National Aeronautics and
Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Land Cover Classification from Satellite Imagery

Instructor: Cindy Schmidt

Week 1

Course Structure

- Two, 4-hour sessions: January 31 and February 7, at 12:00 - 4:00 p.m. EST (UTC-5)
  - Lectures: approximately 1 hour
  - In-Class Exercise: approximately 1 hour, then you will have remaining time to work on the exercise independently
  - Q&A: the instructor will stay online during the entire 4 hour period if you have any questions
  - Homework Exercises
- Webinar recordings, PowerPoint presentations, in-class exercises, and homework assignments can be found after each session at:
  - http://arset.gsfc.nasa.gov/land/webinars/advanced-land-classification
- Q&A: Following each lecture and/or by email: cynthia.l.schmidt@nasa.gov

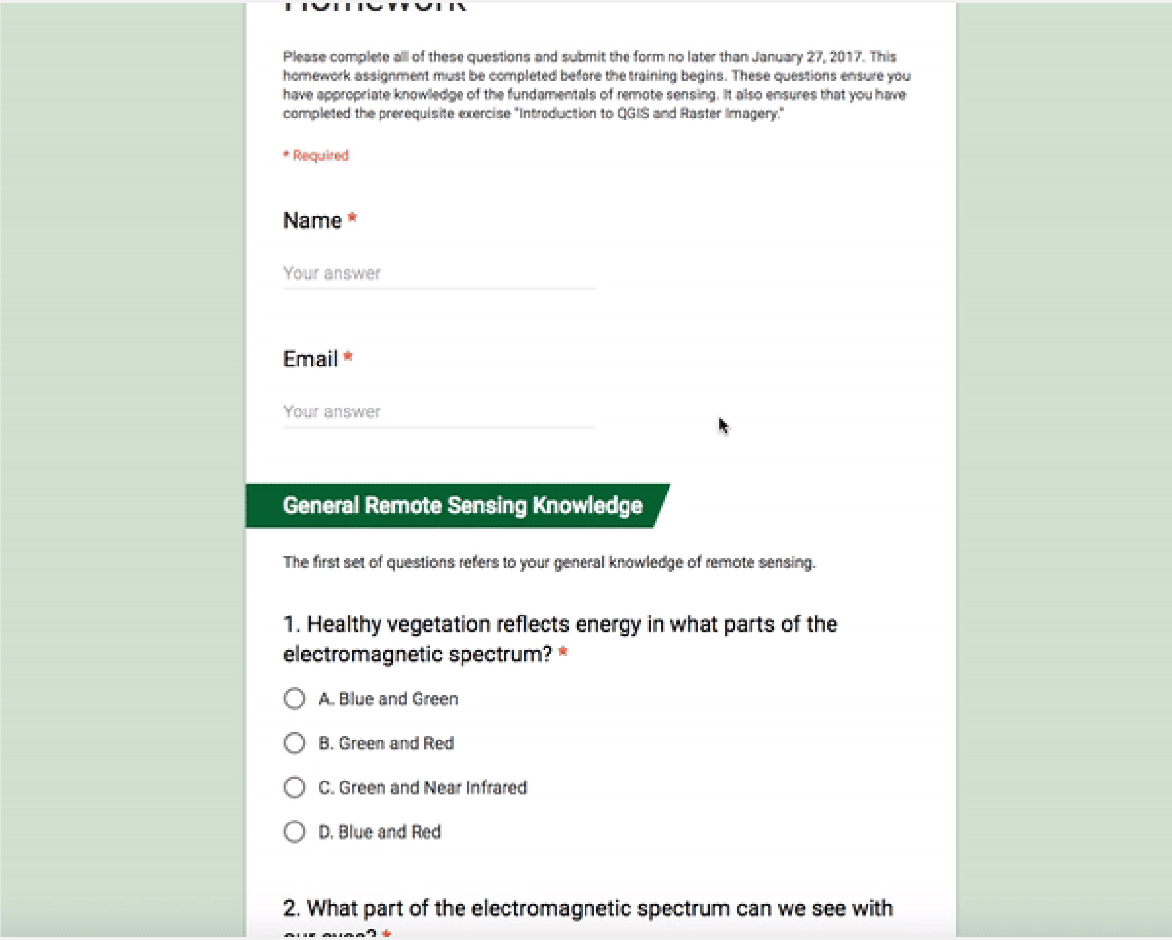
Ground Rules

There are a lot of you and only one of me!

- Questions can only pertain to the topics presented in the webinars
- If you have not watched the prerequisite Introduction to Remote Sensing webinars, you should not watch this webinar.
- Please, no general questions about QGIS unless it pertains to the topics presented in the webinar
- Please, no questions about other remote sensing topics

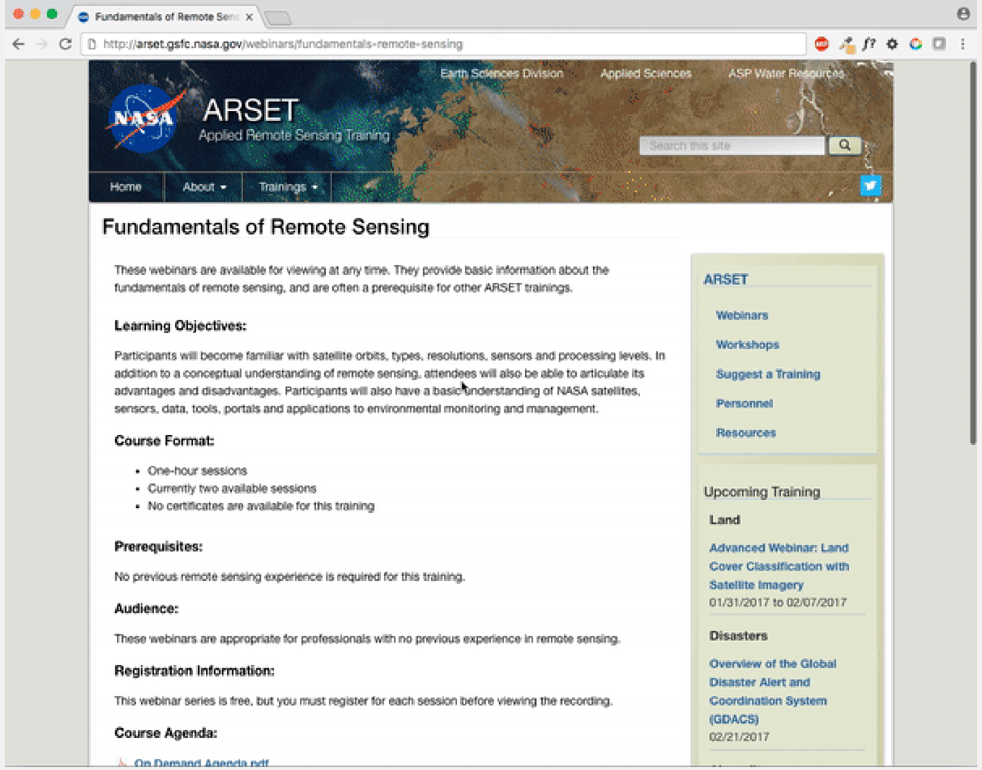
Homework and Certificates

- Homework
  - one prerequisite, one after session 2
  - Answers must be submitted via Google Form
- Certificate of Completion
  - Attend both webinars
  - Complete the prerequisite homework and the homework after session 2
  - You will receive certificates approximately 2 months after the completion of the course from marines.martins@ssaihq.com



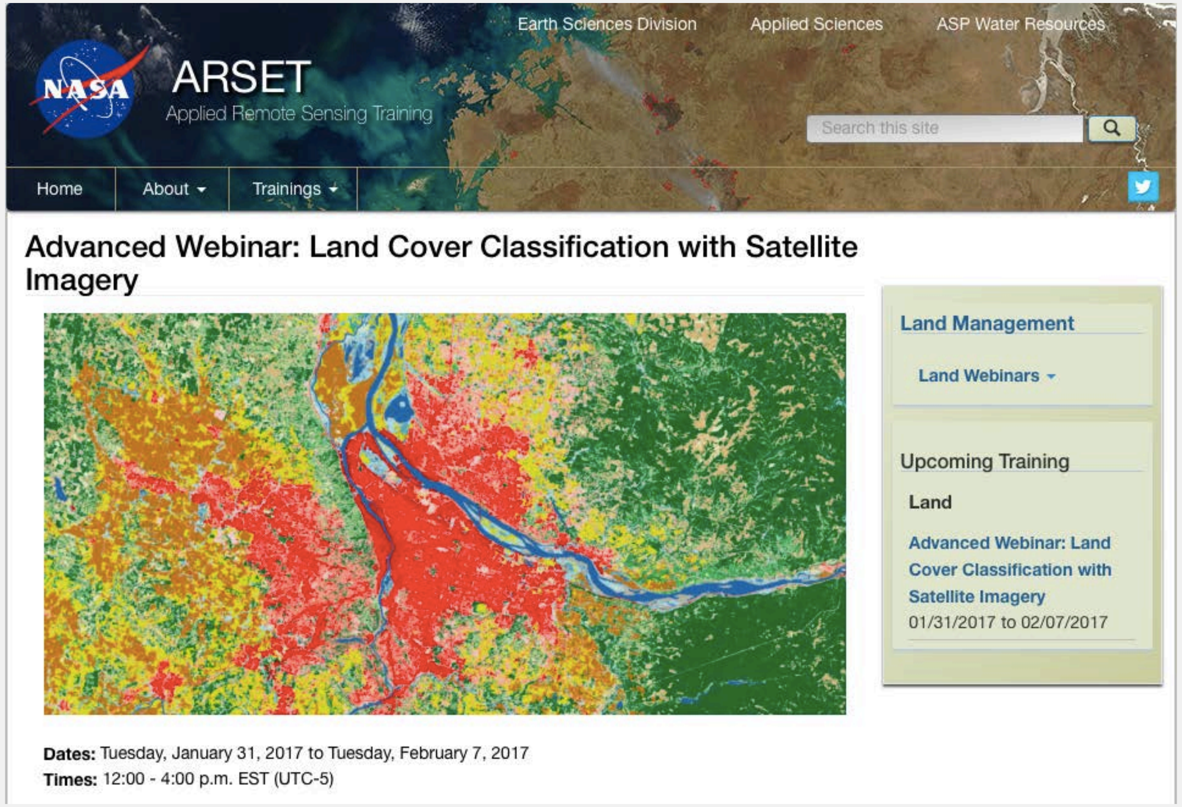
Prerequisites

- Fundamentals of Remote Sensing
  - Sessions 1 and 2A (Land)
  - On-Demand webinar available any time
  - http://bit.ly/ARSET-fundamentals
- Download and Install QGIS
- Complete the Introduction to QGIS and Raster Imagery exercise
  - Download prerequisite data
  - Install QGIS Semi-Automatic Classification Plugin
- Complete prerequisite homework



Accessing Course Materials

http://arset.gsfc.nasa.gov/land/webinars/advanced-land-classification



Course Agenda:

Agenda.pdf

Session One: Introduction to Land Cover Classification and QGIS

January 31, 2017. An overview of land cover classification, including unsupervised and supervised classification.

- Presentation Slides (English) »
- Exercise: Converting Landsat Imagery from Digital Numbers to Reflectance Values »
- Exercise: Creating a Supervised Land Cover Classification »

Session Two: Improving a Supervised Land Cover Classification

February 7, 2017. Analyzing training sites to improve the supervised land cover classification.

