

September 17, 1984



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

Homework for Techniques for Change Detection for Land Cover Mapping

This assignment must be completed by October 19, 2018 to receive a certificate of completion for the training. Once you submit the homework, you will receive an email with a copy of your responses. This is your confirmation that we have received your assignment.

Once you click submit, you may click "View Your Assignment" to see how you did.

*** Required**

Email address *

Your email

Name (First Last) *

Your answer

1. Changes in landcover c

NASA's Applied Remote Sensing Training Program (ARSET) presents a certificate of completion to
Amber McCullum
for completing:
Advanced Webinar: Change Detection for Land Cover Mapping
September 28 – October 5, 2018
Trainers: Cindy Schmidt, Amber McCullum



Prerequisites

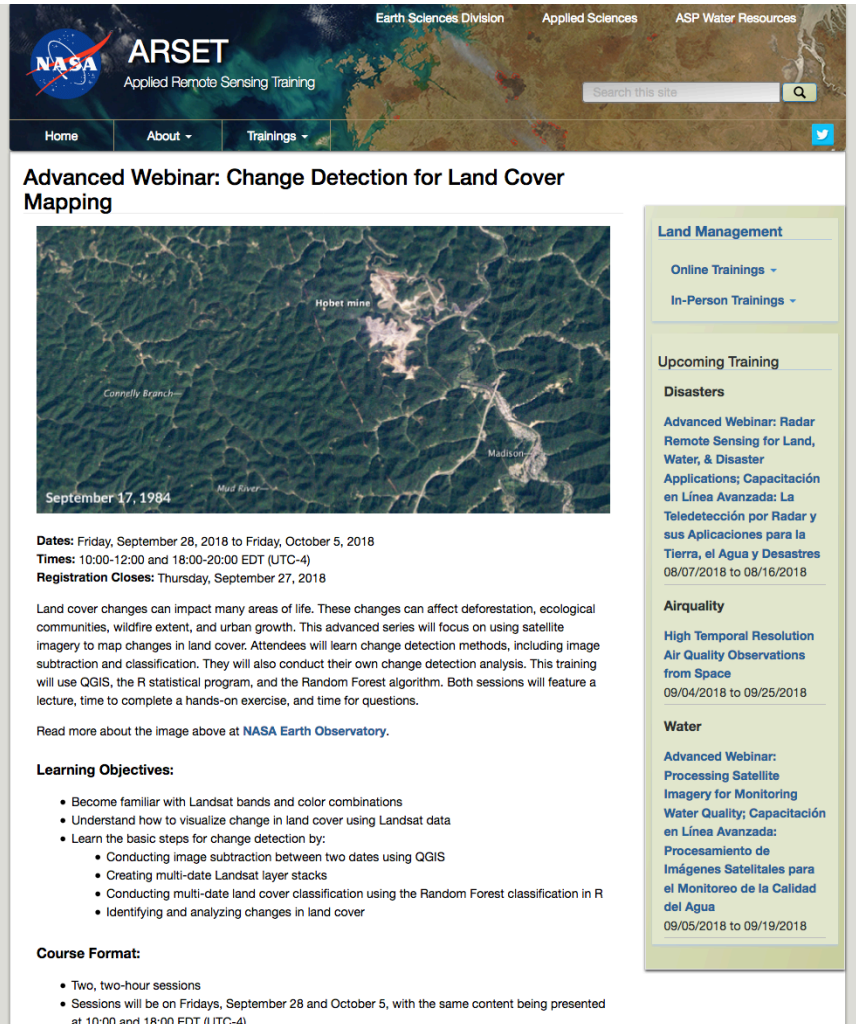
- [Fundamentals of Remote Sensing](#)
 - Sessions 1 and 2A (Land)
 - On demand webinar, available anytime
- [Advanced Webinar: Land Cover Classification with Satellite Imagery](#)
- [Download and install QGIS](#) and all accompanying software Use this exercise for help: [Downloading and Installing QGIS](#)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

The image shows two screenshots. The top screenshot is the ARSET (Applied Remote Sensing Training) website. It features the NASA logo and the text 'ARSET Applied Remote Sensing Training'. A navigation menu includes 'Home', 'About', and 'Trainings'. A dropdown menu for 'Trainings' is open, showing options for 'Fundamentals', 'Disasters', 'Health & Air Quality', 'Land', and 'Water Resources'. A featured section for an 'Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications' is visible, with dates 'Thursdays, June 1-15, 2017, 10 a.m. or 3 p.m. EDT (UTC-4)' and a 'Register Now' button. A sidebar on the right lists 'ARSET' resources like 'Webinars', 'Workshops', and 'Suggest a Training'. The bottom screenshot is the RStudio website, featuring the R logo and the text 'RStudio Open source and enterprise-ready professional software for R'. It includes buttons for 'Download RStudio', 'Discover Shiny', 'shinyapps.io Login', and 'Discover RStudio Connect'.



Accessing Course Materials

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



The screenshot shows the ARSET website interface. At the top, there is a navigation bar with the NASA logo, the text 'ARSET Applied Remote Sensing Training', and links for 'Earth Sciences Division', 'Applied Sciences', and 'ASP Water Resources'. Below this is a search bar and a menu with 'Home', 'About', and 'Trainings'. The main content area features the title 'Advanced Webinar: Change Detection for Land Cover Mapping' and a satellite image of a forested area with labels for 'Hobert mine', 'Connelly Branch', 'Madison', and 'Mud River'. The date 'September 17, 1984' is visible in the bottom left of the image. To the right of the image is a sidebar with sections for 'Land Management', 'Online Trainings', 'In-Person Trainings', 'Upcoming Training', 'Disasters', 'Airquality', and 'Water'. The 'Disasters' section lists the current webinar. Below the main content, there is a 'Dates' section, a 'Times' section, a 'Registration Closes' section, a paragraph of text about land cover changes, a link to 'NASA Earth Observatory', 'Learning Objectives', and 'Course Format'.


ARSET
Applied Remote Sensing Training

Earth Sciences Division Applied Sciences ASP Water Resources

Search this site

Home About Trainings

Advanced Webinar: Change Detection for Land Cover Mapping



Dates: Friday, September 28, 2018 to Friday, October 5, 2018
Times: 10:00-12:00 and 18:00-20:00 EDT (UTC-4)
Registration Closes: Thursday, September 27, 2018

Land cover changes can impact many areas of life. These changes can affect deforestation, ecological communities, wildfire extent, and urban growth. This advanced series will focus on using satellite imagery to map changes in land cover. Attendees will learn change detection methods, including image subtraction and classification. They will also conduct their own change detection analysis. This training will use QGIS, the R statistical program, and the Random Forest algorithm. Both sessions will feature a lecture, time to complete a hands-on exercise, and time for questions.

Read more about the image above at [NASA Earth Observatory](#).

