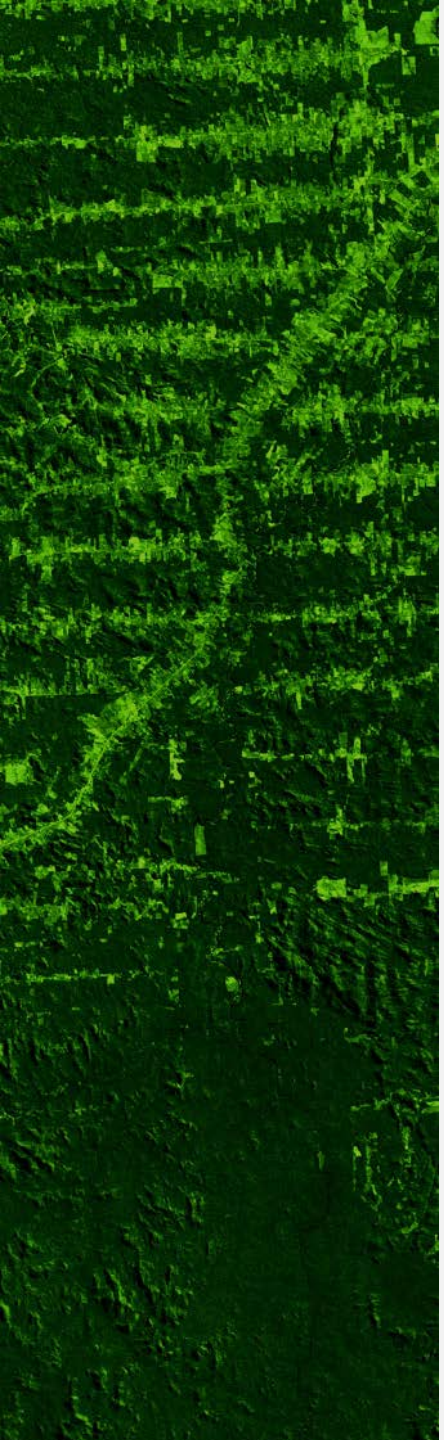


National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Remote Sensing of Land Indicators of Sustainable Development Goal (SDG) 15

Instructors: Cindy Schmidt and Amber McCullum

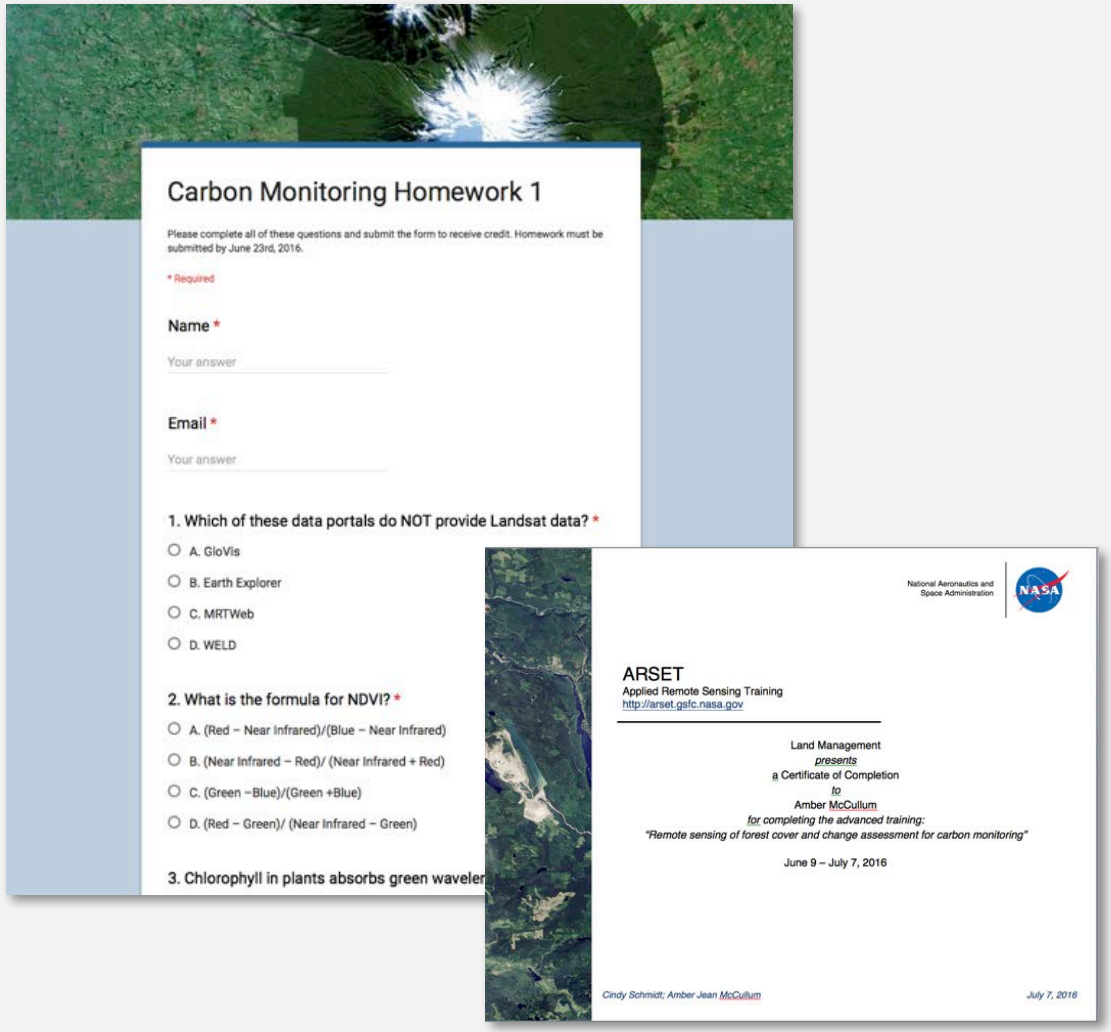
Session 2: June 21, 2017

Course Structure

- Three sessions: Tuesday, June 20; Wednesday, June 21; Thursday, June 22
  - Each session will be given twice:
    - Session A: 1:00 – 2:00 p.m. EDT (UTC-4)
    - Session B: 10:00 – 11:00 p.m. EDT (UTC-4)
  - Please only sign up for and attend the same session each week
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
  - http://arset.gsfc.nasa.gov/land/webinars/sdg15
  - Q&A: Following each lecture and/or by email
    - cynthia.l.schmidt@nasa.gov, or
    - amberjean.mccullum@nasa.gov