- Presentation Slides (English) »
- Exercise: Analyzing Training Sites to Improve the Supervised Classifications »
- Exercise: Creating an Improved Supervised Land Cover Classification »

Course materials are provided here using each specified link and will be active after each week

Course Objectives

- Provide an understanding of land cover classification
- Show participants how to acquire Landsat imagery
- Provide step-by-step training on how to:
  - convert digital numbers to reflectance values
  - clip a Landsat image to a vector shapefile
  - create training sites for a supervised classification
  - analyze training site statistics
  - create a classified land cover map

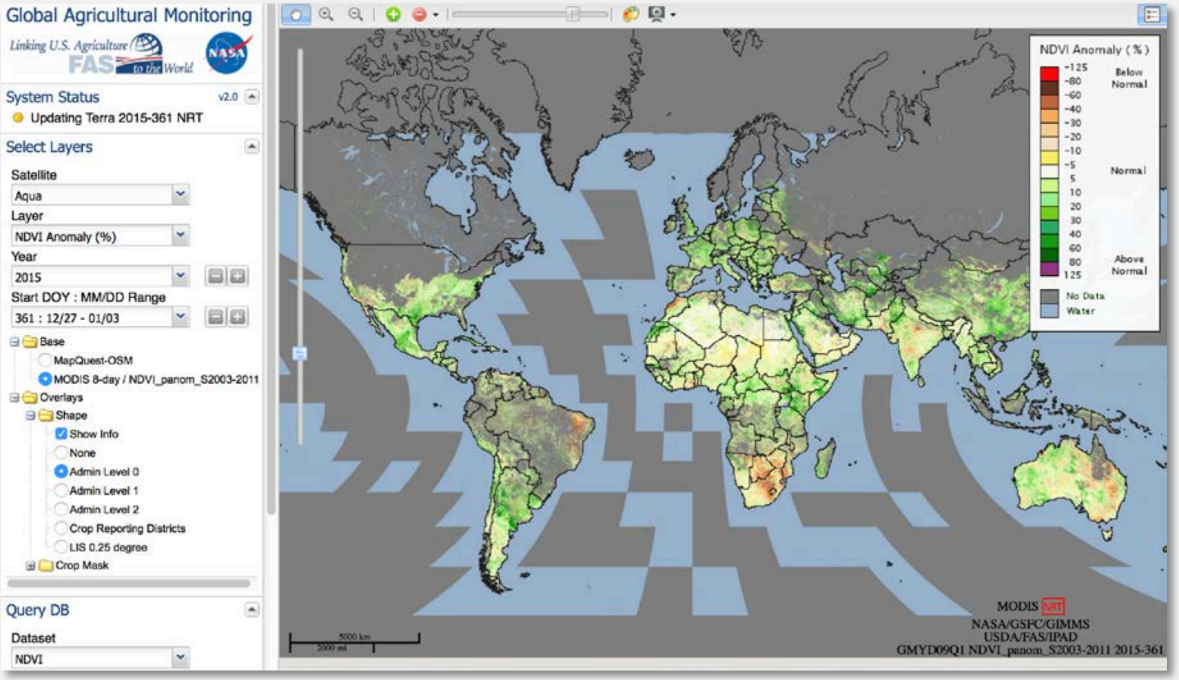


Image Credit: Global Agricultural Monitoring Program.

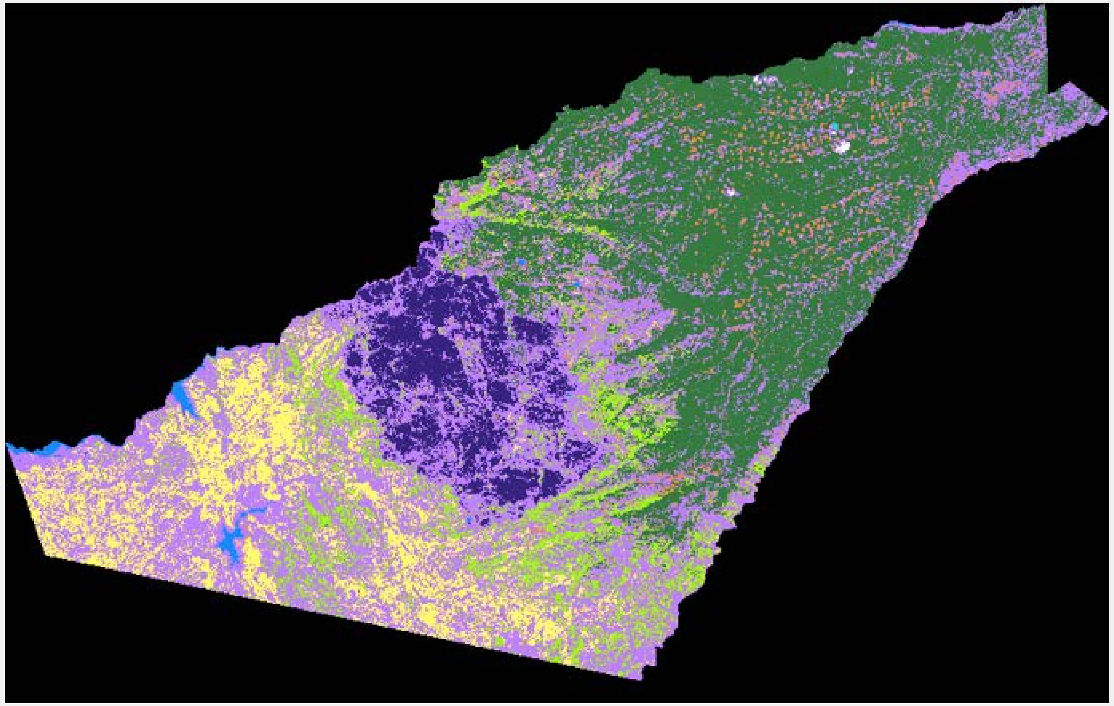
Course outline

Week 1:

Introduction to Land Cover Classification

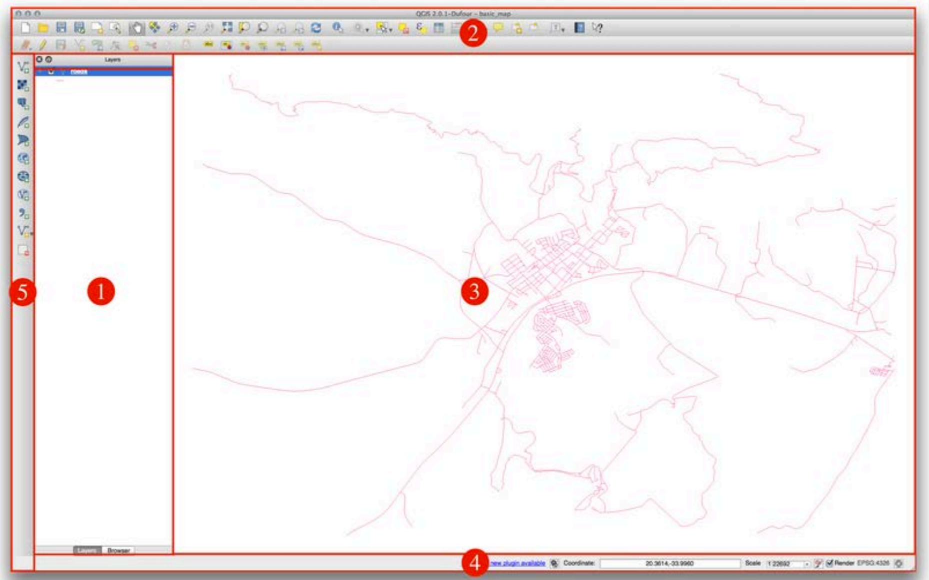
Week 2:

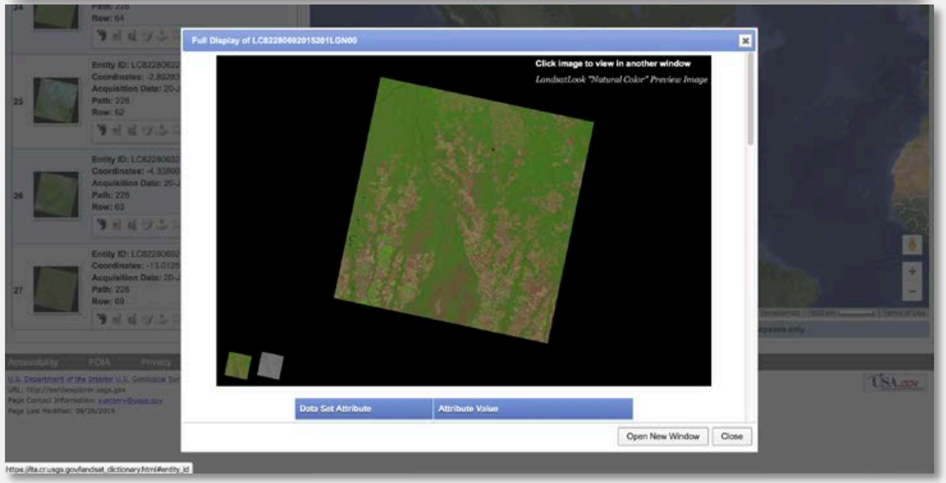
Improving a Supervised Classification



Week 1 Agenda

- Overview of Land Cover Classification (Lecture)
- Creating a Supervised Land Cover Classification (Exercise)
- Q&A

