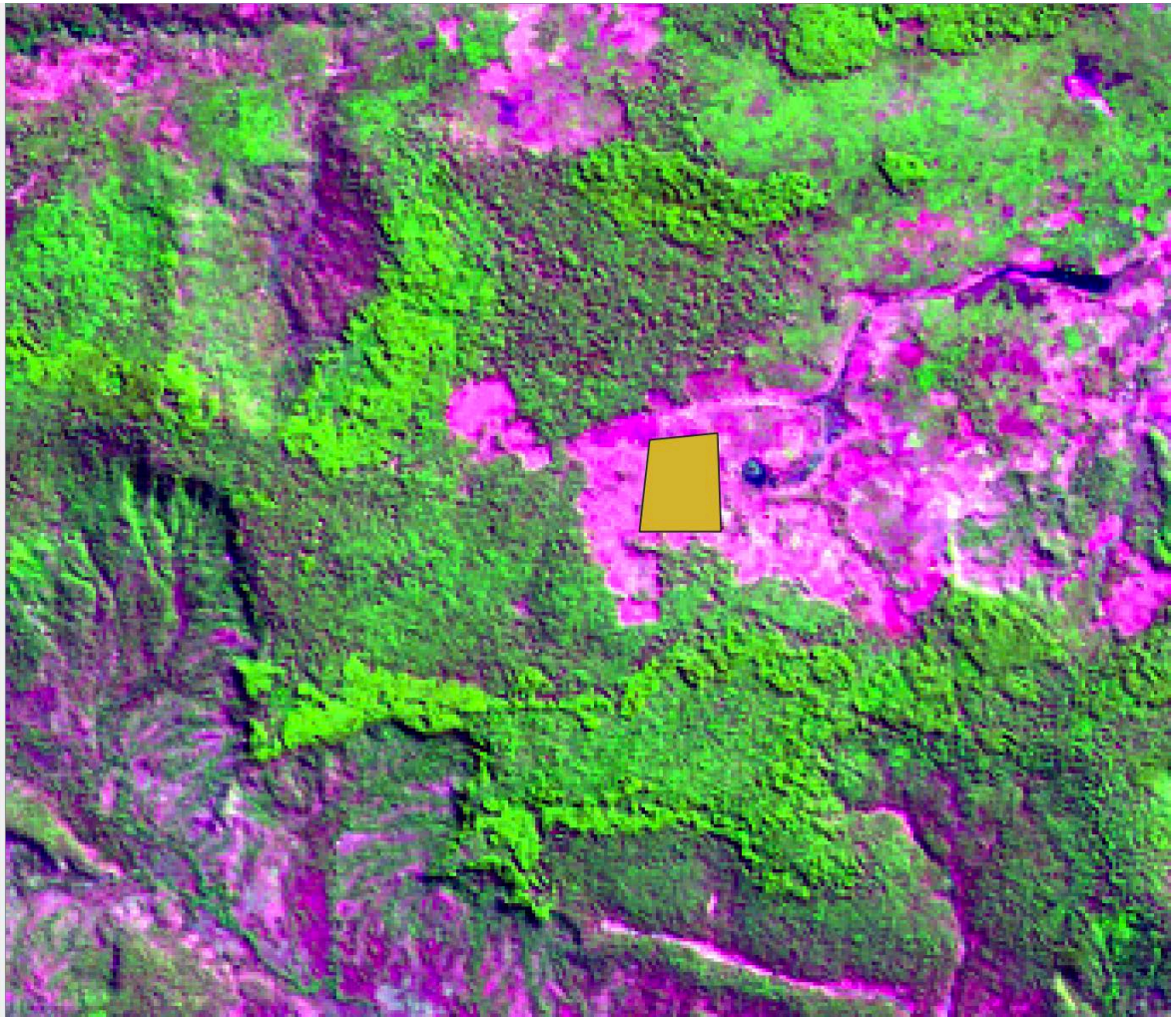






Training Site Guidelines

- Training sites should be distributed across the entire scene
- Both change and non-change should be included
- Size of training sites will depend on spectral characteristics of image
  - Simple images → large training sites
  - Spectrally complex → small training sites
- **Key: All spectral variability in the image must be captured**