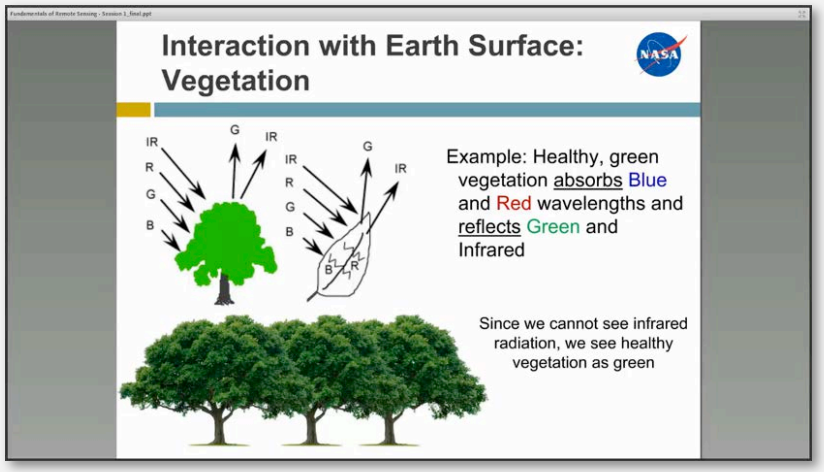
Homework and Certificates

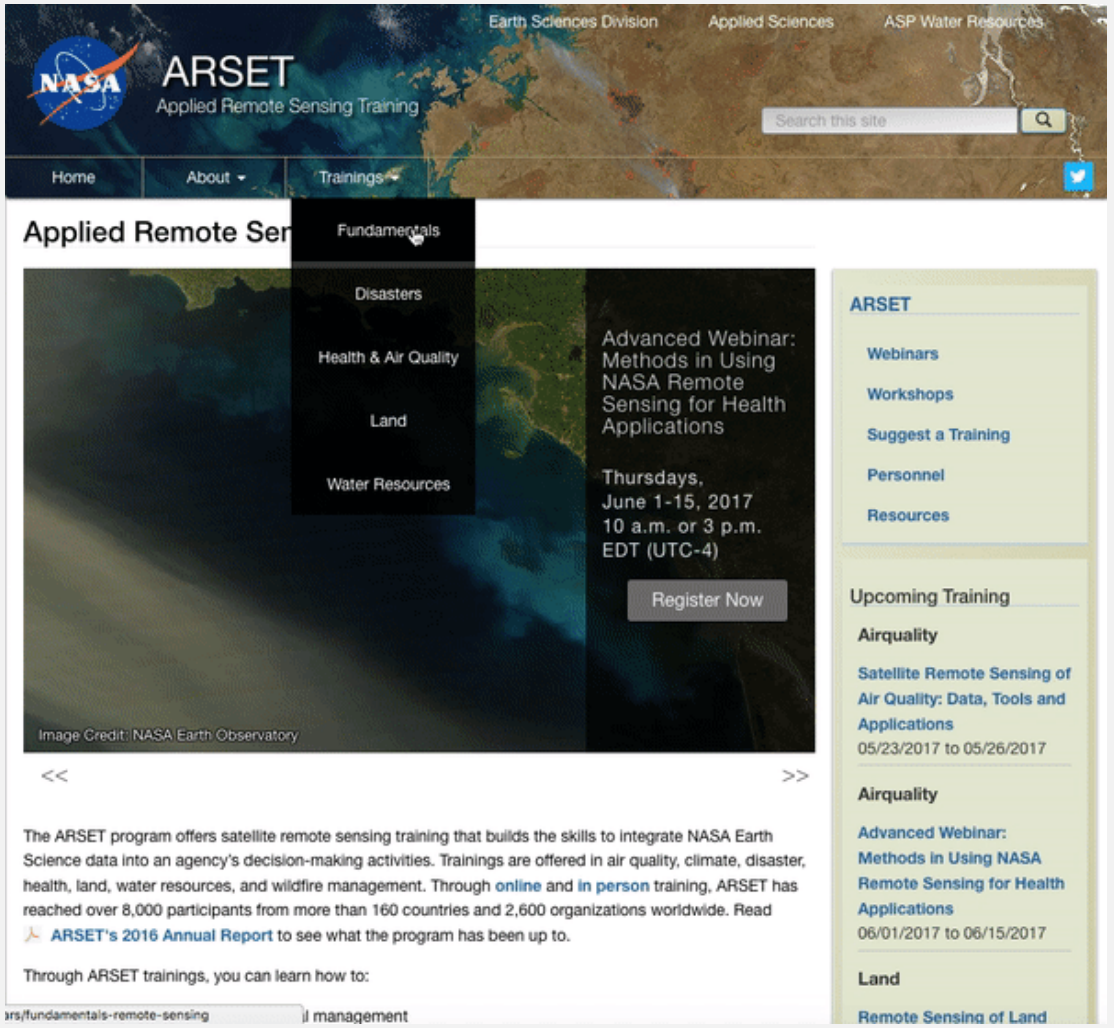
- Homework
  - Answers must be submitted via Google Form
- Certificate of Completion:
  - Attend all 3 webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
    - HW Deadline: July 6th
  - You will receive certificates approx. two months after the completion of the course from: marines.martins@ssaihq.com