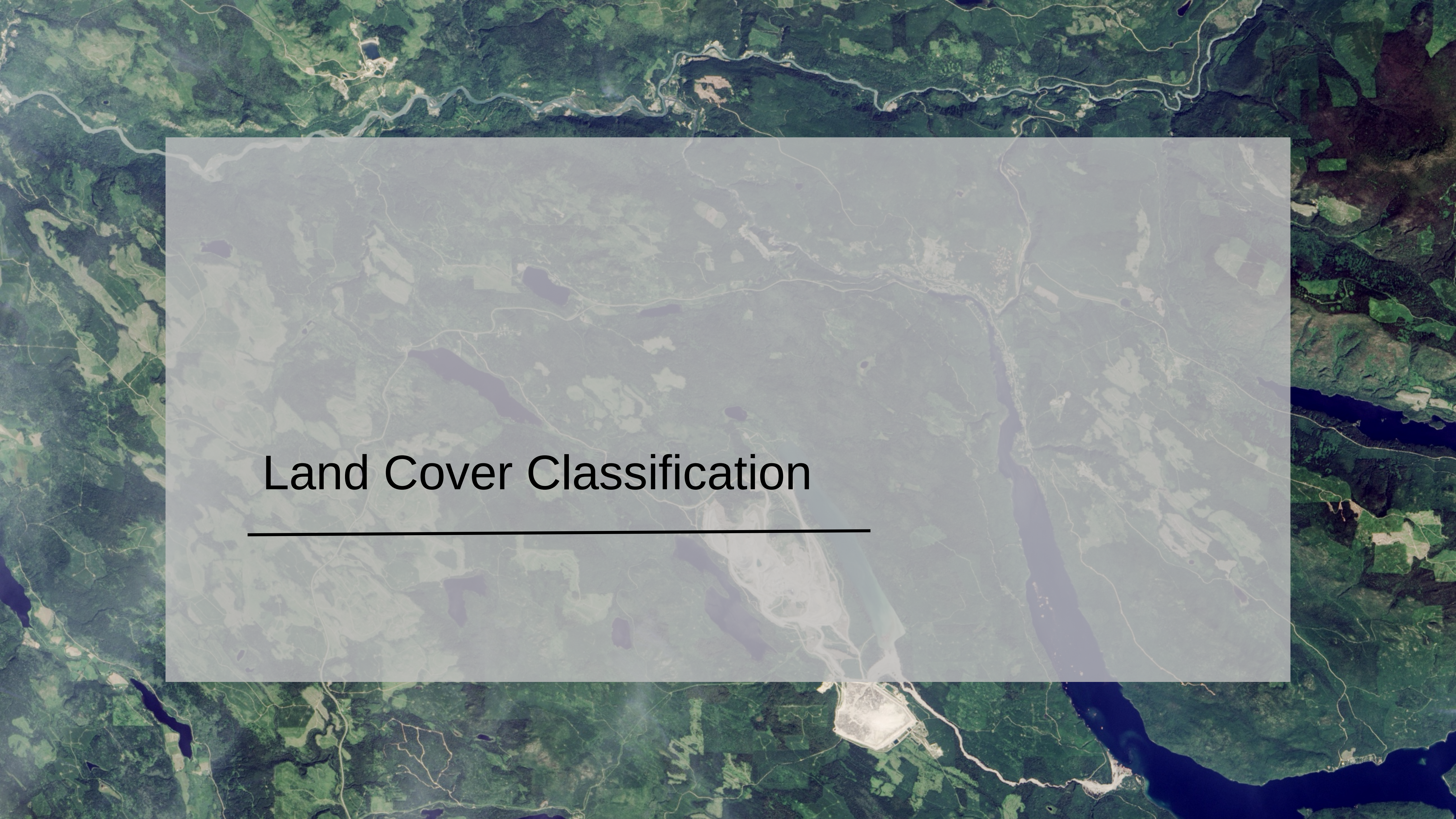




Top: QGIS User Interface

Bottom: USGS Earth Explorer

Land Cover Classification



Turning Data Into Information

Spectral vs. Informational Classes

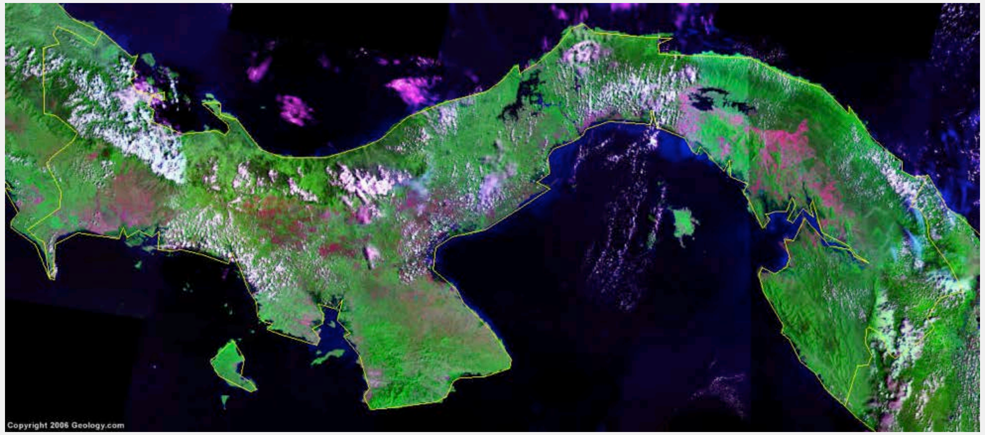
Spectral Classes

- Groups of pixels that are uniform with respect to their pixel values in several spectral bands

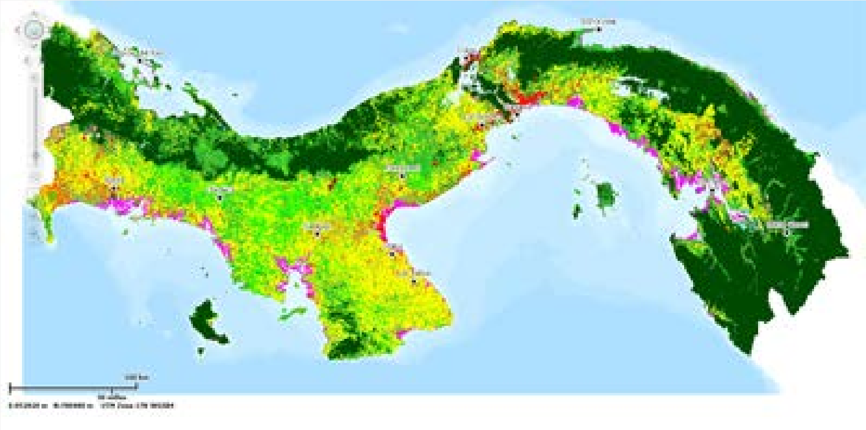
Informational Classes

- Categories of interest to users of the data (i.e. water, forest, urban, agriculture, etc.)

Image classification is the process of grouping spectral classes and assigning them informational class names



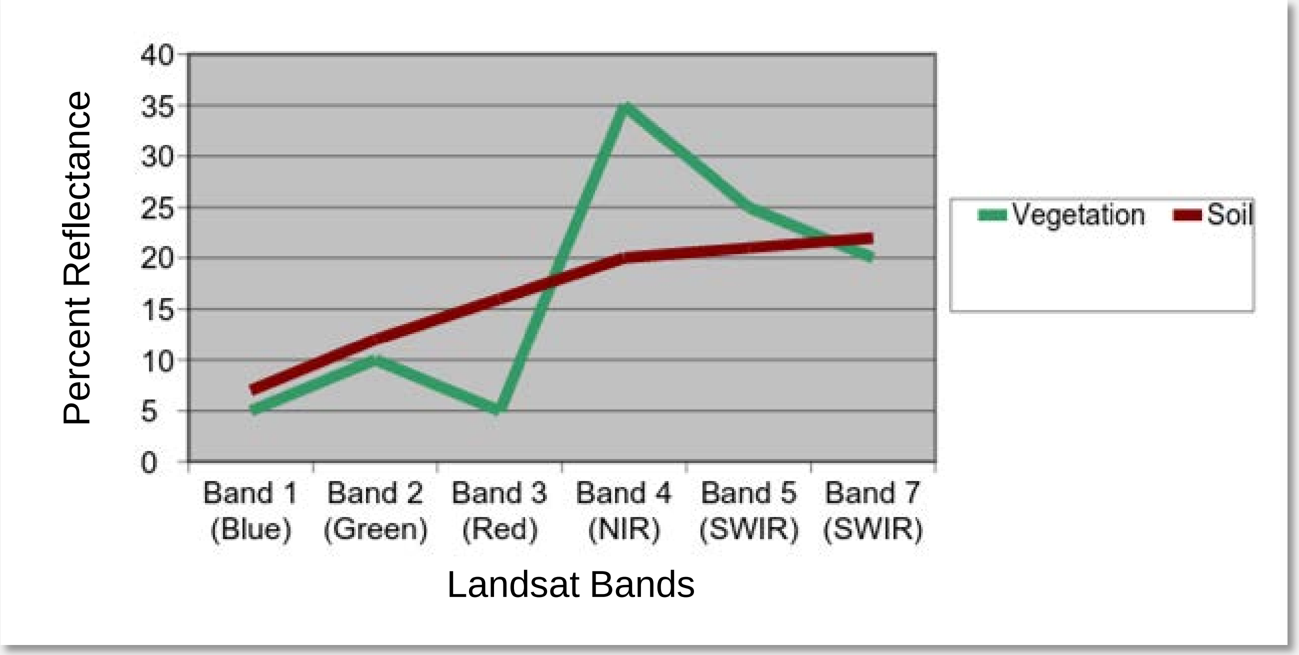
Satellite image of Panama



Land cover map of Panama

Land Cover Mapping Basics

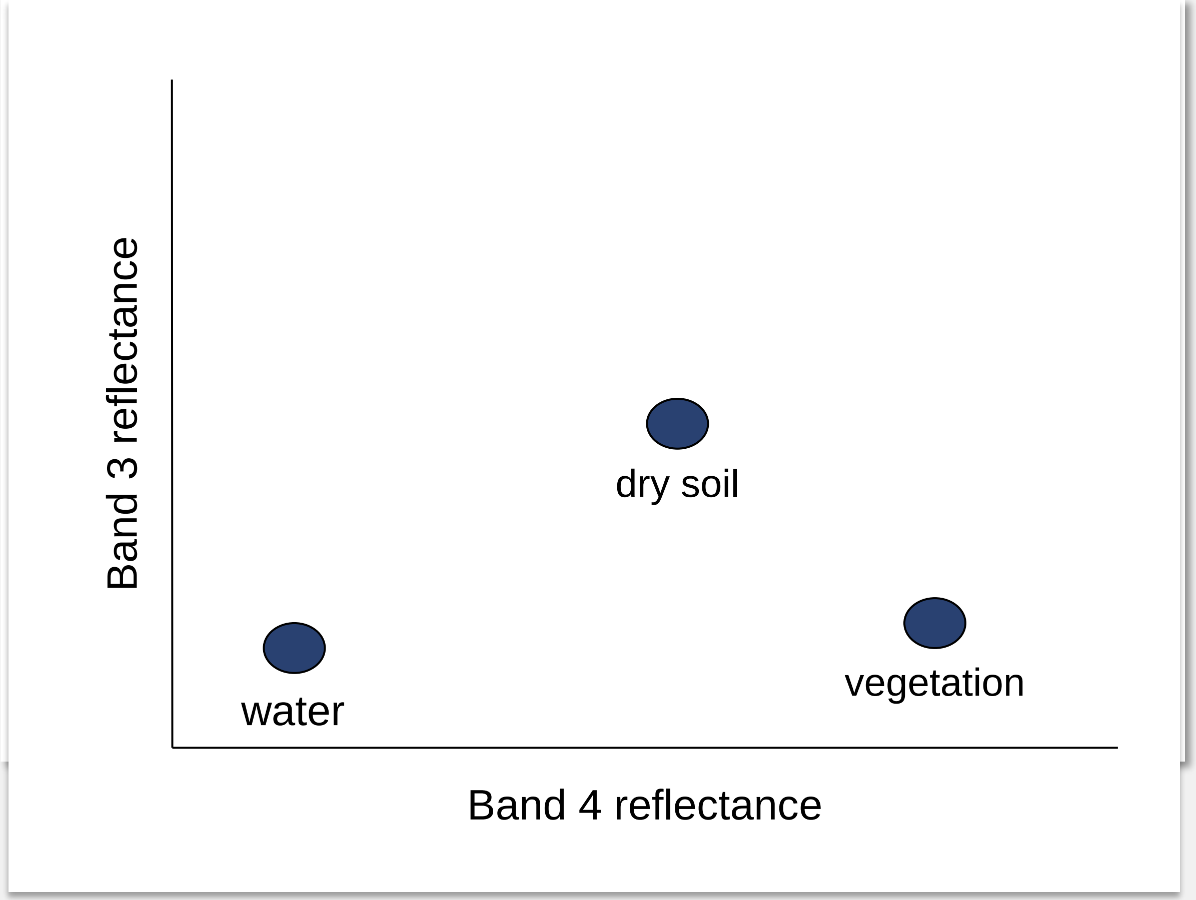
- Remember that objects on the ground reflect electromagnetic radiation differently in different wavelengths
- That is called the object's **spectral signature**
- Example: Green vegetation absorbs Red wavelengths but reflects NIR wavelengths



Land Cover Mapping Basics

Spectral Plots

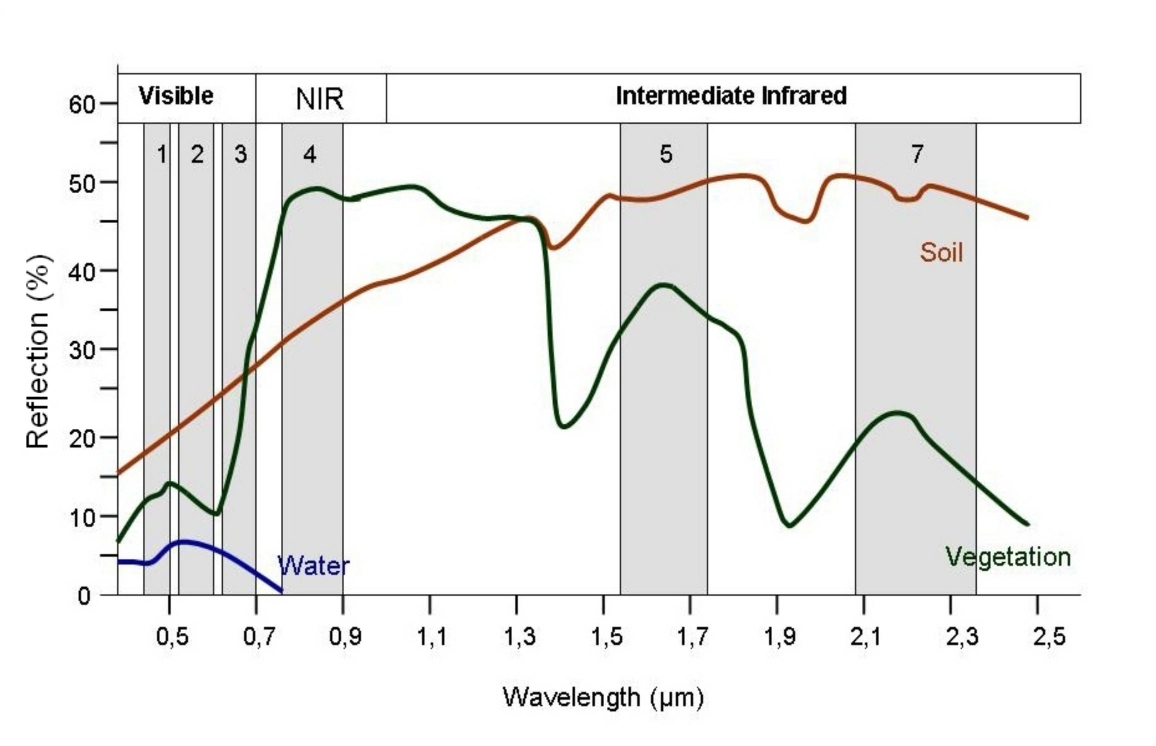
- Look at spectral signatures by plotting Band 3 (Red) vs. Band 4 (NIR) reflectance values
- Objects (soil, water, and vegetation) fall in different places in the plot
- The software uses this to distinguish between different land cover types