Learning Objectives:

- Become familiar with Landsat bands and color combinations
- Understand how to visualize change in land cover using Landsat data
- Learn the basic steps for change detection by:
 - Conducting image subtraction between two dates using QGIS
 - Creating multi-date Landsat layer stacks
 - Conducting multi-date land cover classification using the Random Forest classification in R
 - Identifying and analyzing changes in land cover

Course Format:

- Two, two-hour sessions
- Sessions will be on Fridays, September 28 and October 5, with the same content being presented at 10:00 and 18:00 EDT (UTC-4)

Land Management

Online Trainings -

In-Person Trainings -

Upcoming Training

Disasters

Advanced Webinar: Radar Remote Sensing for Land, Water, & Disaster Applications; Capacitación en Línea Avanzada: La Teledetección por Radar y sus Aplicaciones para la Tierra, el Agua y Desastres
08/07/2018 to 08/16/2018

Airquality

High Temporal Resolution Air Quality Observations from Space
09/04/2018 to 09/25/2018

Water

Advanced Webinar: Processing Satellite Imagery for Monitoring Water Quality; Capacitación en Línea Avanzada: Procesamiento de Imágenes Satelitales para el Monitoreo de la Calidad del Agua
09/05/2018 to 09/19/2018

Course Format:

- Two, two-hour sessions
- Sessions will be on Fridays, September 28 and October 5, with the same content being presented at 10:00 and 18:00 EDT (UTC-4)
 - [Convert to your local time »](#)
- A certificate of completion will be provided to participants that attend all live webinars and complete the homework assignment. Note: Certificates of completion only indicate the attendee participated in all aspects of the training. They do not imply proficiency on the subject matter, nor should they be seen as a professional certification.

Prerequisites:

- Complete [Sessions 1 & 2A of Fundamentals of Remote Sensing](#), or equivalent experience
- Download and install QGIS and all accompanying software.
 - Further instructions to come on which version of QGIS will be used during this training
 - This advanced training will use QGIS software, and although previous experience with this software is not required, some experience with geospatial software will be helpful. **We strongly recommend you open QGIS and ensure the software is working prior to starting the webinar.**
- Download and install the R statistical program – <http://www.r-project.org/> - an open source statistical program that will be used for the classification algorithm called Random Forest, a type of decision tree classifier.
 - Download and install R studio – <http://www.rstudio.com/ide/download/>
 - Freely available graphical user interface which, although not required for the methodology, it will provide a more user-friendly interface for running the R statistical program, especially for users unfamiliar with R.

Audience:

Local, regional, state, federal, and international organizations interested in assessing vegetation conditions and analyzing land cover changes using satellite imagery. Professional organizations in the public and private sectors engaged in environmental management and monitoring will be given preference over organizations focused primarily on research.

Registration Information:

There is no cost for the webinar, but you must register to attend the sessions. Because we anticipate a high demand for this training, please only sign up for one session.

- [Register for Session A, 10:00-12:00 EDT \(UTC-4\) »](#)
- [Register for Session B, 18:00-20:00 EDT \(UTC-4\) »](#)

Course Agenda:

 [Agenda.pdf](#)

Session One: September 28

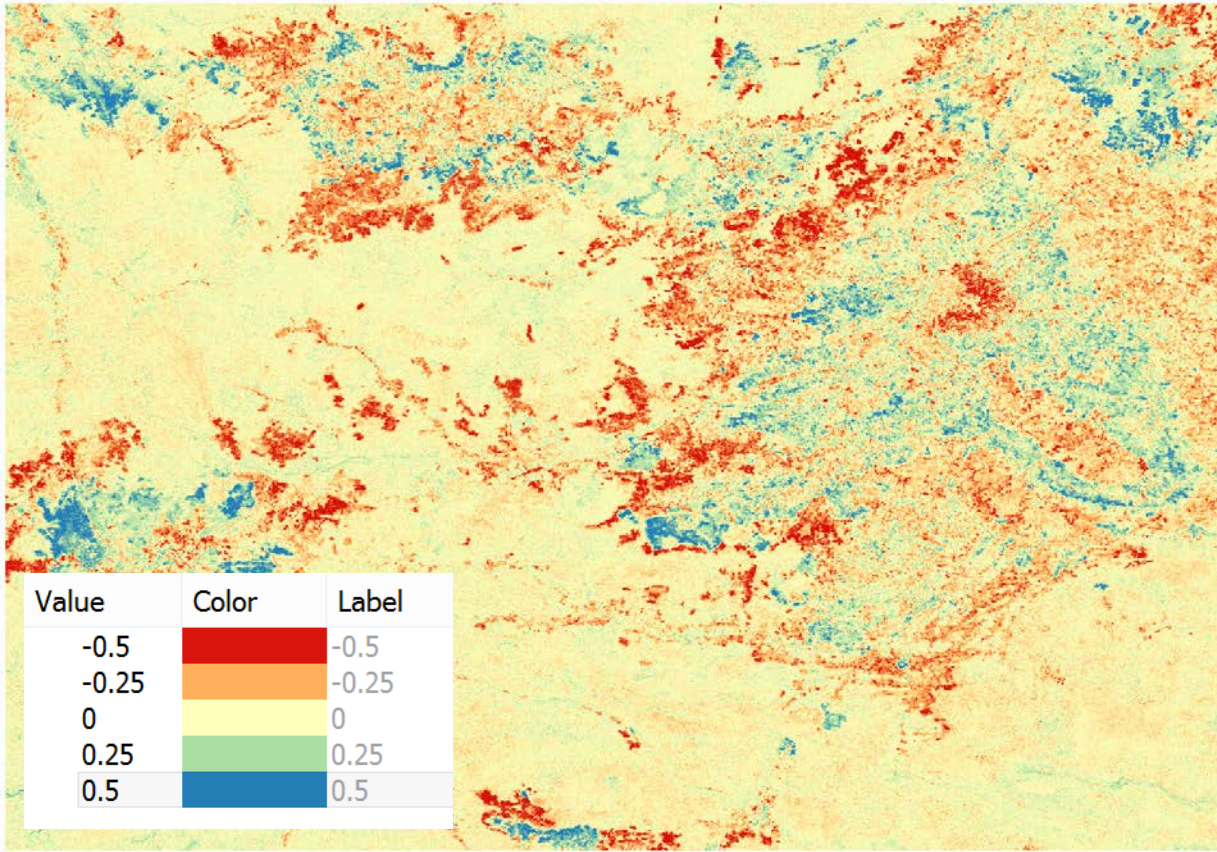
This session will focus on an introduction to change detection. Included will be an overview of change detection, how to visualize change, and how to analyze land cover change using the image subtraction method.