Change Land Cover Classes

Normally you would have a single digit code for a single-date classification:

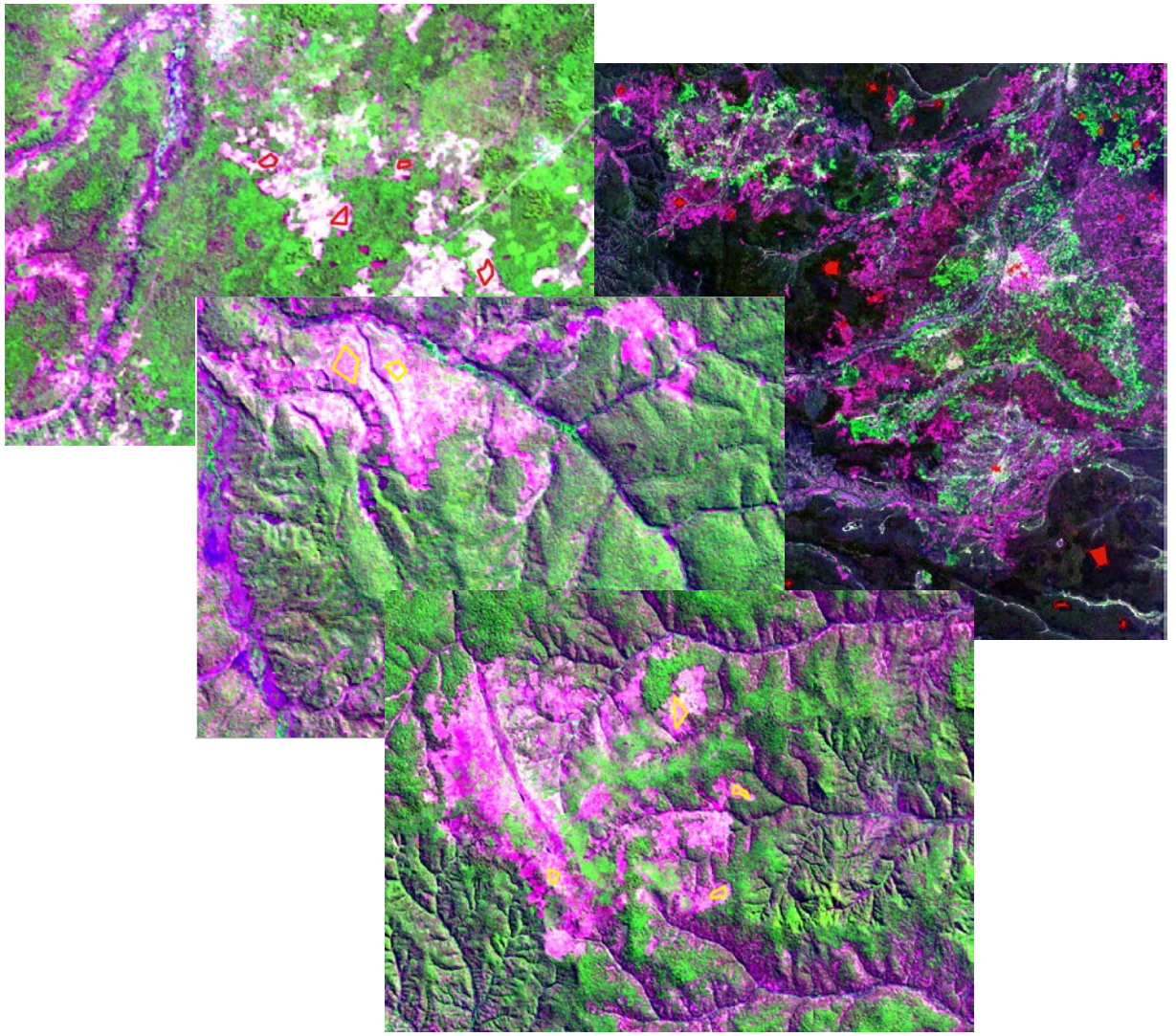
Cover Class	Code
Forest	1
Non-Forest	2
Water	3
Urban	4
Cloud	5
Shadow	6