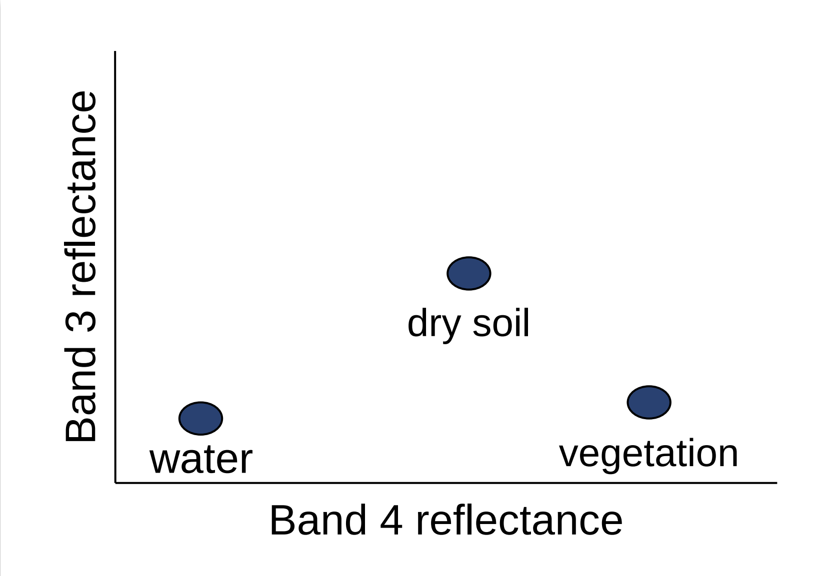
Land Cover Mapping Basics

Spectral Plots

- Now we will look at spectral signatures a little differently by plotting Band 3 (Red) vs. Band 4 (NIR) reflectance values

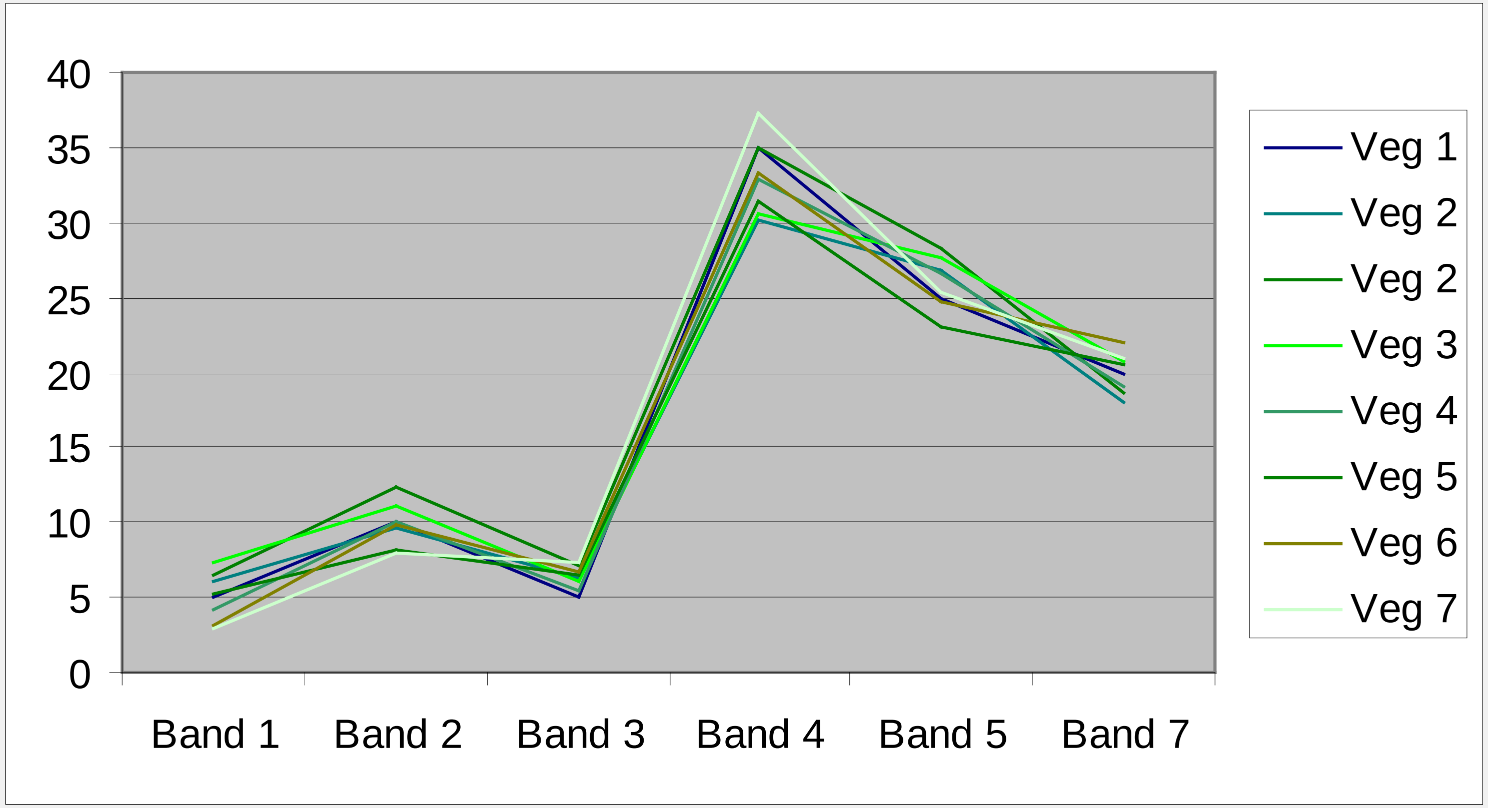


- When you do this, you see the objects (soil, water, and vegetation) fall in different places in the plot
- The software (QGIS and others) uses this information to distinguish between different land cover types



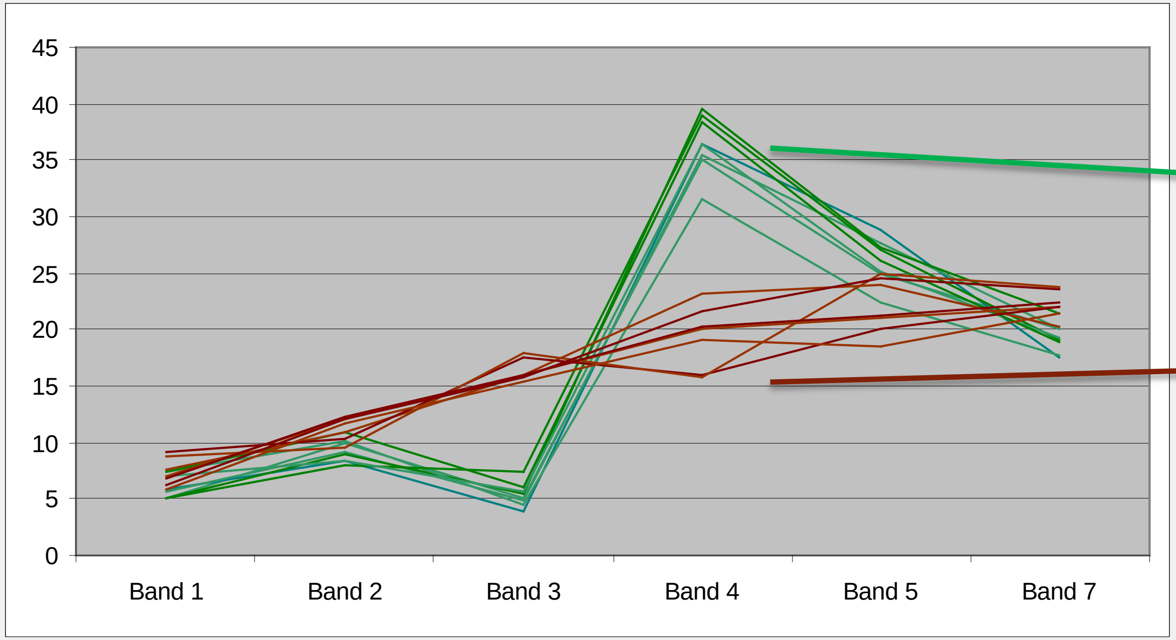
Spectral Signatures

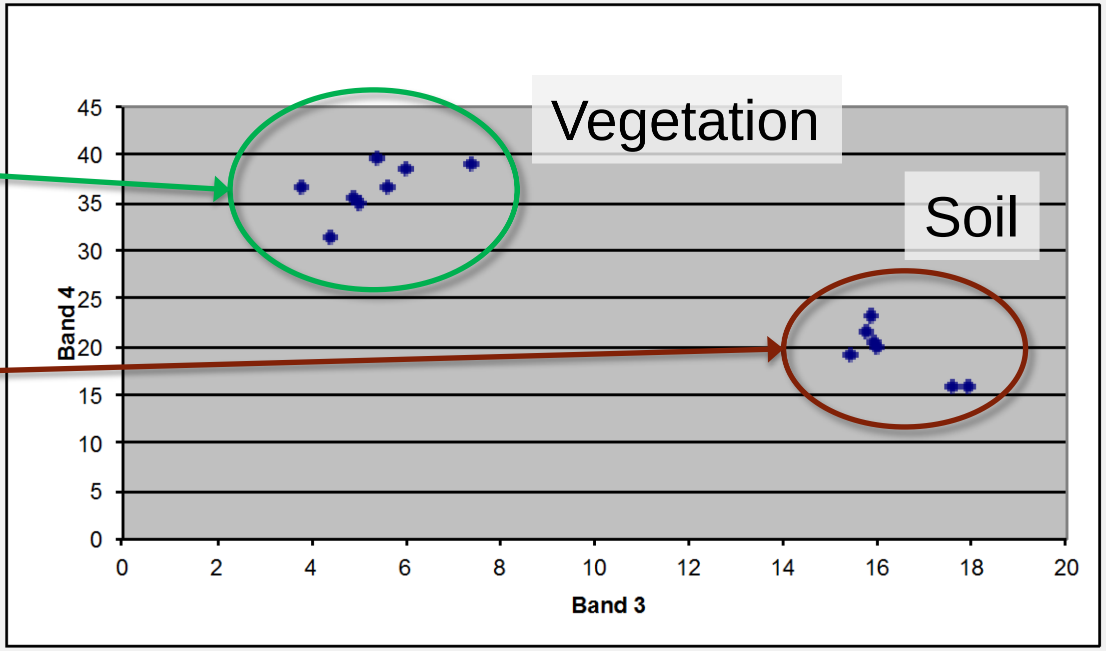
- There is some variation in reflectance values at different wavelengths
- Depending on the land cover classes you want, the trick is to identify this variability



Spectral Variation

- Easier: distinguishing between broad classes
  – e.g. vegetation and soil
- Harder: distinguishing *within* broad classes
  – e.g. vegetation types
- Variation within and between type (broad classes) is below