Session Two: October 5

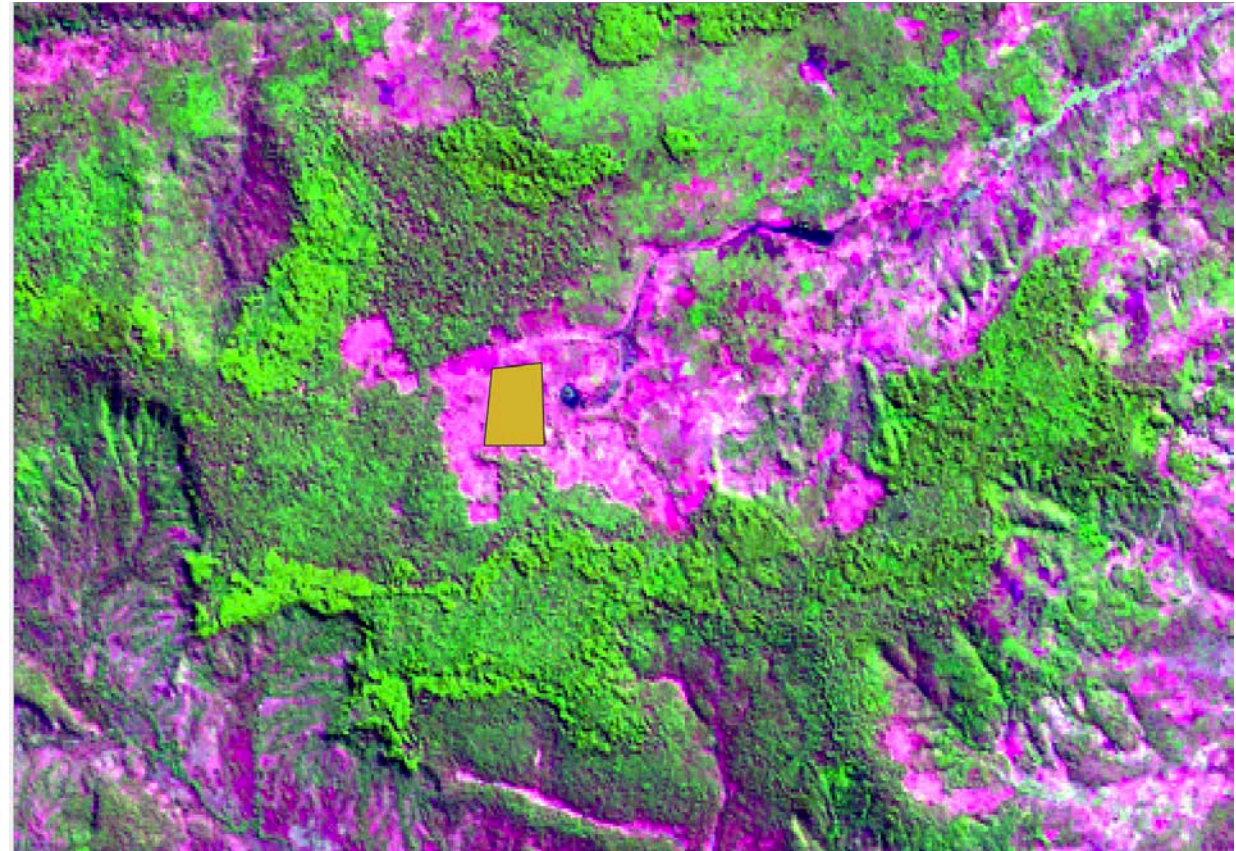
This session will continue with conducting a change detection analysis and will include analyzing land cover change using different classification methods.



Course Outline



Session 1: Introduction to Change Detection

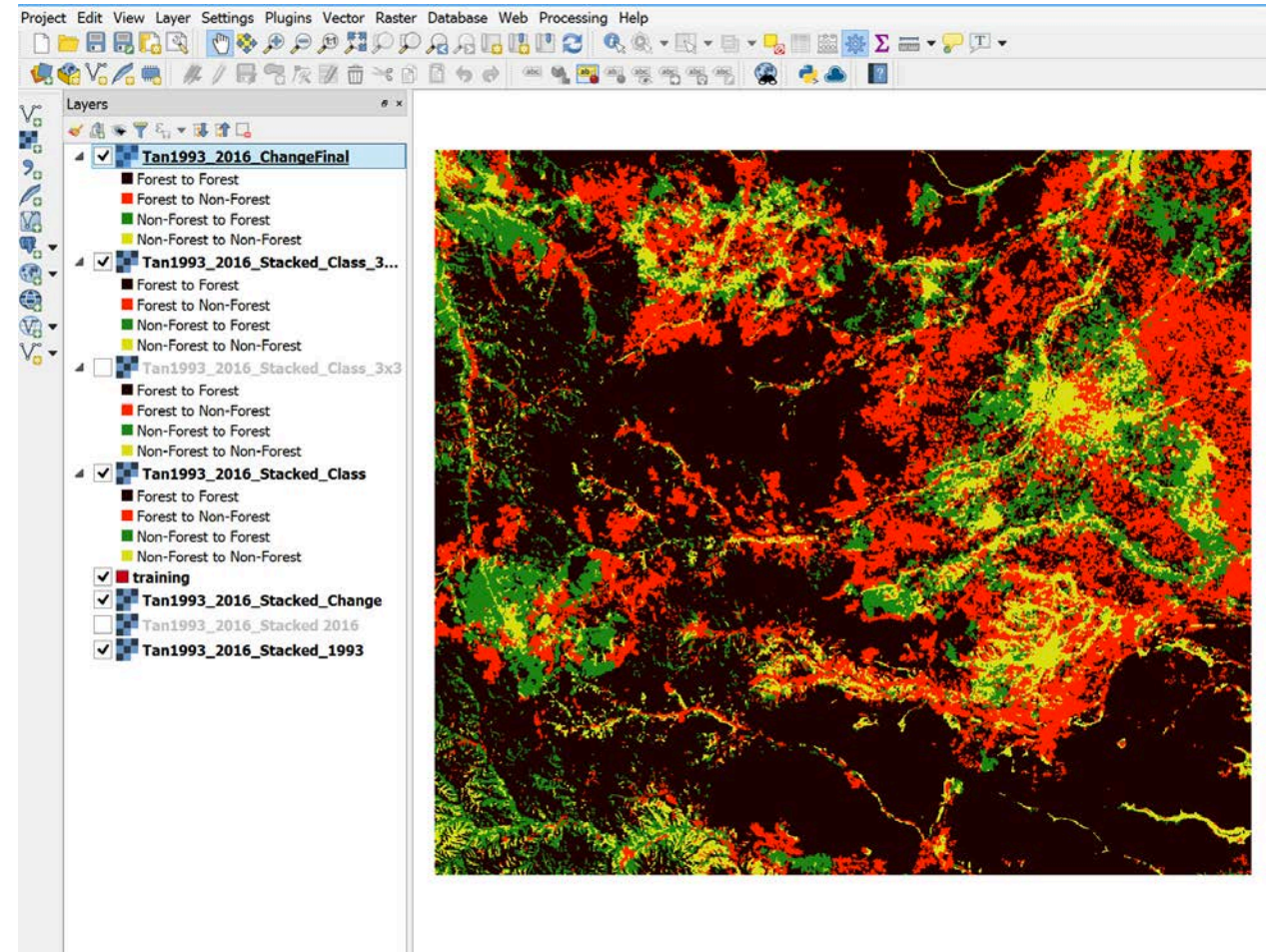


Session 2: Conducting Change Detection with QGIS & R



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





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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