For two-date change classification, codes will be 2 digits:

Cover Class	Code
Forest-Forest	11
Forest-NonForest	12
NonForest-Forest	21
Water-Water	33
Urban-Urban	44

Training Sites for two-date classification

- Since we are using a decision tree classification (in this case Random Forest) we do not need training sites to be homogenous
- That means you can mix forest types or non-forest land cover types
- You should try and capture the range of spectral signatures included in each class
- If you have an image with background pixels, you will need to add a class and create a training area in the no-data (background) area
  - Assign it 88 (unclassified)

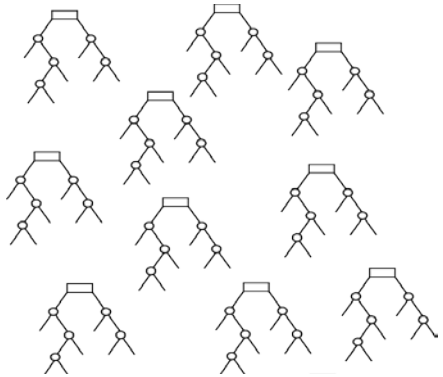


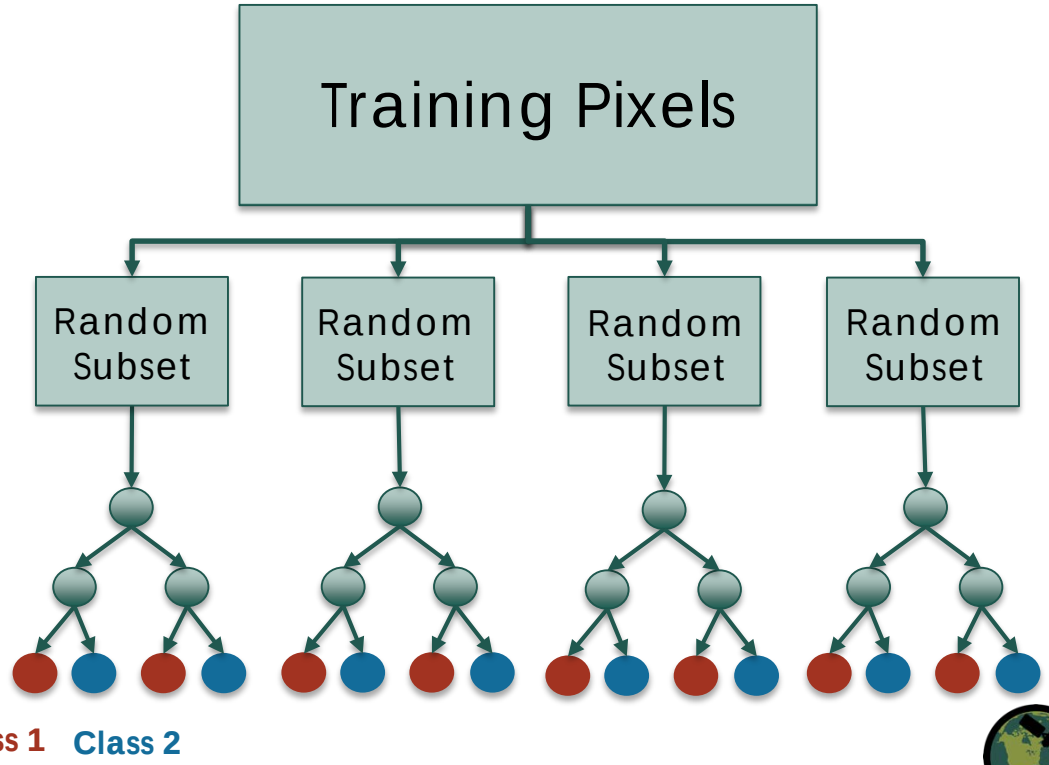
Classification Algorithms

- Used to classify the whole image by comparing spectral characteristics of each pixel to the spectral characteristics of the training sites for land cover classes
- Different available methods
  - Minimum Distance
  - Maximum Likelihood
  - Spectral Angle Mapping
  - Random Forest*
- These methods determine different ways for the classes to be defined based on their statistics