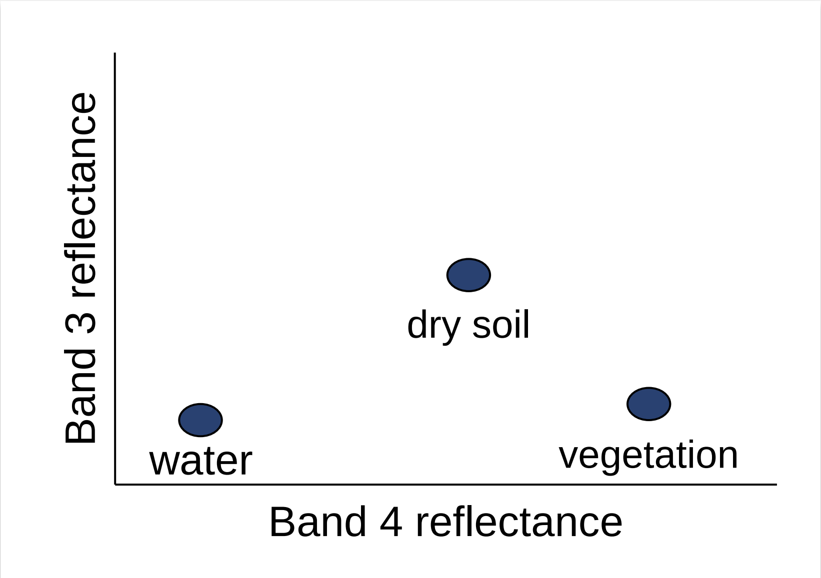




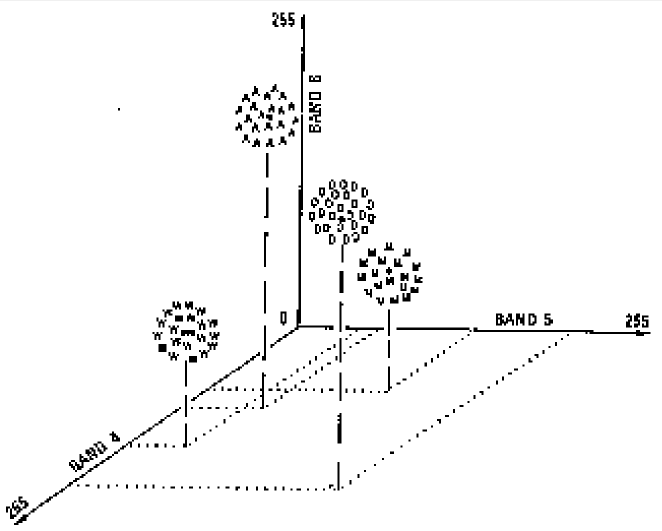
Multi-Dimensional Spectral Plots

To make things even more confusing…

- When looking at spectral plots, each band represents a different dimension
- For example, this is a 2 dimensional plot



- In a spectral plot, pixels are plotted in n-dimensional space (where n represents the number of bands)
- This is an example of a 3 dimensional spectral plot:



Sabins, F. F. (1987). *Remote Sensing: Principles and Interpretation* (2nd ed.). W.H. Freeman and Company.

Image Classification

- Requires delineating boundaries of classes in n-dimensional space using class statistics
- Each group of pixels is characterized by:
  - min.
  - max.
  - mean
  - standard deviation
- All the pixels in the image that fall within those statistics are given those labels

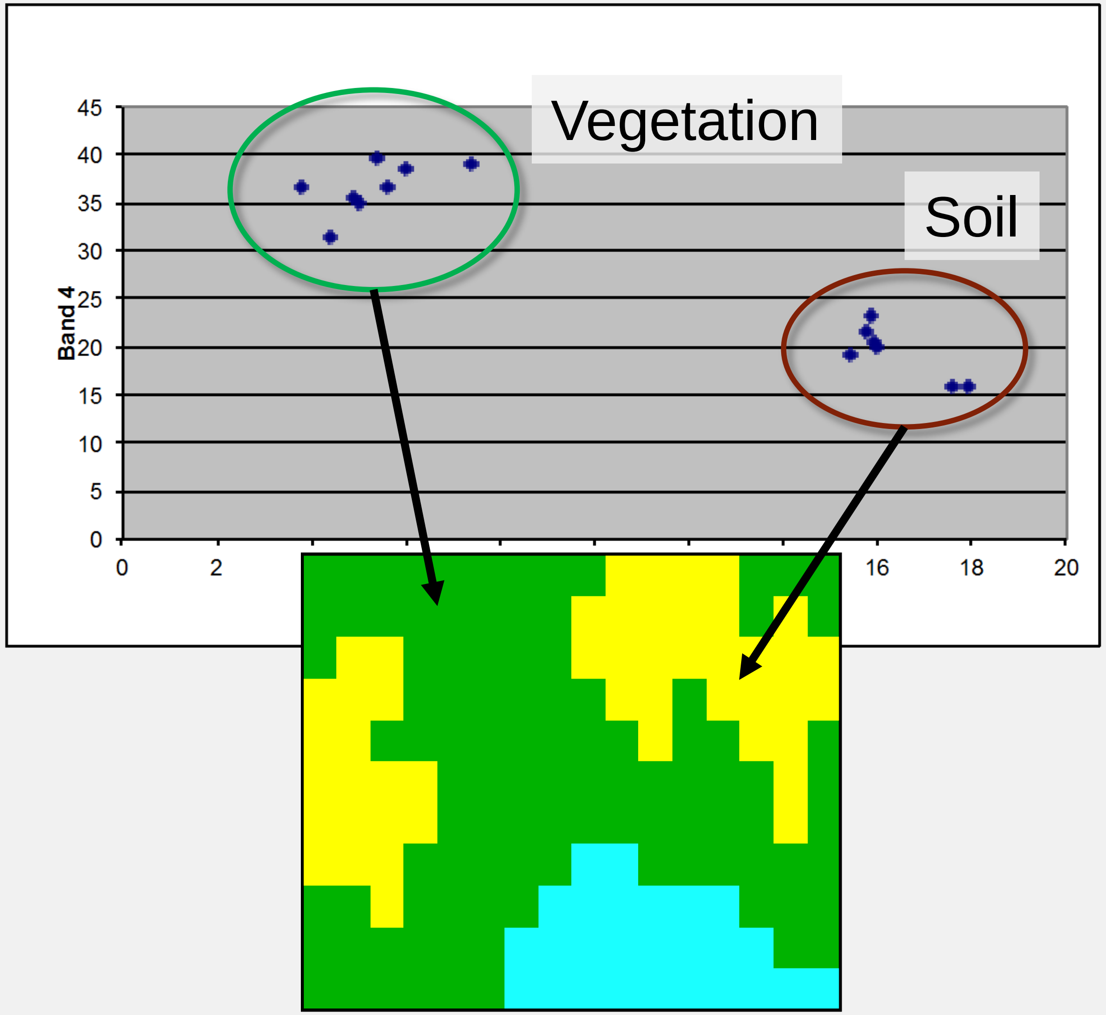


Image Classification

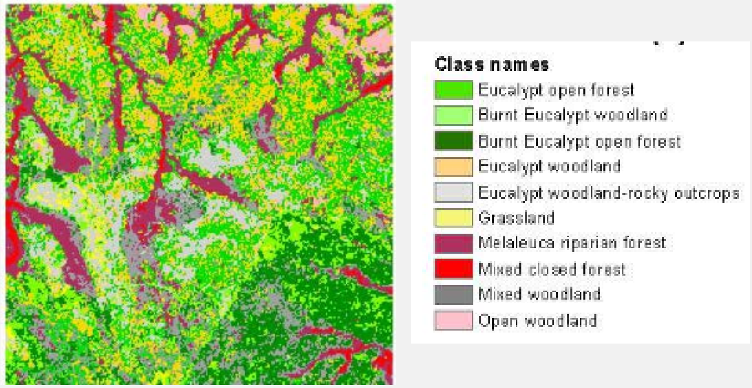
Approaches

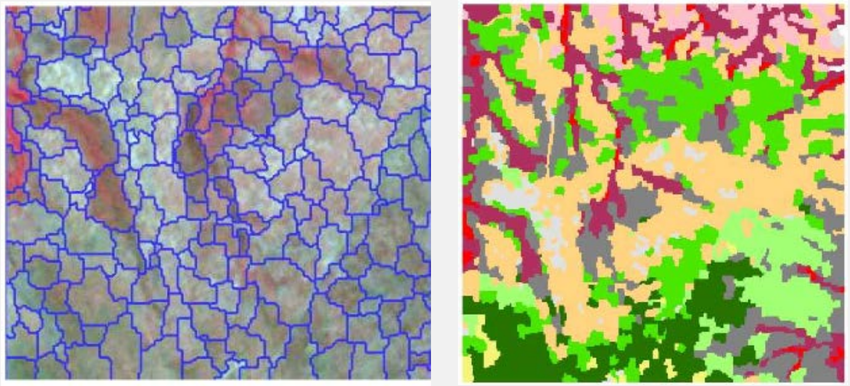
Pixel-Based

- Each pixel is grouped in a class
- Useful for multiple changes in land use within a short period of time
- Best for complete data coverage and a need for methods to ensure time series consistency at the pixel level

Object-Based

- Pixels with common spectral characteristics are first grouped together (segmentation)
- Useful for:
  - reducing speckle noise in radar images
  - high resolution imagery





Whiteside, T., & Ahmad, W. (2005, September). A comparison of object-oriented and pixel-based classification methods for mapping land cover in northern Australia. *Proceedings of SSC2005 Spatial intelligence, innovation and praxis: The national biennial Conference of the Spatial Sciences Institute*.

Image Classification

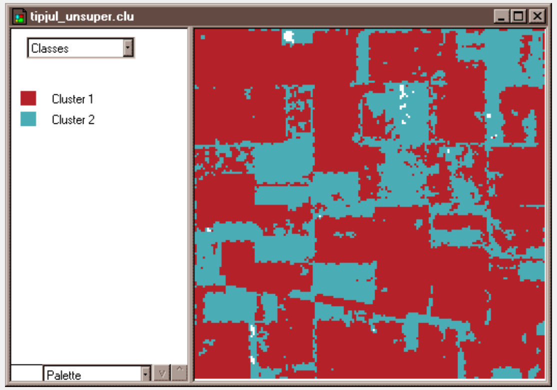
Methods

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

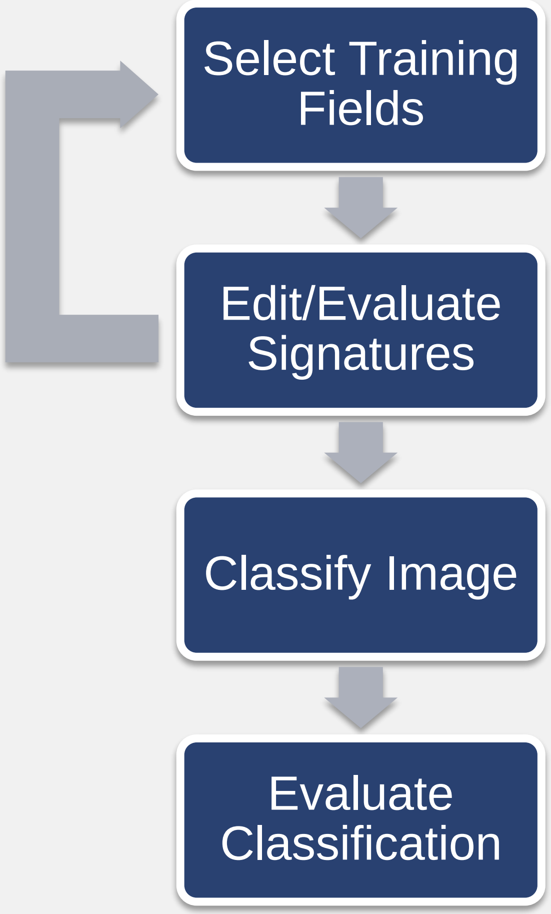
- Uses classification algorithms to assign pixels into one of a number of user-specified class groupings
- Interpreters assign each of the groupings of pixels a value corresponding to a land cover class