Credit: David DiBiase, Penn State Department of Geography

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

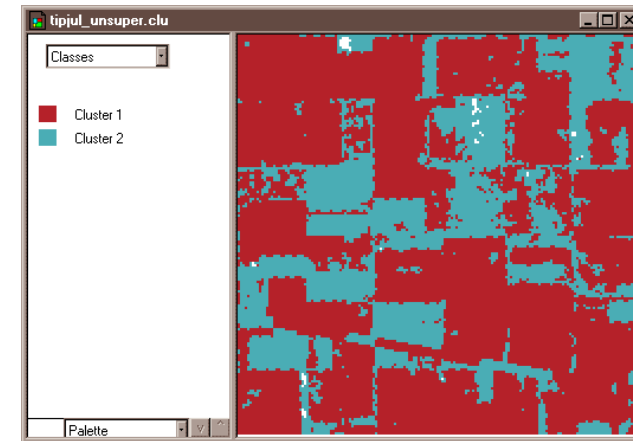
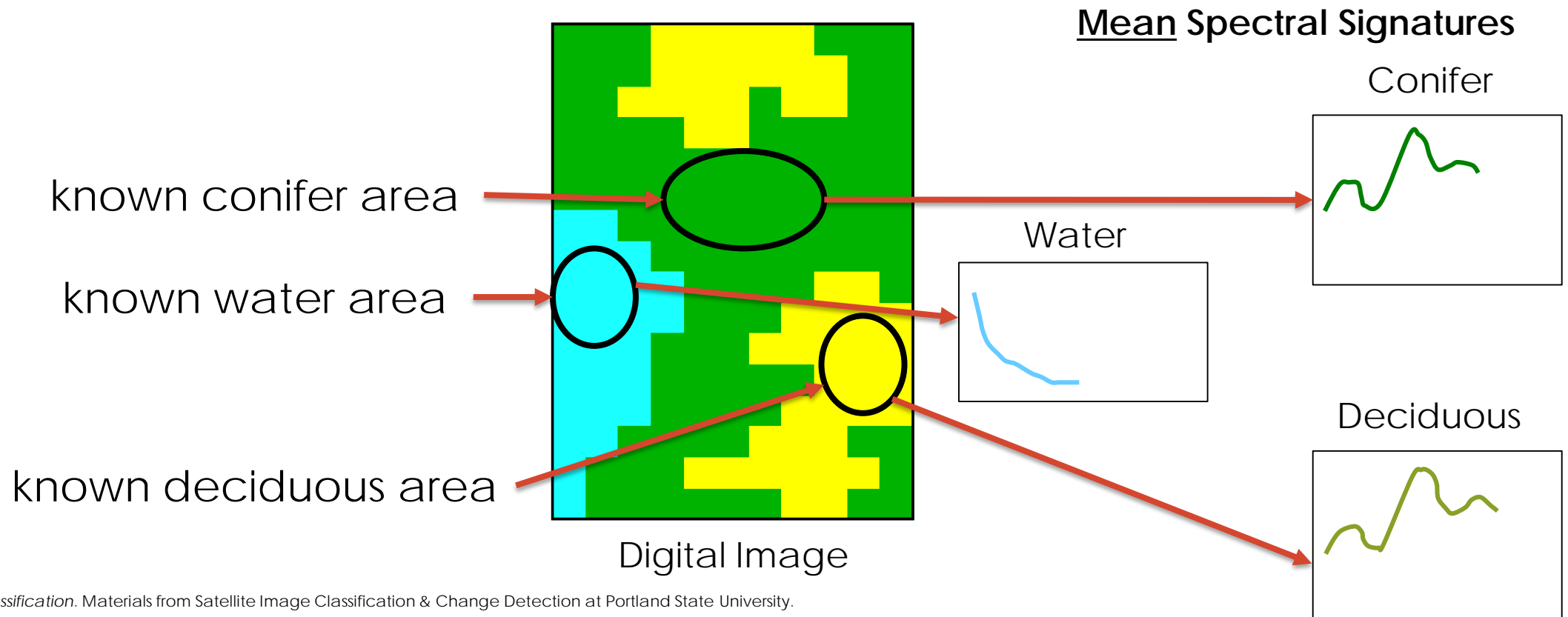


Image Classification

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



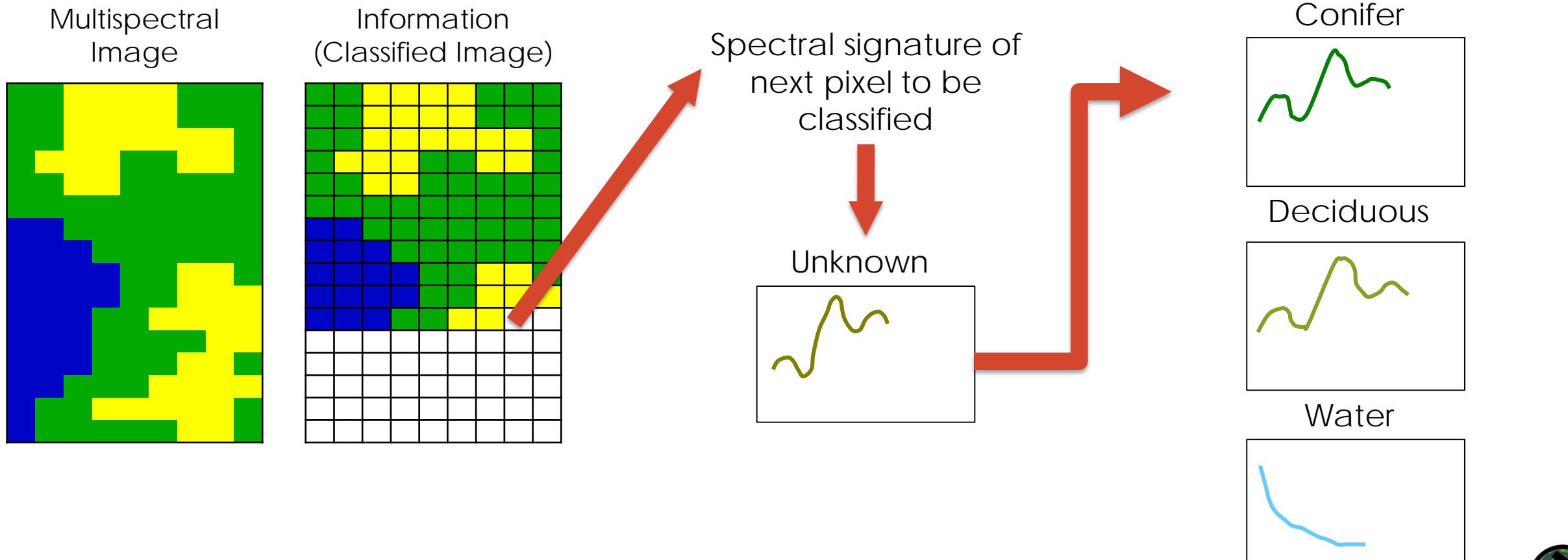
Sutton, L. *Image Classification*. Materials from Satellite Image Classification & Change Detection at Portland State University.