Prerequisite

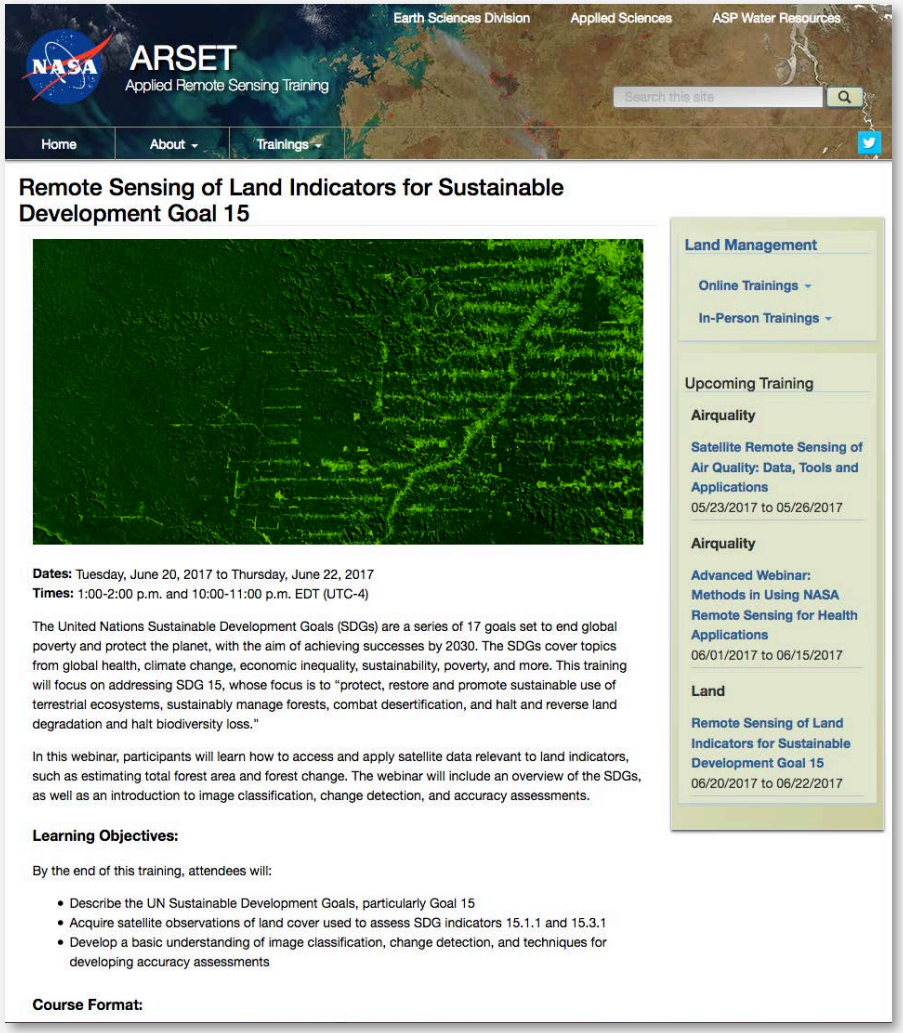
- Fundamentals of Remote Sensing
  - Sessions 1 and 2A (Land)
  - On demand webinar, available anytime
  - http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing

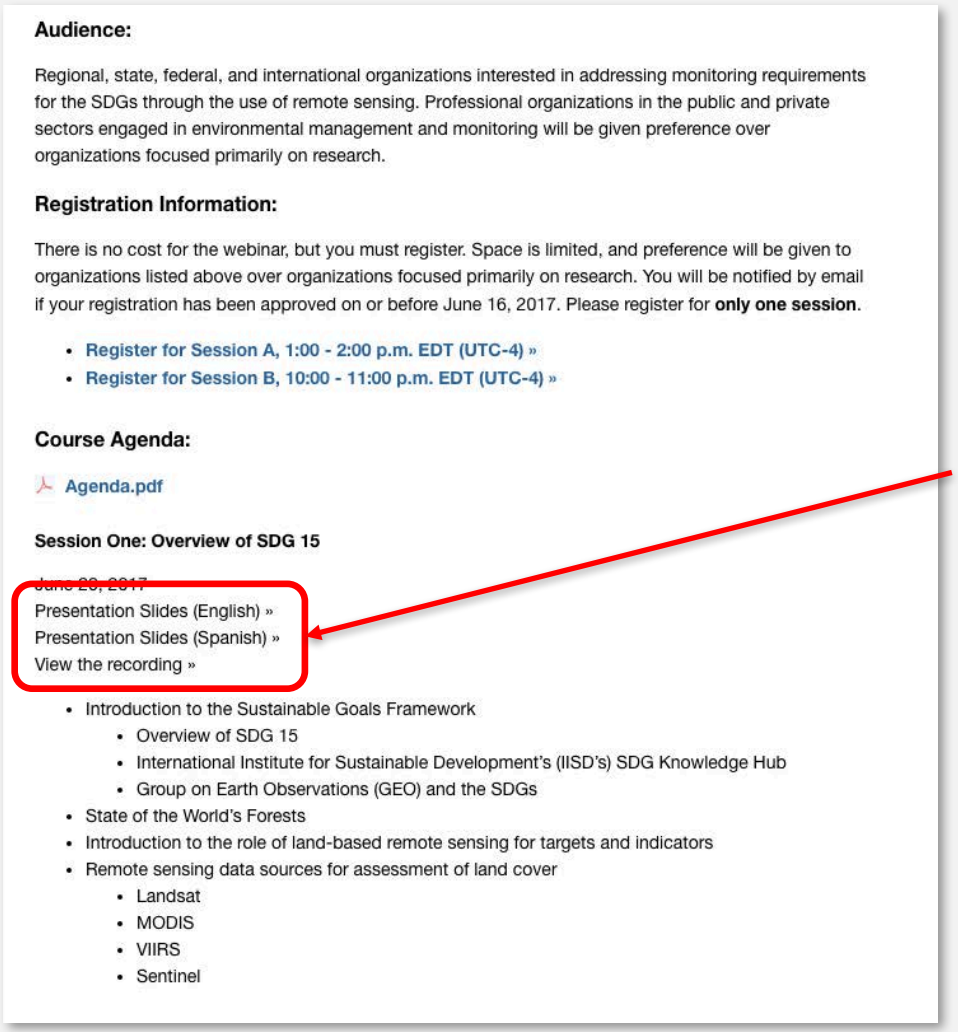




Accessing Course Materials

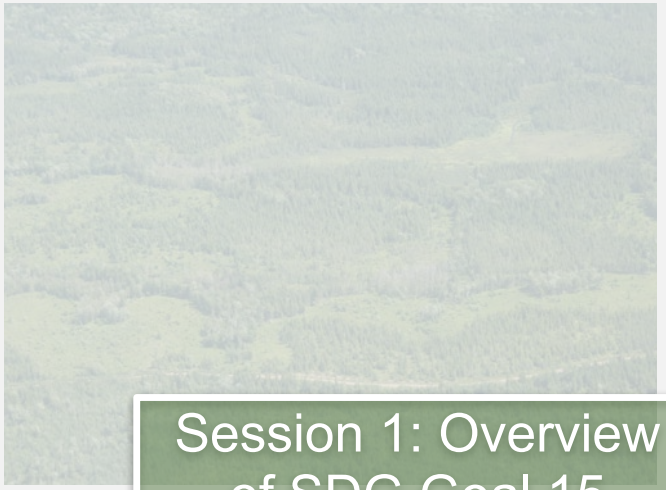
http://arset.gsfc.nasa.gov/land/webinars/sdg15/