Credit: David DiBiase, Penn State Department of Geography

Supervised vs. Unsupervised

Supervised



Unsupervised

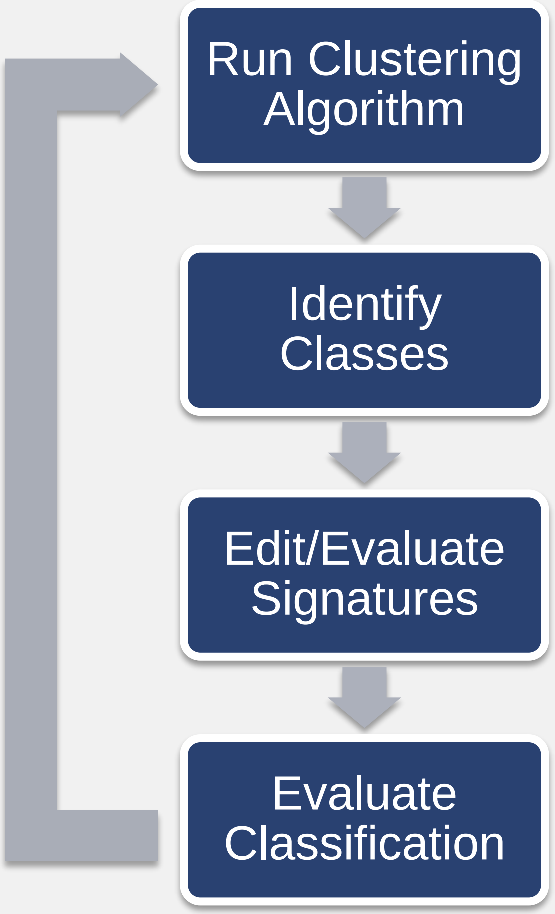
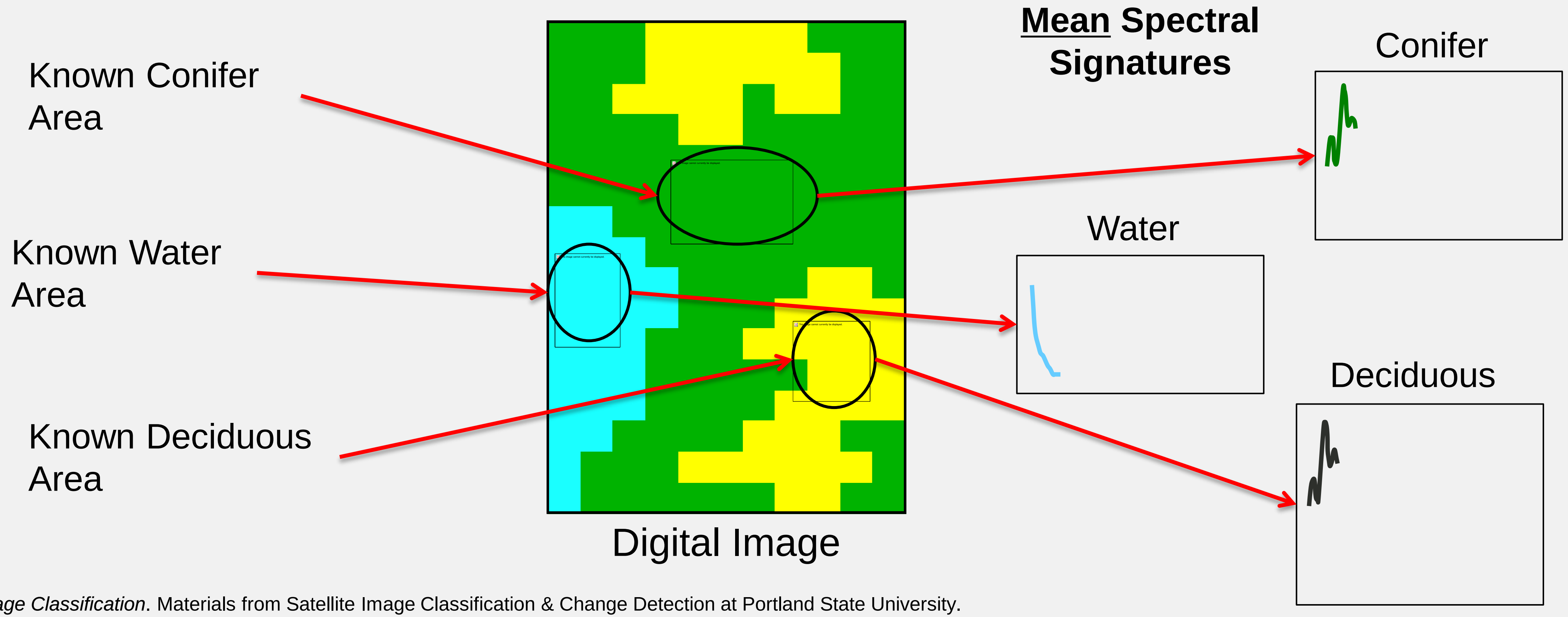


Image Classification

Supervised Method

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

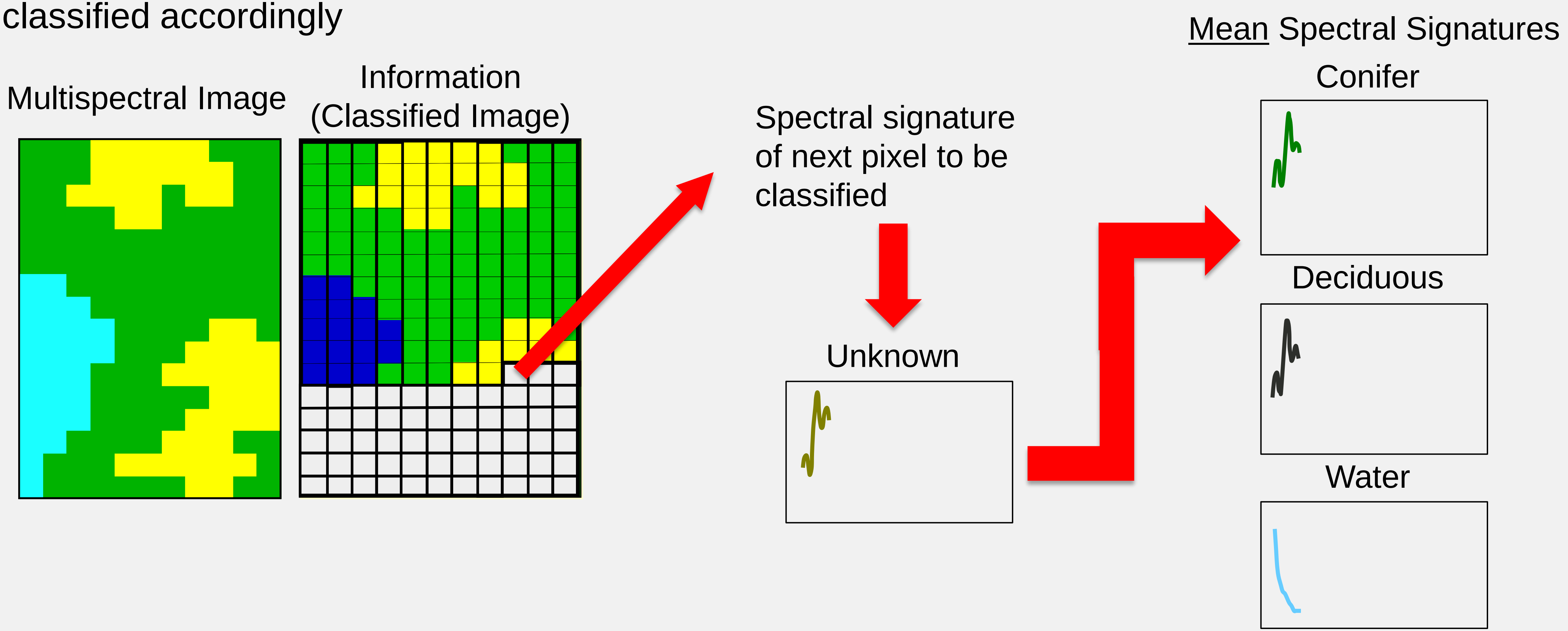


Sutton, L. *Image Classification*. Materials from Satellite Image Classification & Change Detection at Portland State University.

Image Classification

Supervised Method

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



Training Sites (or Regions of Interest)

Key Characteristics

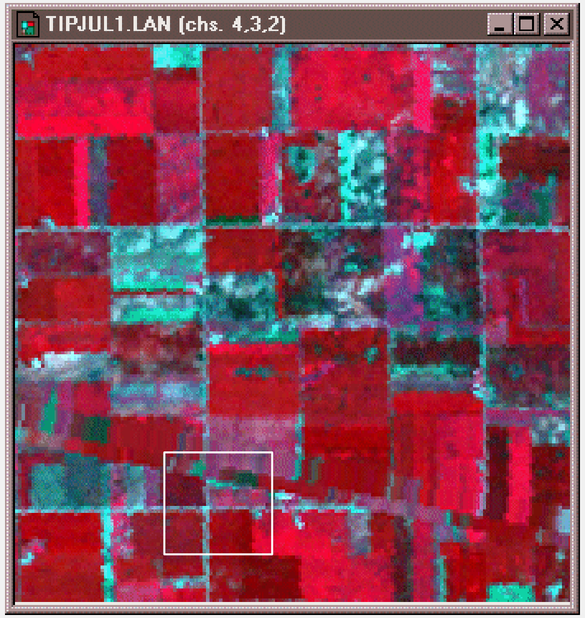
- **General rule:** If using n bands of data, then >10n pixels of training data should be collected for each class
- **Size:** Must be large enough to provide accurate estimates of the properties of each class
- **Location:** Each class should be represented by several training areas positioned throughout the image
- **Number:** 5 to 10 per class minimum. You want to make sure spectral properties of each class are represented
- **Uniformity:** Each training area should exhibit unimodal frequency distribution for each spectral band.

Selecting training sites

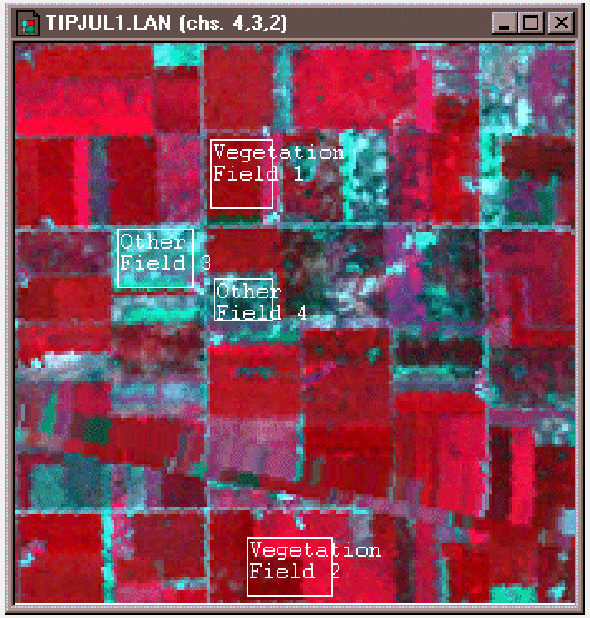
Minimizing confusion

- Confusion of land cover classes is common in land cover classification because:
  - Land cover types are spectrally similar (i.e. different vegetation or crop types)
  - Shadows or clouds
  - Training sites are delineated too broadly OR they are not capturing enough variability.