Image Classification

Supervised Method

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





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Two-Date Supervised Classification and Change Detection

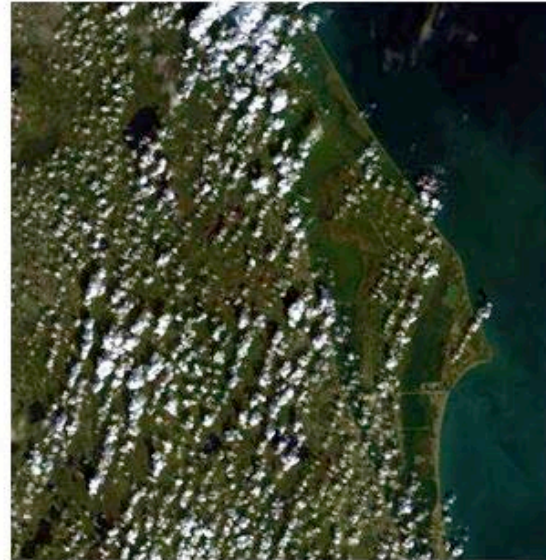
Methodology



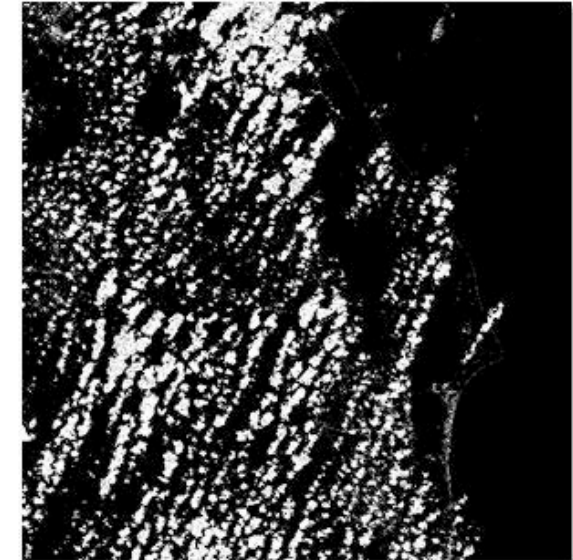
Cloud Masking

- 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

Landsat 8: RGB



QA: Cloud



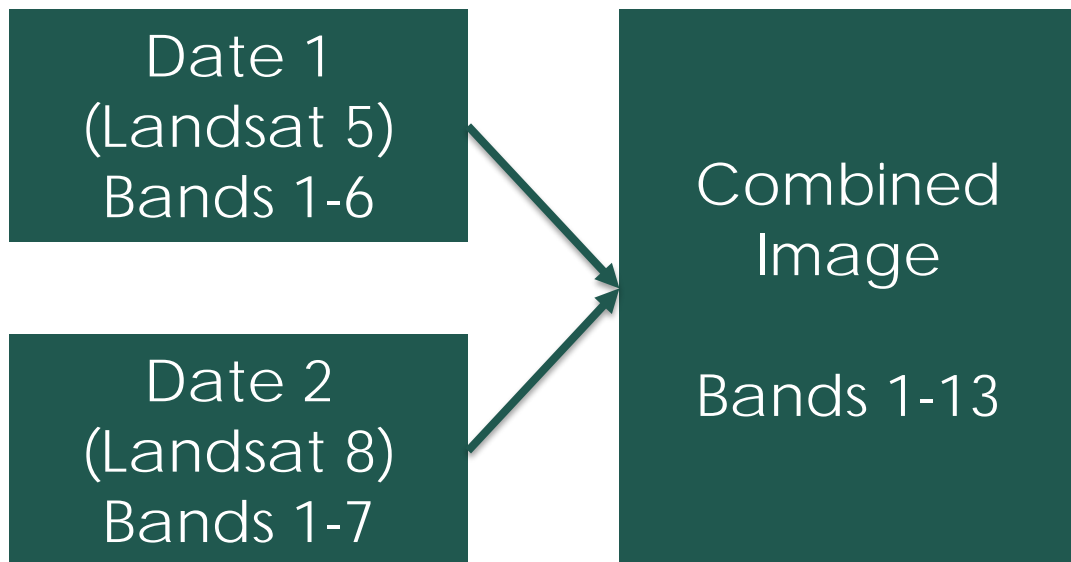
This example illustrates QA output for a subset Landsat 8 scene of Lake Tahoe acquired on April 12, 2014

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





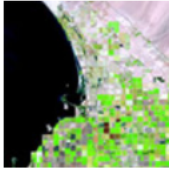


Bands Date 1	Name	Bands Date 2
	Blue 1	7
1	Blue 2	8
2	Green	9
3	Red	10
4	NIR	11
5	SWIR 1	12
6	SWIR 2	13

Bands in new combined stack



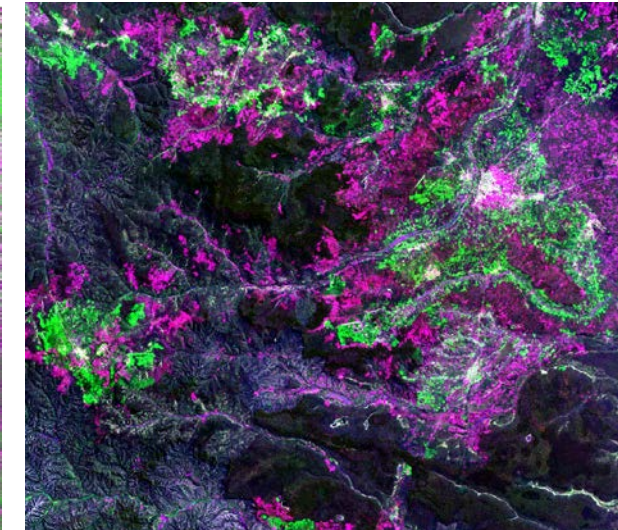
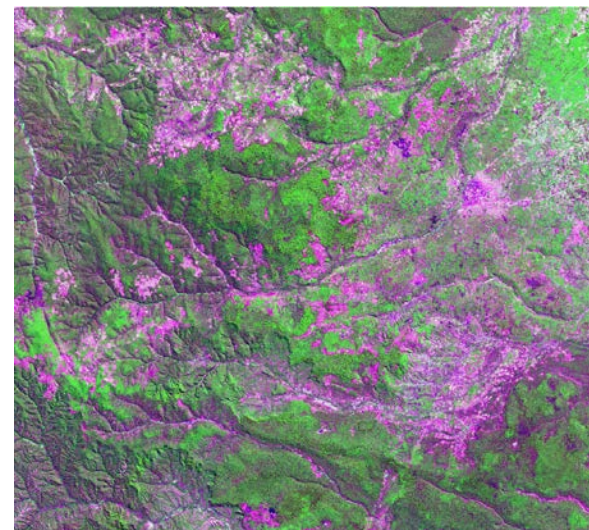
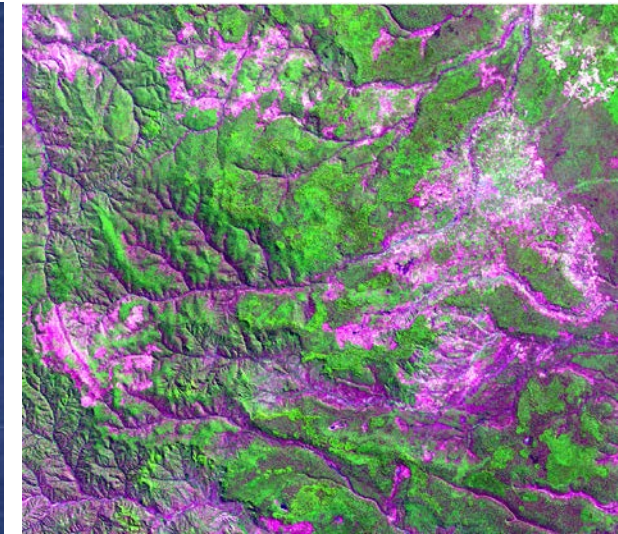
Image Enhancement