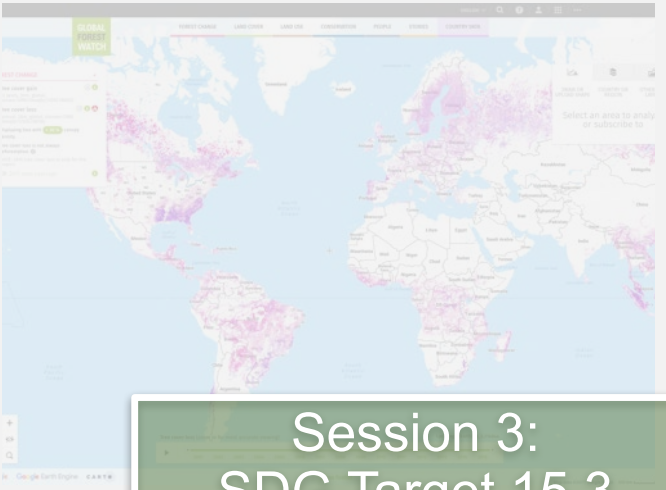
Course materials are provided here and will be active after each week

Course Outline



Session 1: Overview of SDG Goal 15

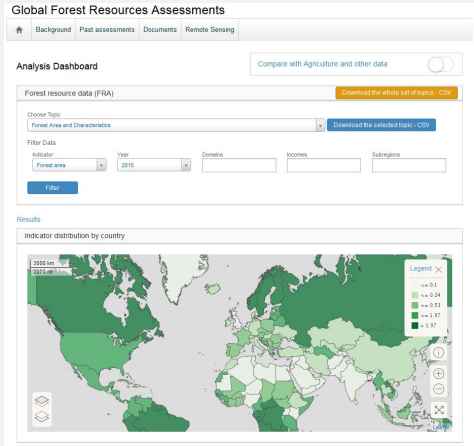
Session 2: SDG Target 15.1



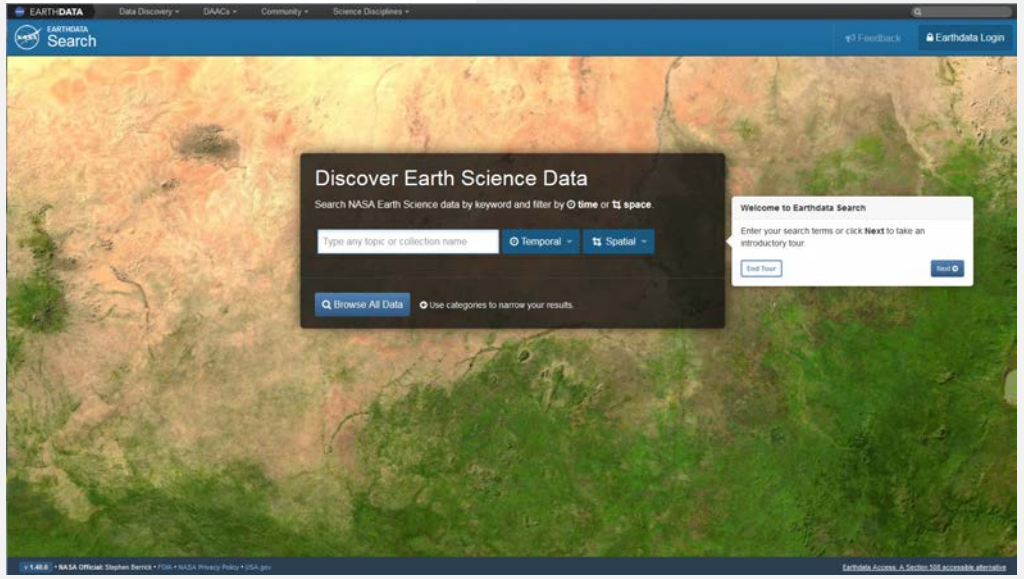
Session 3: SDG Target 15.3

Session 2 Agenda

- SDG Target 15.1 and Indicator 15.1.1
- Land cover visualization and data access tools
- Land cover classification from satellite imagery
- Demo: MODIS Land Cover and Global Forest Watch



(Left) Global Forest Resource Assessment, Credit: Food and Agriculture Organization .
(Below) Earthdata Search



Target 15.1 and Land Cover Tools

SDG: Target 15.1

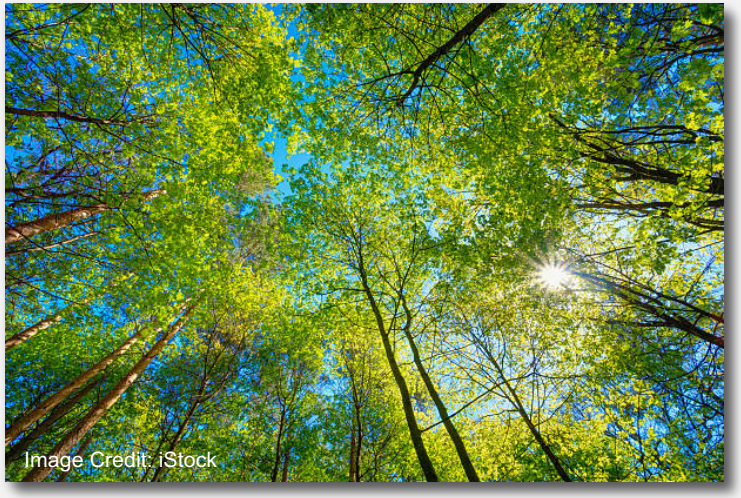
- By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements
  – Indicator: 15.1.1: Forest area as a proportion of total land area

May be used as a rough proxy for the extent to which the forests in a country are being conserved or restored, but it is only partly a measure for the extent to which they are sustainably managed