This training site includes too many land cover types and therefore too much spectral variability



These training sites better represent the spectral variability in agricultural fields

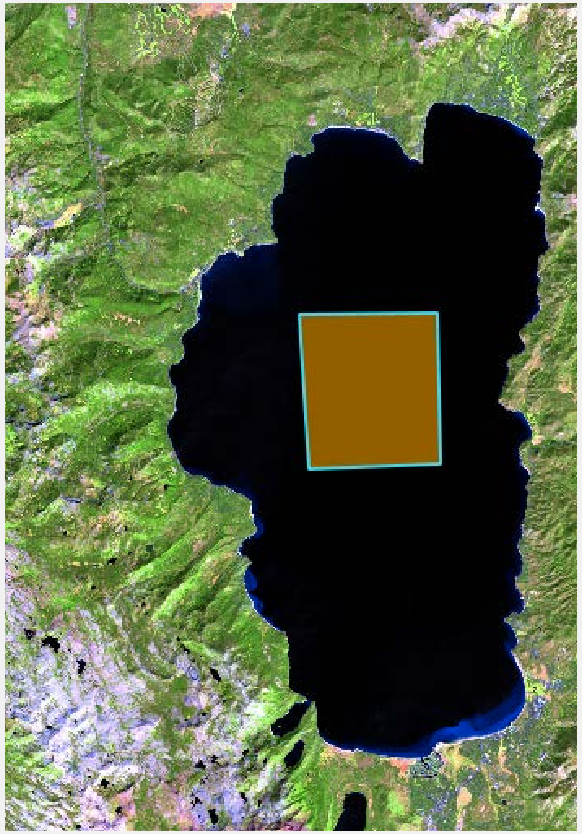


Selecting Training Sites

Creating a polygon vs. Region growing

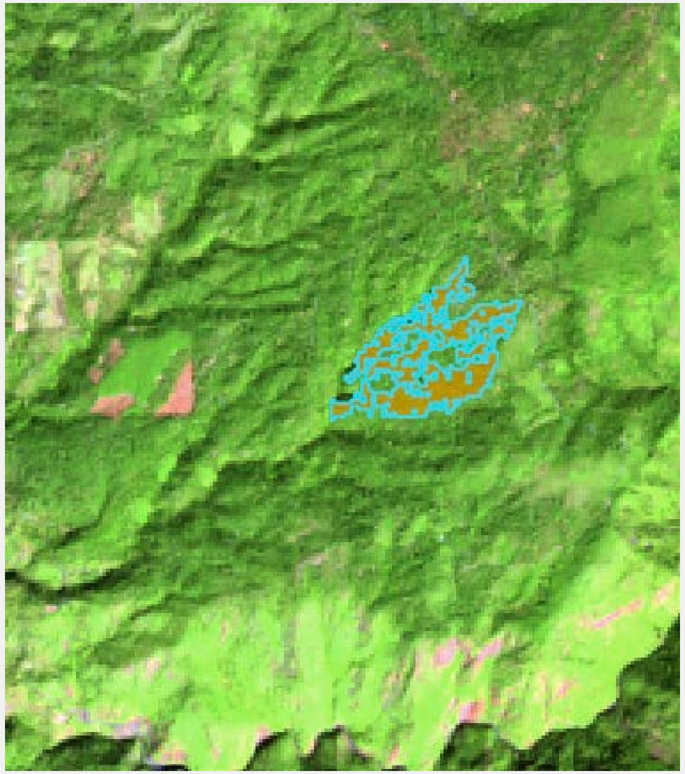
Creating a Polygon

For large areas that are fairly homogeneous (such as large water bodies), you can draw your own training site



Region Growing

However, in areas that have a lot of spectral variation it is better to use a region growing tool

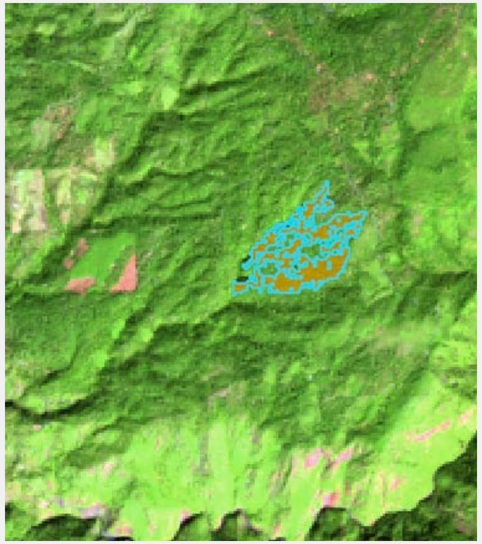


Selecting Training Sites

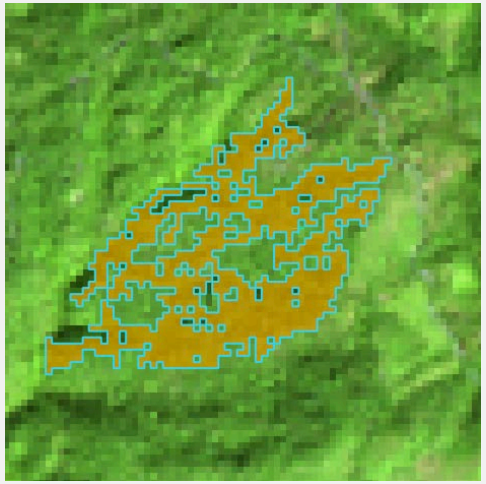
What is region growing?

- **Region Growing Tool:** create a training site based on the spectral characteristics
- **Training Site:** created by including adjacent pixels within a spectral threshold that you choose.
- **Threshold:** based on the pixel values in the image.
- **Example:**
  - for an image that has been converted to reflectance values (which will range from 0.01 to 1), your spectral threshold might be 0.08.

This training site was created in a vegetated area with a lot of spectral variation

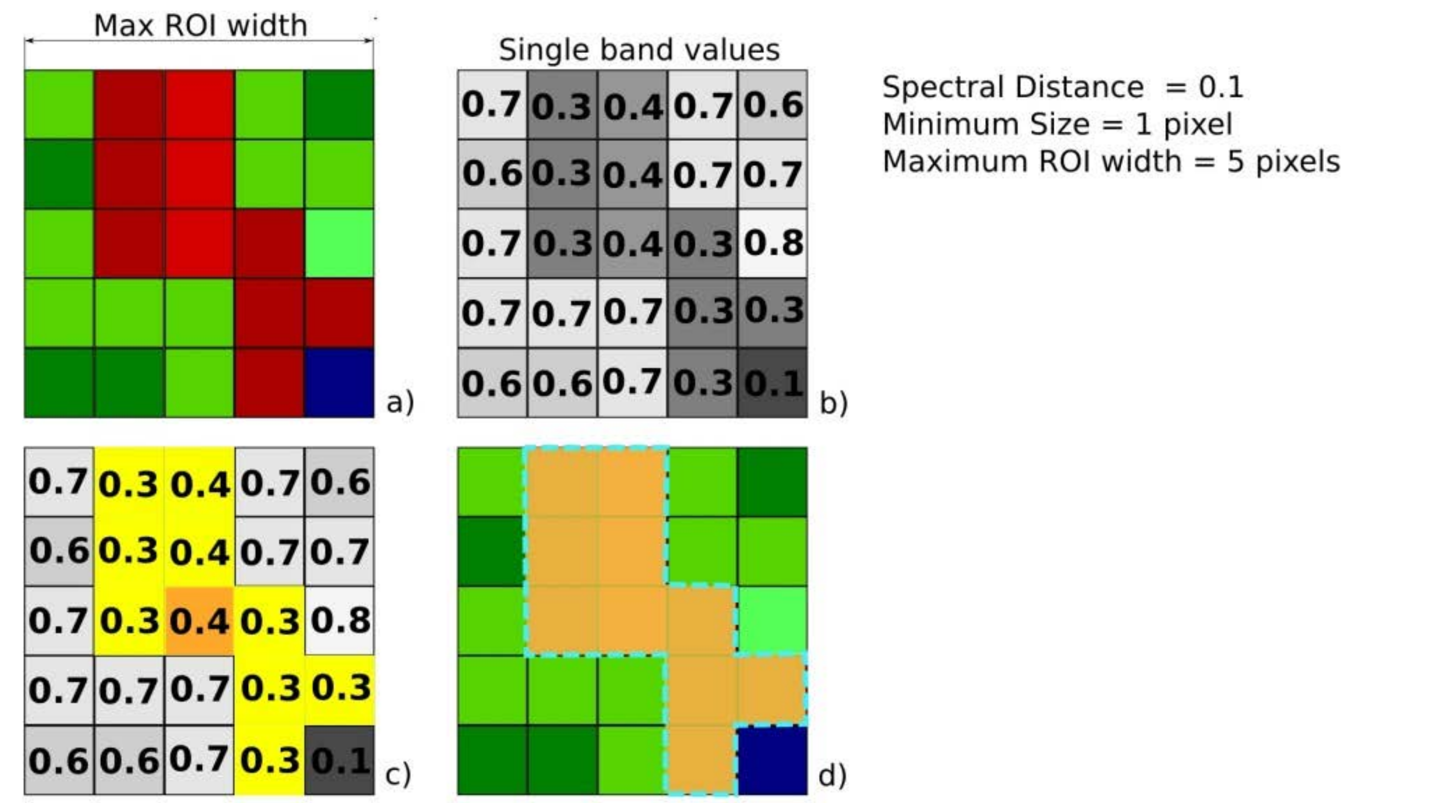


If you zoom into this training area, you will see that it is only including certain pixels with values that are similar to each other



Region Growing Example

- In this example, the central pixel in **image a)** is used as the seed or the starting point to grow the region
- The training site parameters are defined on the far right
- The pixel values for a single band are shown in **image b)**
- The training area is created based on the training site parameters in **c) and d)**



Credit: Semi-Automatic Classification Plugin Documentation

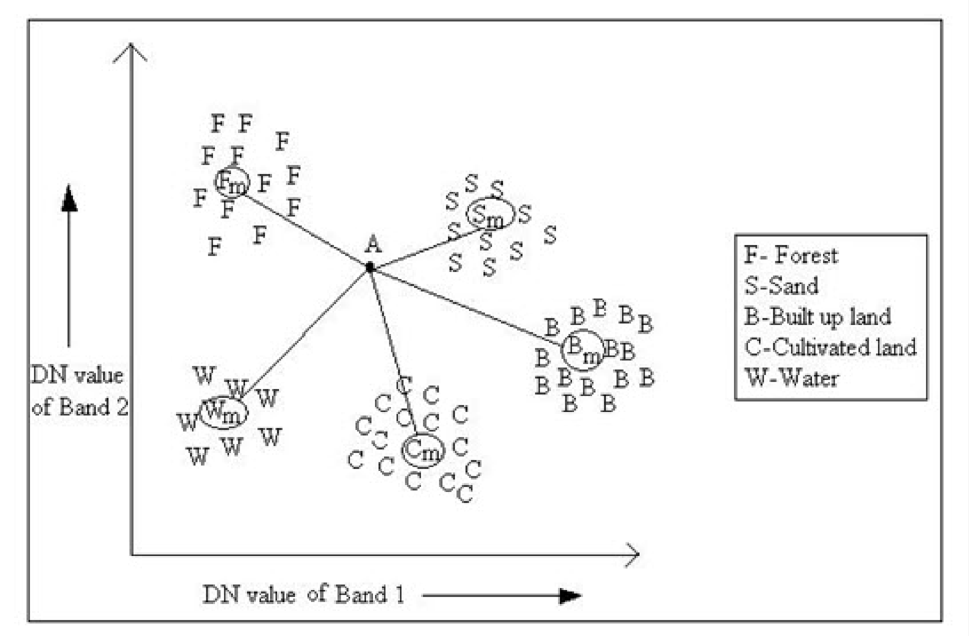
Classification Algorithms

- Used to classify the whole image by comparing spectral characteristics of each pixel to the spectral characteristics of the training for land cover classes
- Different available methods - QGIS Semi-Automated Classification Plugin:
  - Minimum Distance
  - Maximum Likelihood
  - Spectral Angle Mapping
- These methods determine different ways for the classes to be defined based on their statistics
- Next slide: Example: Minimum Distance vs. Maximum Likelihood