Random Forest Algorithm

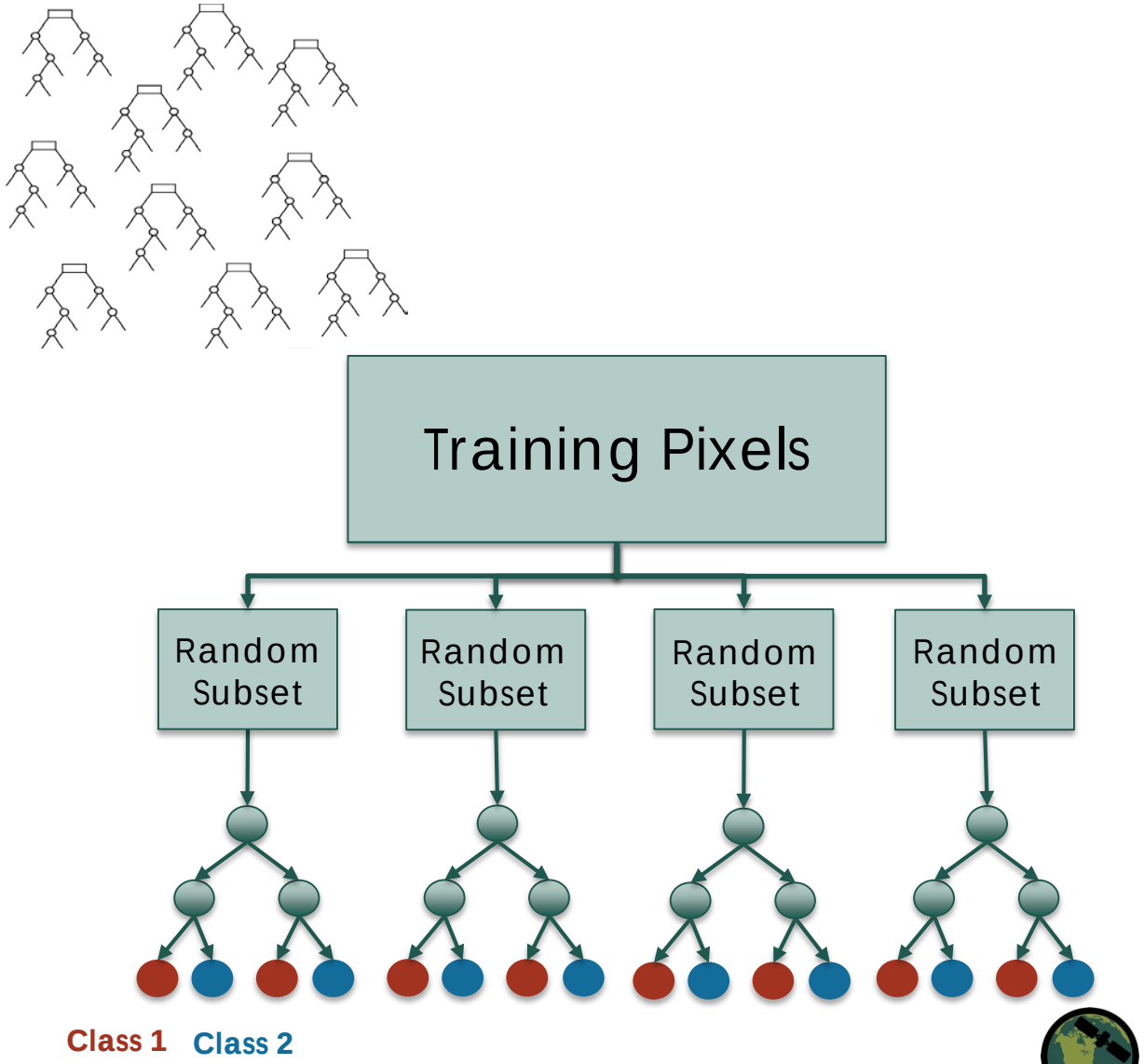
- Example of an ensemble model (combines the results from model models; logic → result from a combination will be better than from a single model)
- Supervised learning
- Random Forest algorithm takes a random set of training sites (usually 2/3) and builds multiple decision (classification) trees; remaining ~1/3 used to estimate error and importance of each predictor variable