Indicator 15.1.1

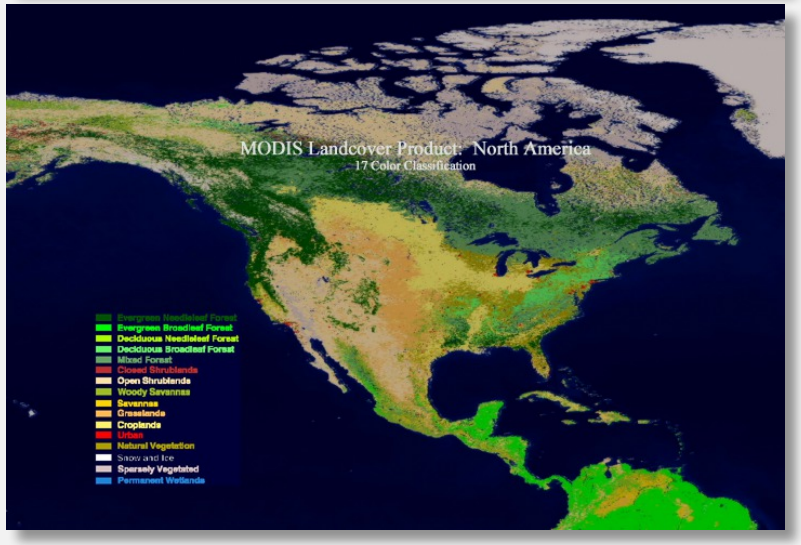
Definitions

- **Forest**: “land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use” (Food and Agriculture Organization (FAO))
- **Total Land Area**: “total surface area of a country less the area covered by inland waters, like major rivers and lakes” (BIP)



Global Forest and Land Cover Data

- Global Forest Watch (Hansen, et al. 2013)
- FAO Global Forest Resource Assessments and the Forest Land Use Data Explorer
- FAO Global Land Cover SHARE (GLC-SHARE)
- European Space Agency Climate Change Initiative Land Cover
- GlobeLand30 (China)
- MODIS Land Cover



Global Forest Watch

www.globalforestwatch.org

- Area of tree cover with varying canopy densities
- Spatial resolution: 30 meters
- Date of Data: 2000
- Definition: All vegetation taller than 5 meters in height