Minimum Distance vs. Maximum Likelihood

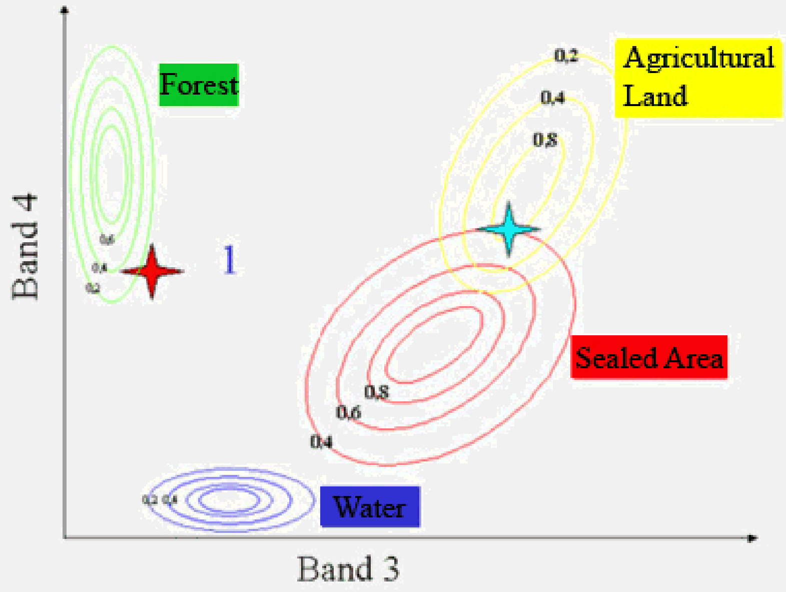
Minimum Distance:

- The mean value for each class and each band is calculated
- Each pixel is assigned to a class which has the shortest Euclidean distance



Maximum Likelihood:

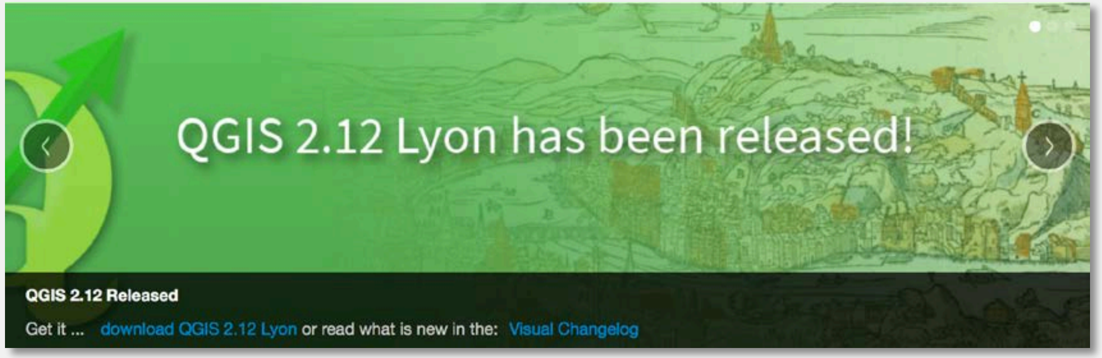
- The mean and standard deviations for each class and each band are calculated
- Calculates the probability that a pixel falls within a particular class



QGIS

QGIS

- Freely-available open source Geographic Information System (GIS) licensed under the GNU General Public License
- Volunteer-driven project
- Runs on Windows and Mac operating systems
- Plugins allow users to perform advanced geospatial analysis
- Compatible with many data formats including:
  - Shapefiles
  - Geotiff
  - Geodatabases, etc.

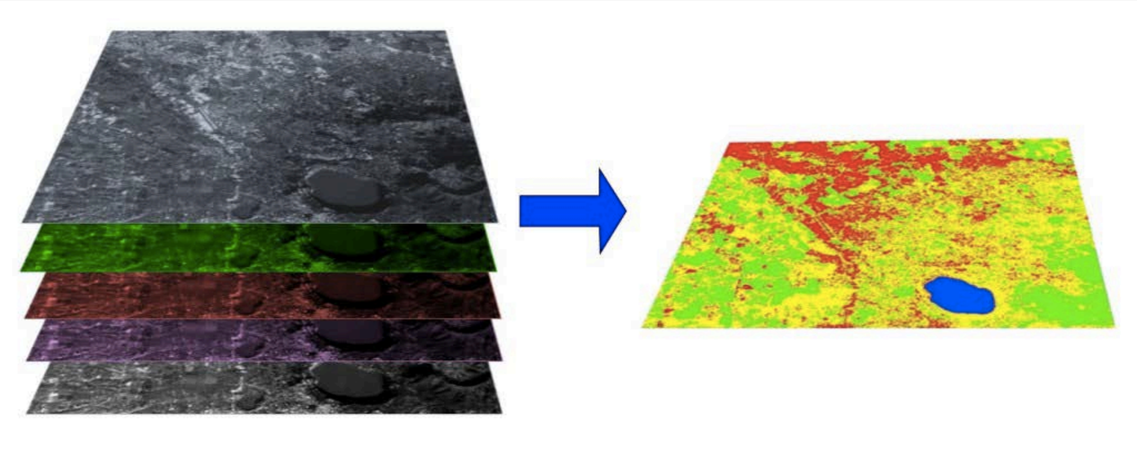


Semi-Automatic Classification Plugin (SCP)

- Developed by Luca Congedo
- Free, open-source plugin for QGIS that allows for supervised classification
- It provides:
  - Several tools for the download of imagery
  - Preprocessing (Digital Numbers to Top of Atmosphere Reflectance)
  - Training site selection and analysis
  - Classification algorithms
- Documentation: Congedo, Luca (2016). Semi-Automatic Classification Plugin Documentation.
  - https://fromgistors.blogspot.com/p/semi-automatic-classification-plugin.html

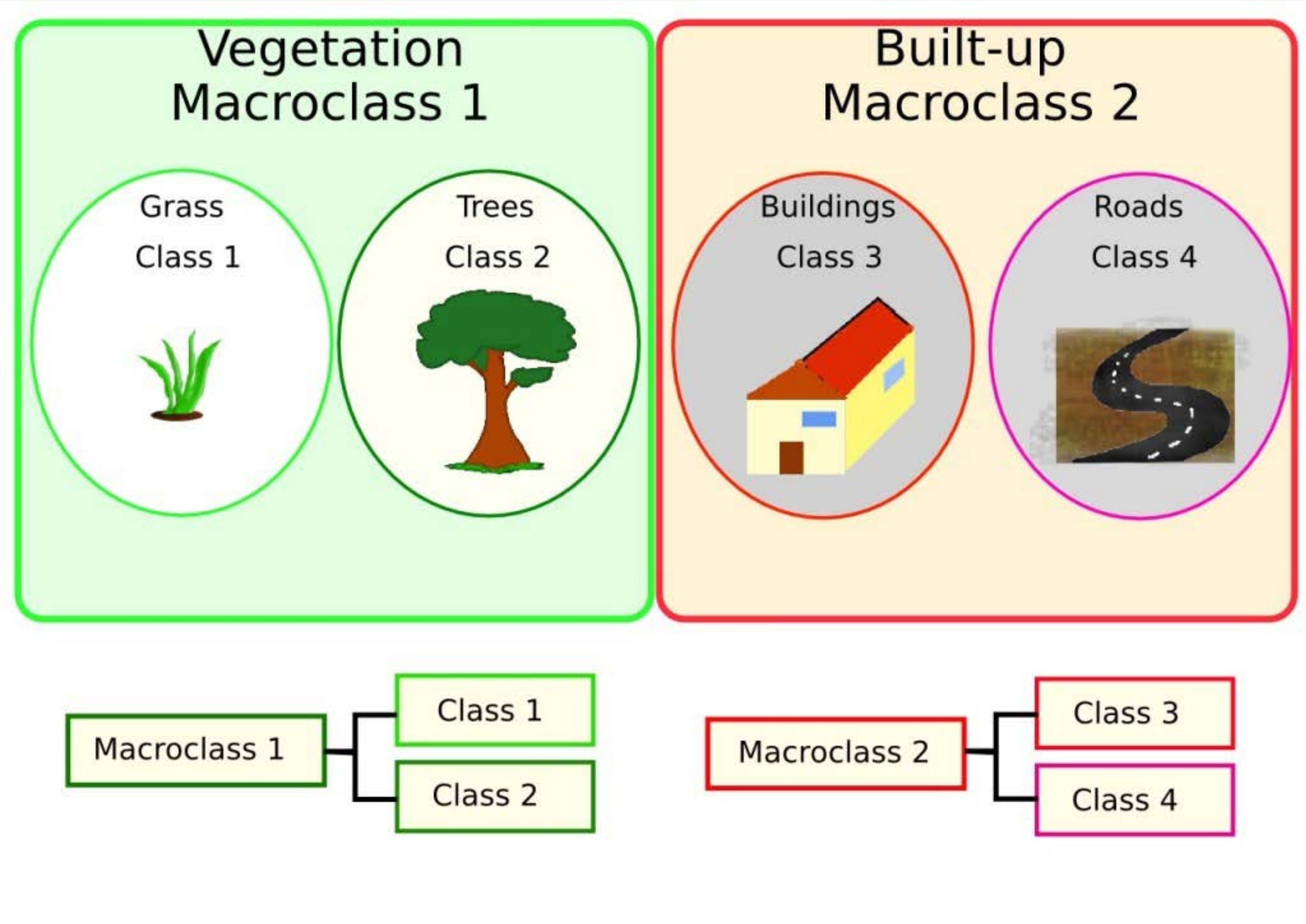
QGIS SCP Process Flow

1. Convert the image to surface reflectance (week 1)
2. Subset the image (week 1)
3. Set the input image (week 1)
4. Create the training input file (week 1)
5. Create the Region of Interest (ROIs) (weeks 1 and 2)
6. Analyze the ROIs (week 2)
7. Create a classification preview (weeks 1 and 2)
8. Create the classification output (weeks 1 and 2)



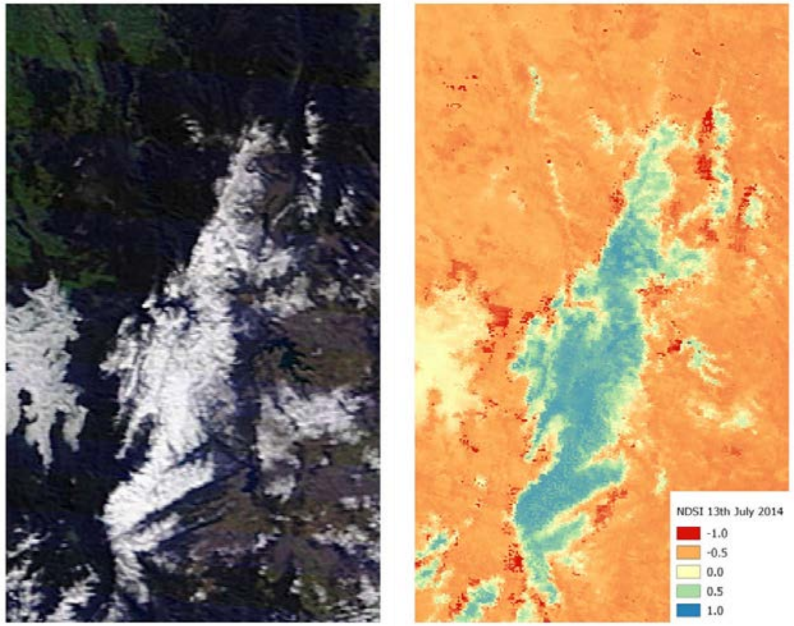
QGIS SCP

Class definition



QGIS: Support

- User Guide and Training Manual Available
  - http://www.qgis.org/en/site/forusers/index.html
- User Support on StackExchange
  - Use QGIS Tag
  - http://gis.stackexchange.com/
- Case Studies
  - Example: using the processing toolbox to automate snow classification
    - Similar to NDVI classification
    - http://www.qgis.org/en/site/about/case_studies/australia_snowyhydro.html



MODIS Truecolor NDSI Output

Case study: use of QGIS for calculating the Normalized Difference Snow Index (NDSI). Image Credit: Andrew Jeffrey.


QGIS Exercise

Contacts

- ARSET Land Management and Wildfire Contacts
  - Cynthia Schmidt: cynthia.l.schmidt@nasa.gov
  - Amber McCullum: amberjean.mccullum@nasa.gov
- General ARSET Queries
  - Ana Prados: aprados@umbc.edu
- ARSET Website:
  - http://arset.gsfc.nasa.gov/

National Aeronautics and
Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Thank You!

Next Week:

Improving the supervised classification