Random Forest Algorithm

- Trees have branches (nodes) and leaves (class labels)
- There is a random component to each decision – think about a coin toss
- Classes are assigned to the pixels based on the majority rule, as if each random decision tree "votes" on what the class for that pixel should be
- The exercise in this webinar uses spectral data, but you could also use other data, such as DEMs, climate layers, and soil maps (continuous or categorical)



Random Forest Algorithm: Advantages and Limitations

Advantages

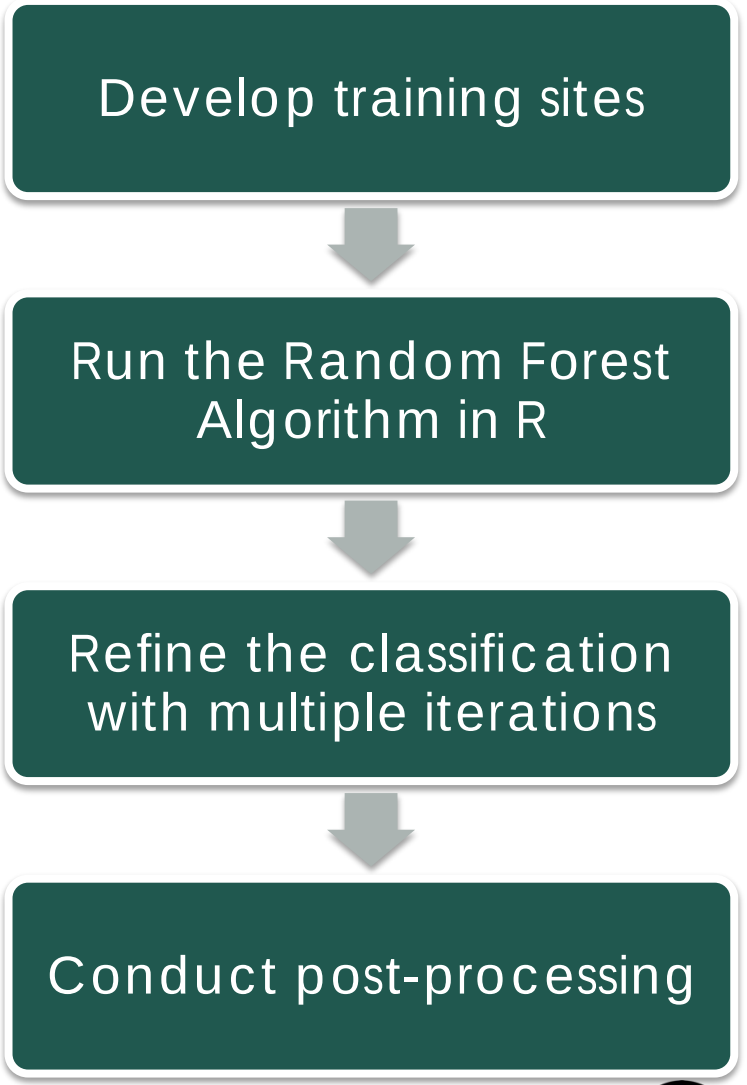
- No need for pruning
- Overfitting is not a problem
- Not sensitive to outliers in training data
- Easy to parameterize

Limitations

- Algorithm cannot predict spectral range beyond training data
- Training data much capture entire spectral range