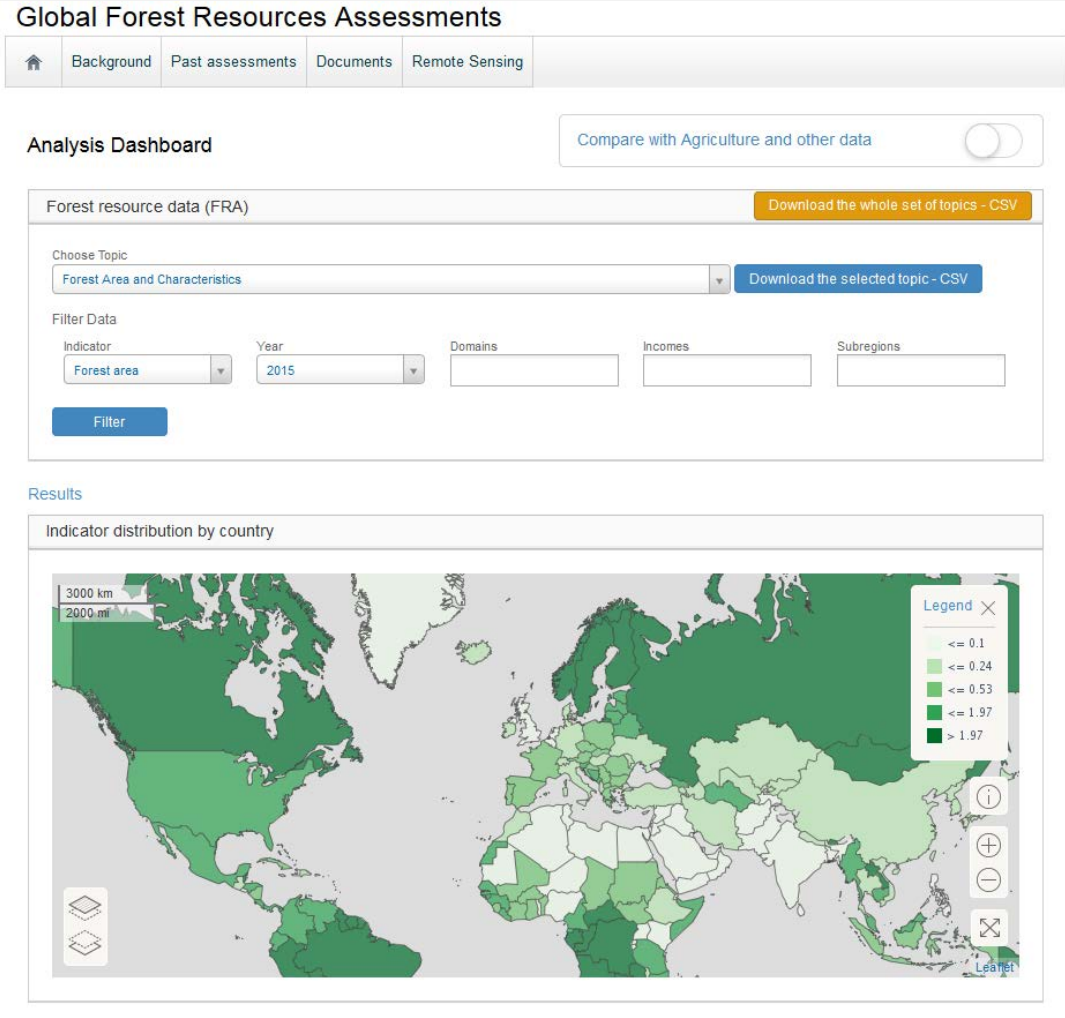
Source: Hansen et al. 2013

FAO Global Forest Resource Assessments

http://www.fao.org/forest-resources-assessment/en/

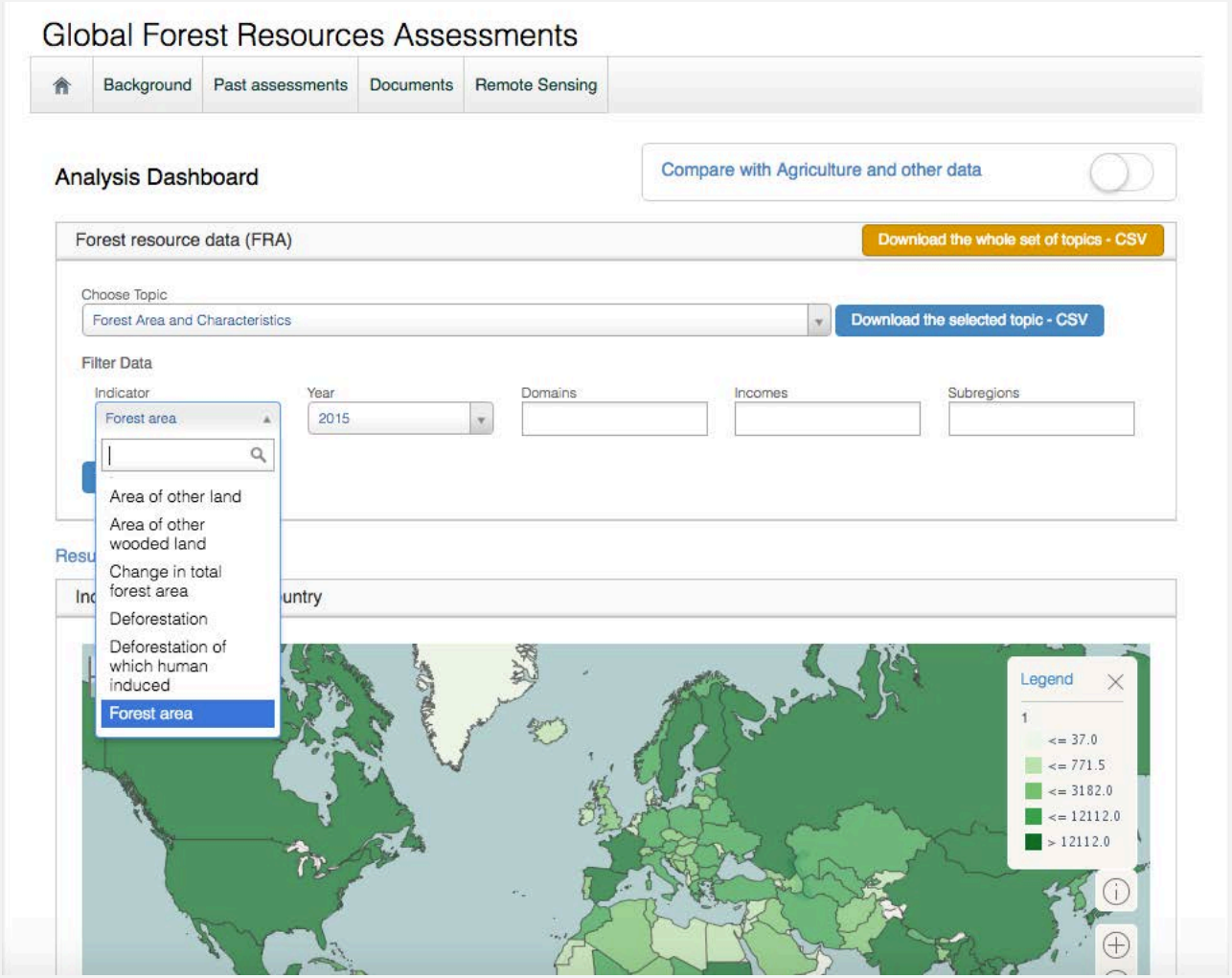
- Produced every five years
- Based on two primary sources of data:
  - country reports prepared by national correspondents
  - remote sensing conducted by FAO and national and regional partners
- Key Outputs:
  - synthesis document: “How are the World’s Forests Changing?”
  - country reports
  - maps (downloadable images)
  - Forest Land Use Data Explorer (FLUDE) – online visualization platform