- 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

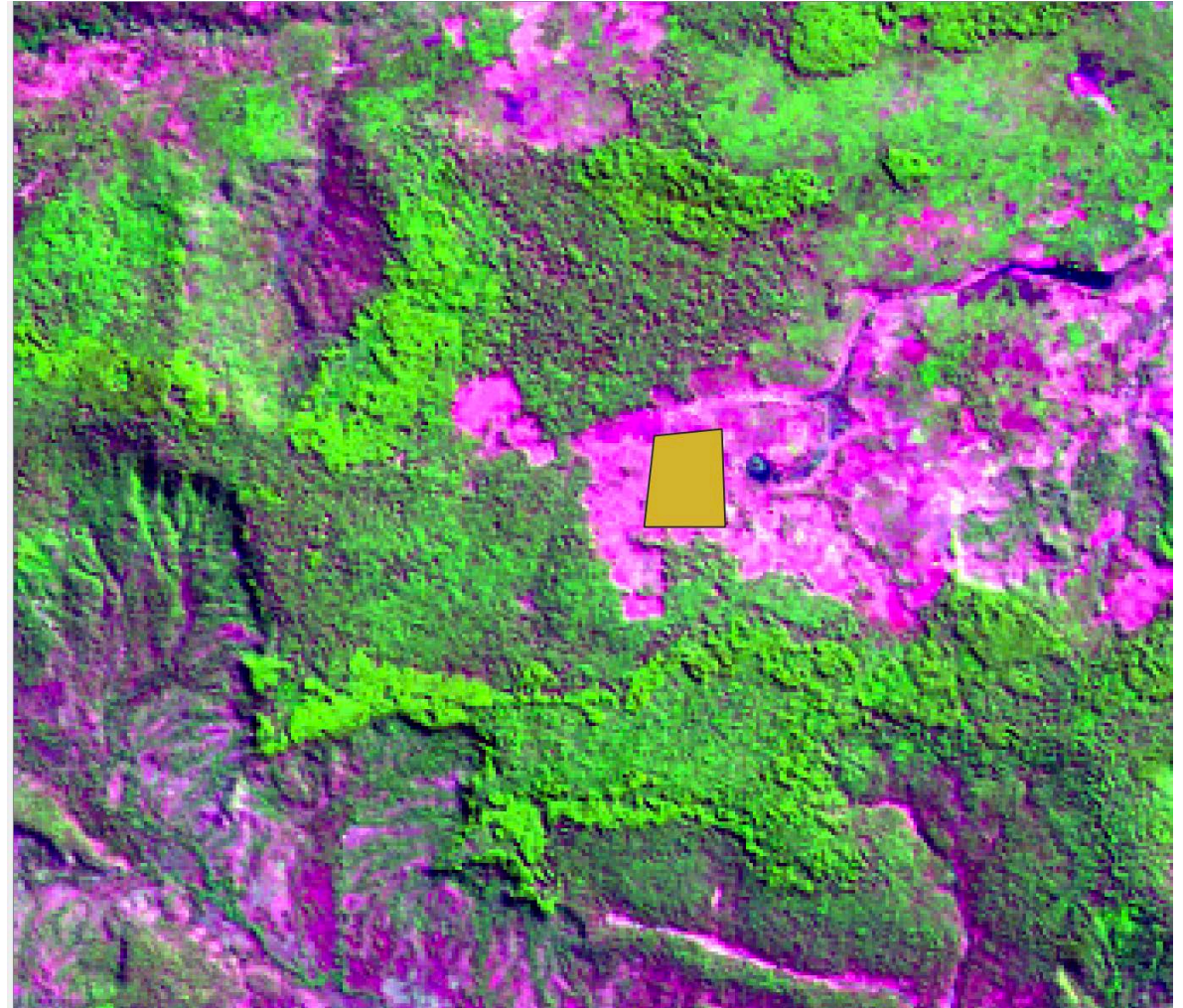
Multi-Date Image Enhancement

- 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

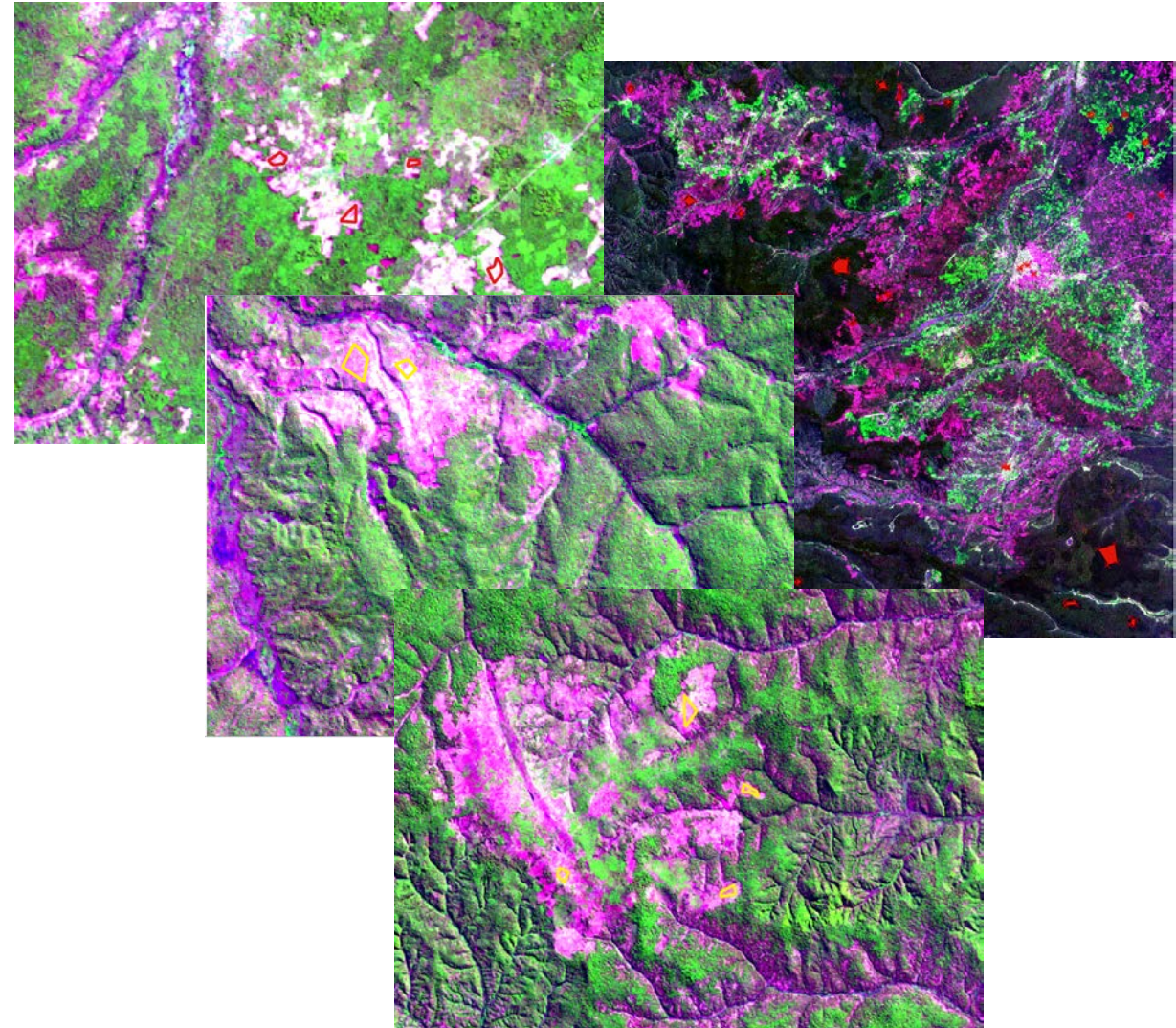
For two-date change classification, codes will be 2 digits:

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)



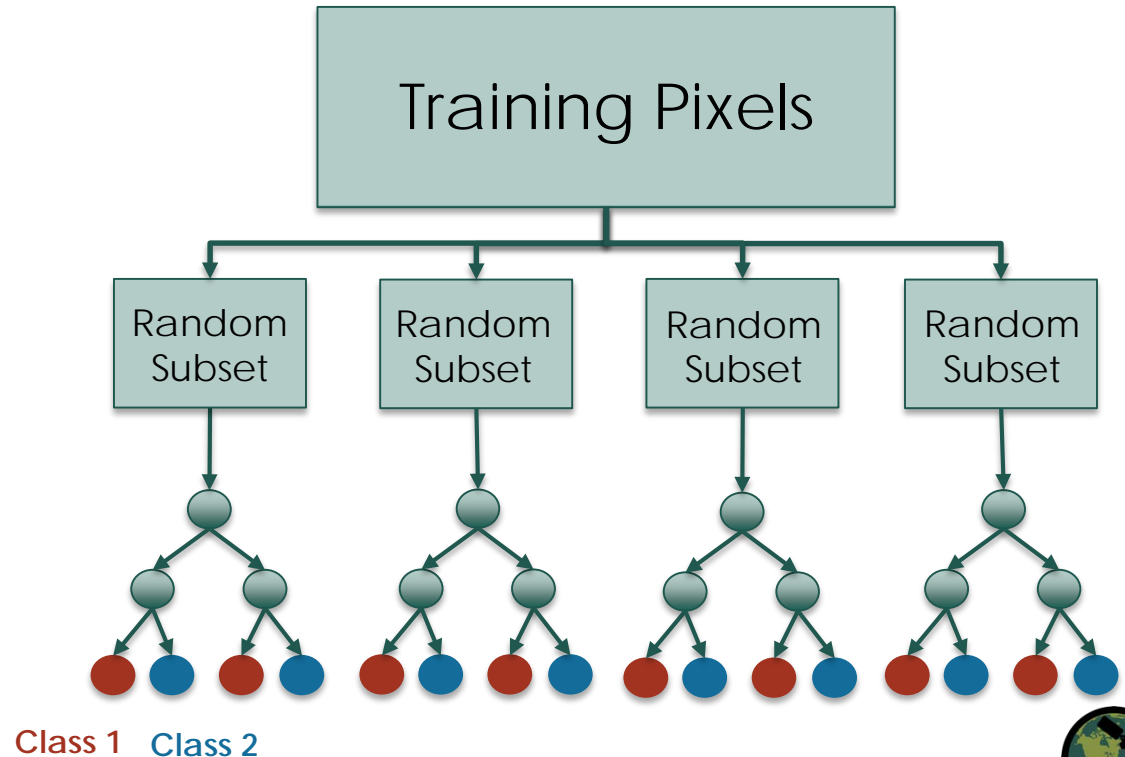
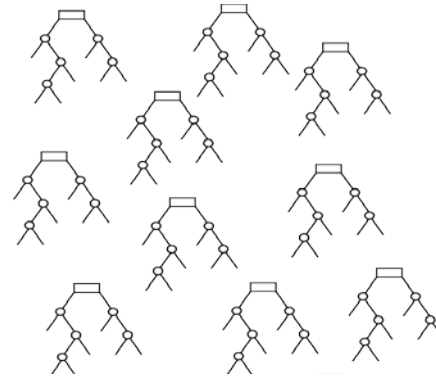
Classification Algorithms

- 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



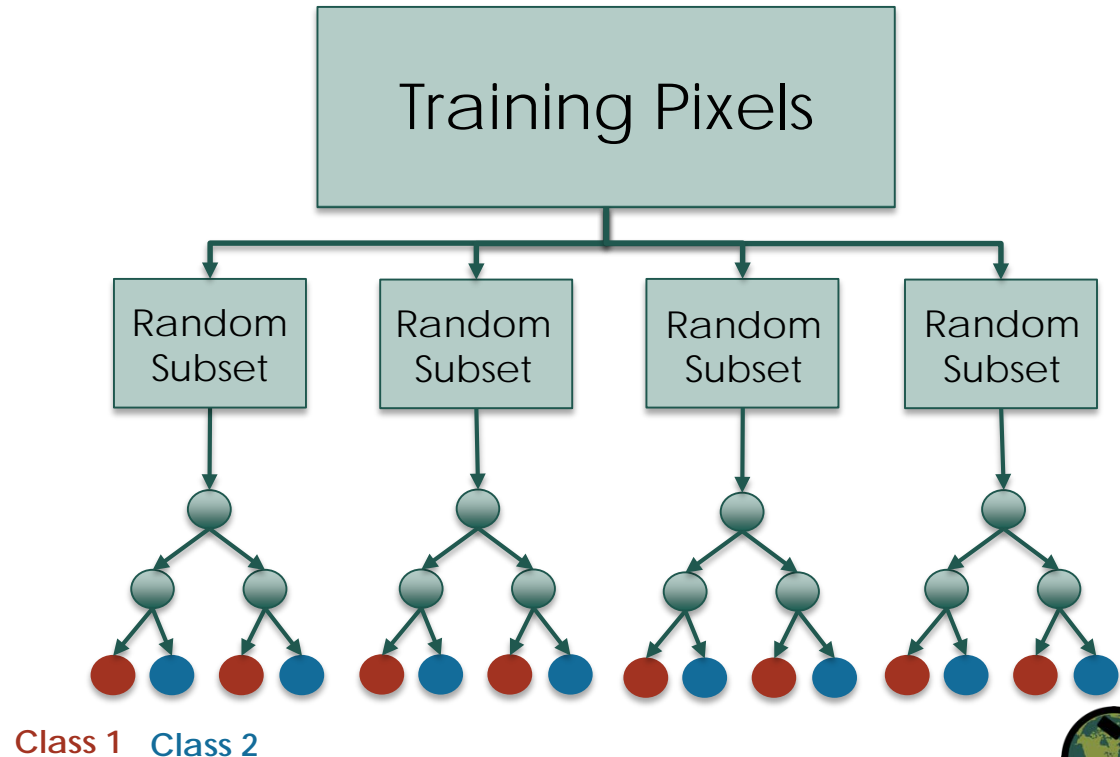
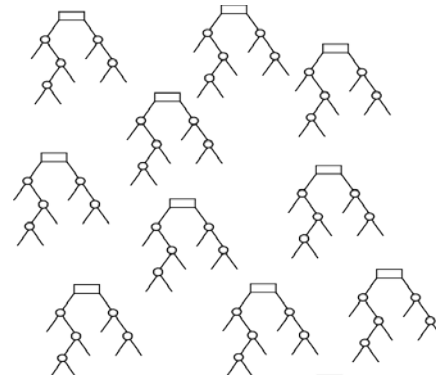
Random Forest Algorithm