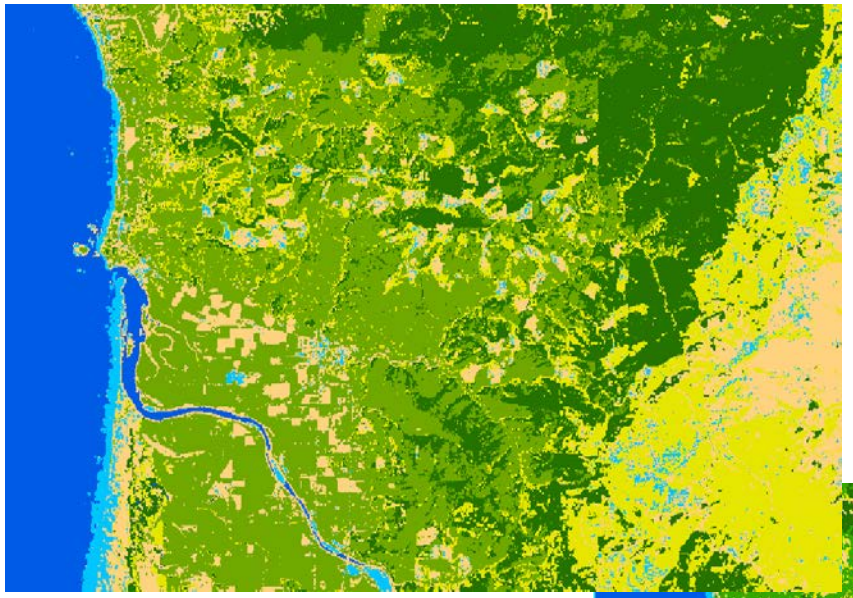
Multiple Iterations

- Image classification is an iterative process
- Number of iterations will depend on:
  - Image complexity
  - Number of classes
  - Intended use of final product: How accurate do you need your map to be?
- Review results:
  - Check map accuracy
  - Change/update training sites
  - Re-run Random Forest Algorithm with new training sites
  - Conduct filtering
  - Check map accuracy again

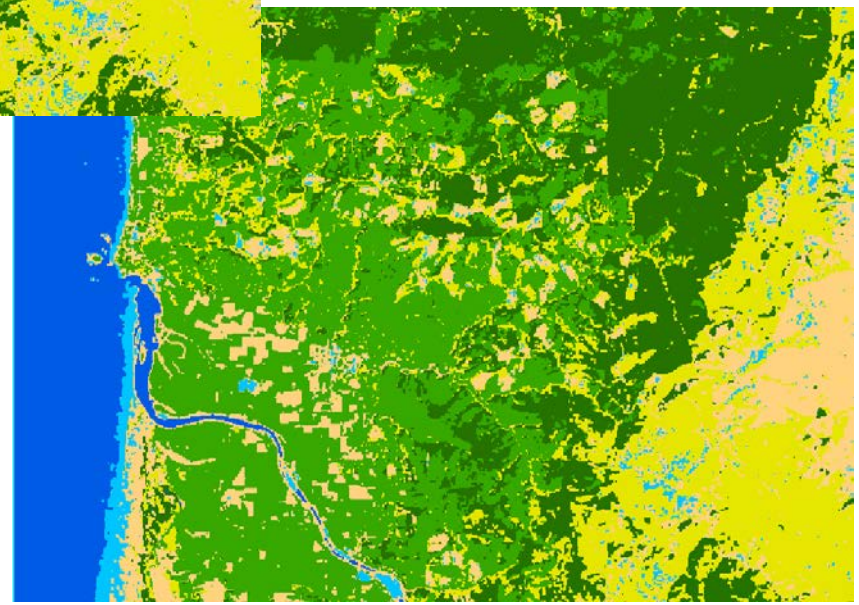


Post-Processing

- Filtering can be used to remove "noise" or isolated pixels that may be incorrectly classified, from an image
- Majority filter:
  - Each group of pixels are considered in a map
  - The filter assigns the predominant class to the central pixel
  - User-defined number of pixels surrounding the central pixel may be changed to the class of the central pixel



Unfiltered



Filtered

Exercise: 2-Date Image Classification and Change Detection

Contacts

- ARSET Land Management & Wildfire Contacts
  - Cynthia Schmidt: Cynthia.L.Schmidt@nasa.gov
  - Amber McCullum: AmberJean.Mccullum@nasa.gov
- General ARSET Inquiries
  - Ana Prados: aprados@umbc.edu
- ARSET Website:
  - http://arset.gsfc.nasa.gov

Thank You

Remember to Complete the Homework by October 19, 2018