Forest Land Use Data Explorer

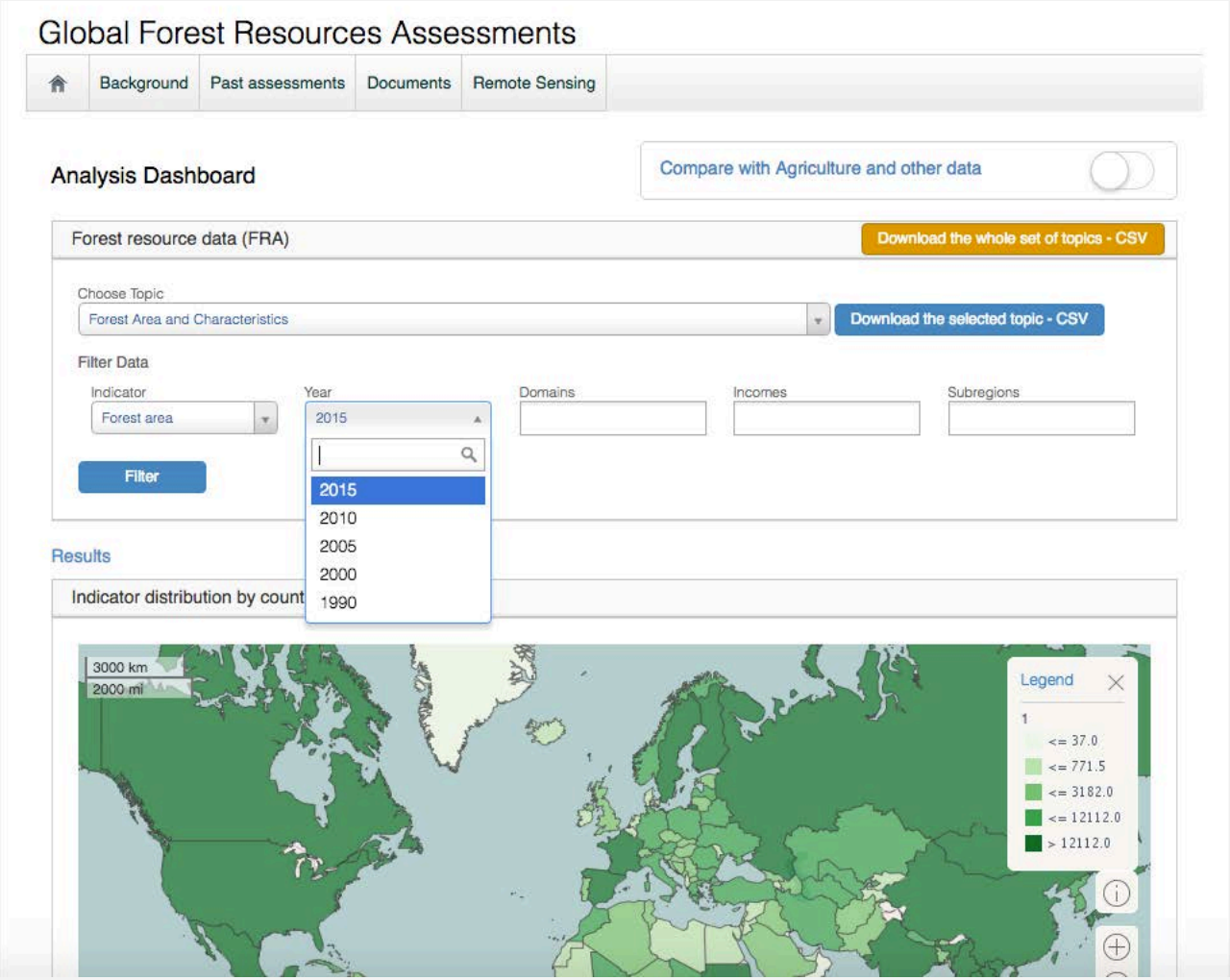


- Most data from the Global Forest Resources Assessment from 2015
- Provides access to datasets that relate to forests, including:
  - agriculture
  - rangelands
  - demographics
  - market prices
  - land use classifications and maps
- You can download data or assemble and analyze data