- 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

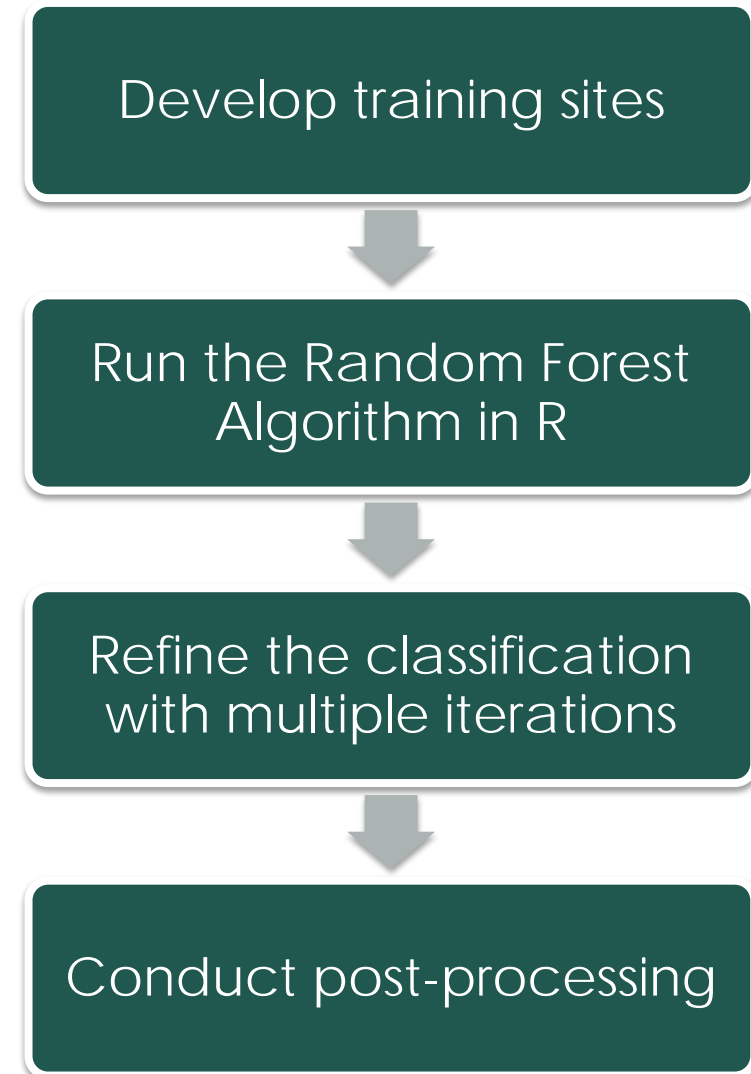
Limitations

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



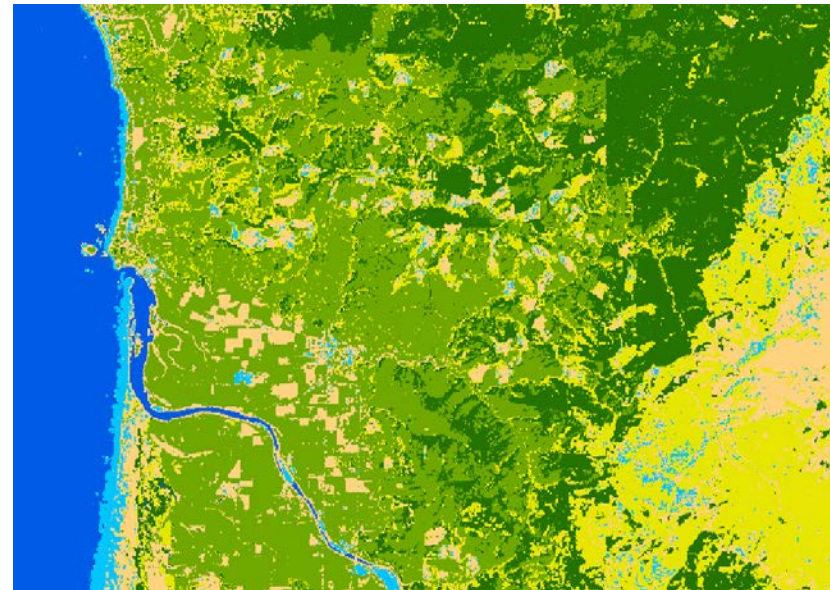
Multiple Iterations

- 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

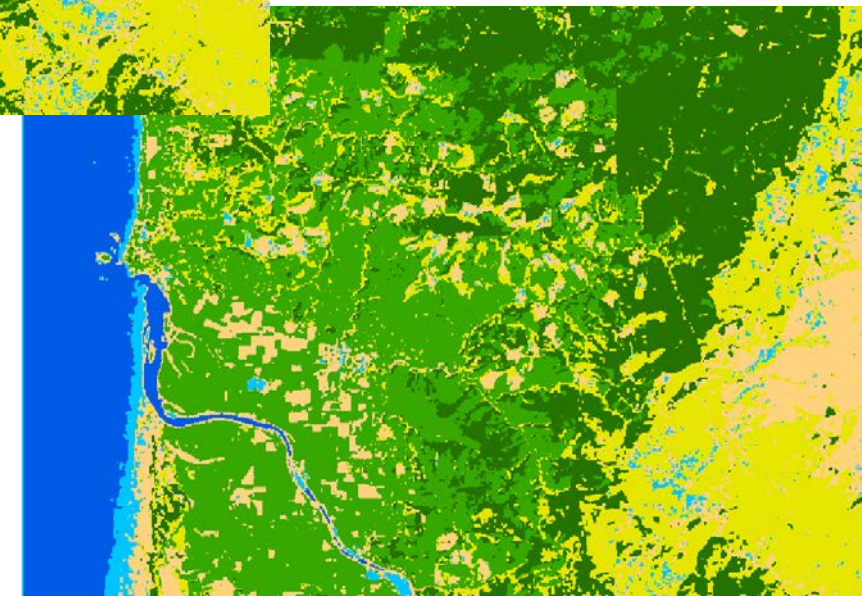


Post-Processing

- 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





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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>





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Thank You

Remember to Complete the Homework by October 19, 2018