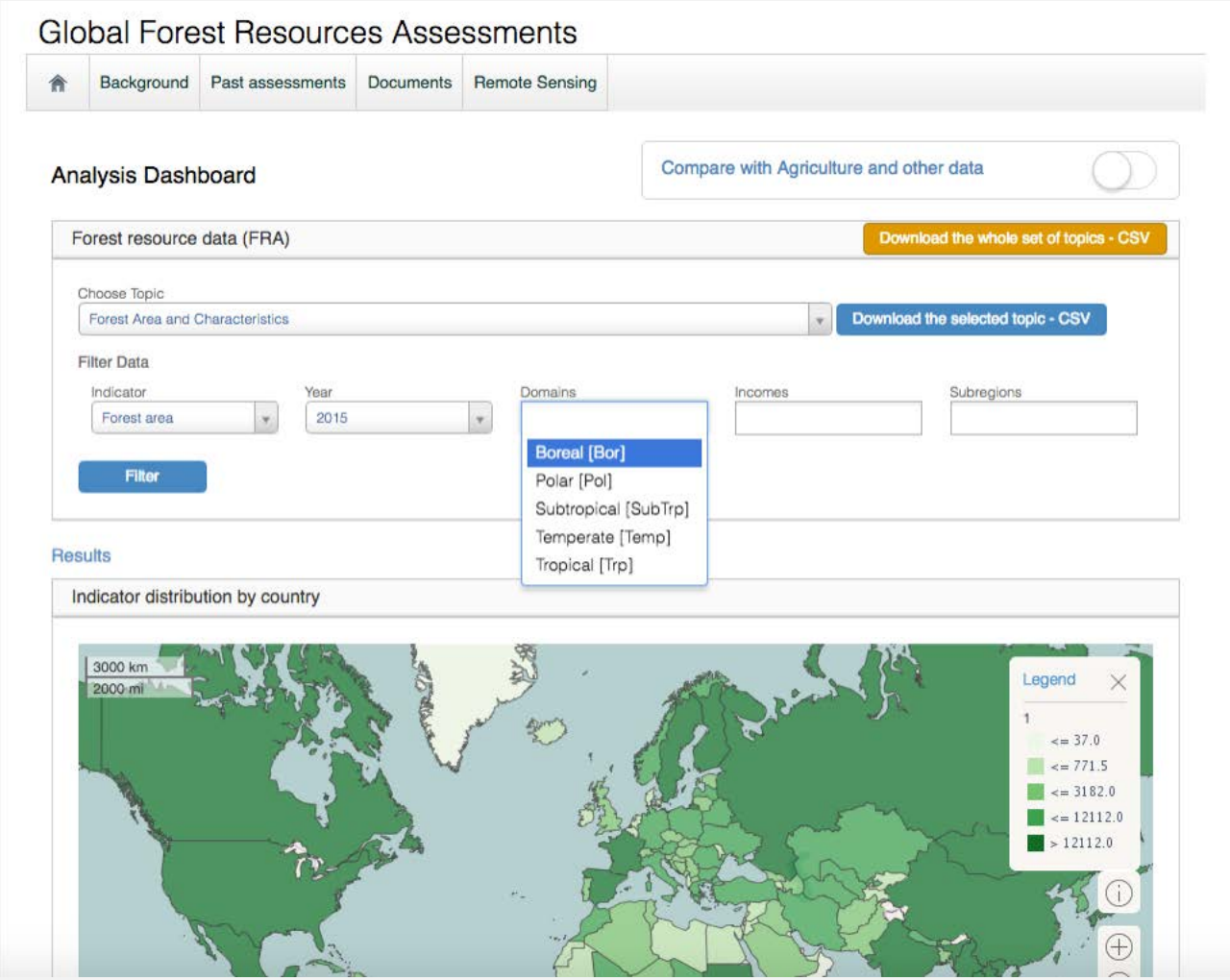
Forest Land Use Data Explorer



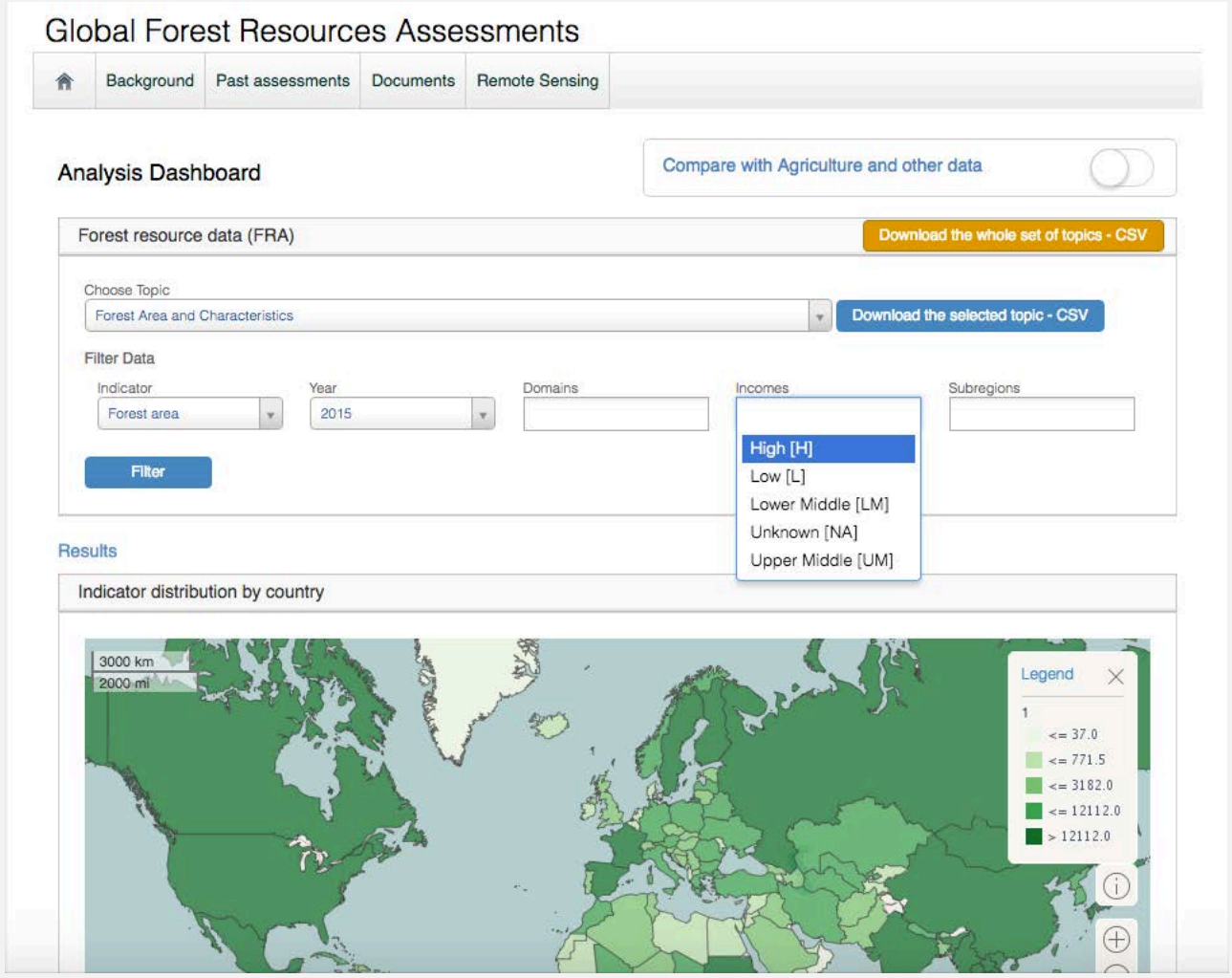
Forest Land Use Data Explorer



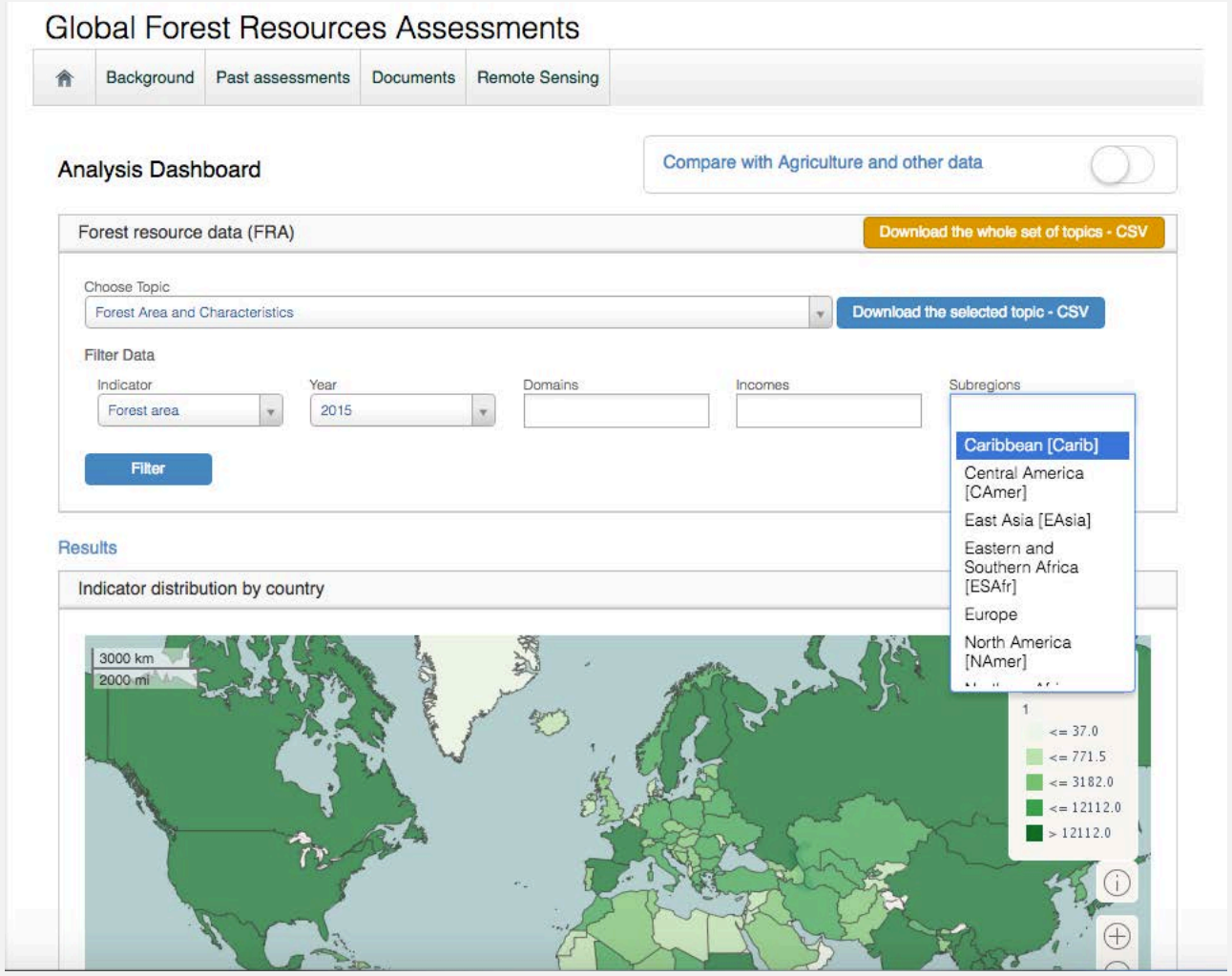
Forest Land Use Data Explorer



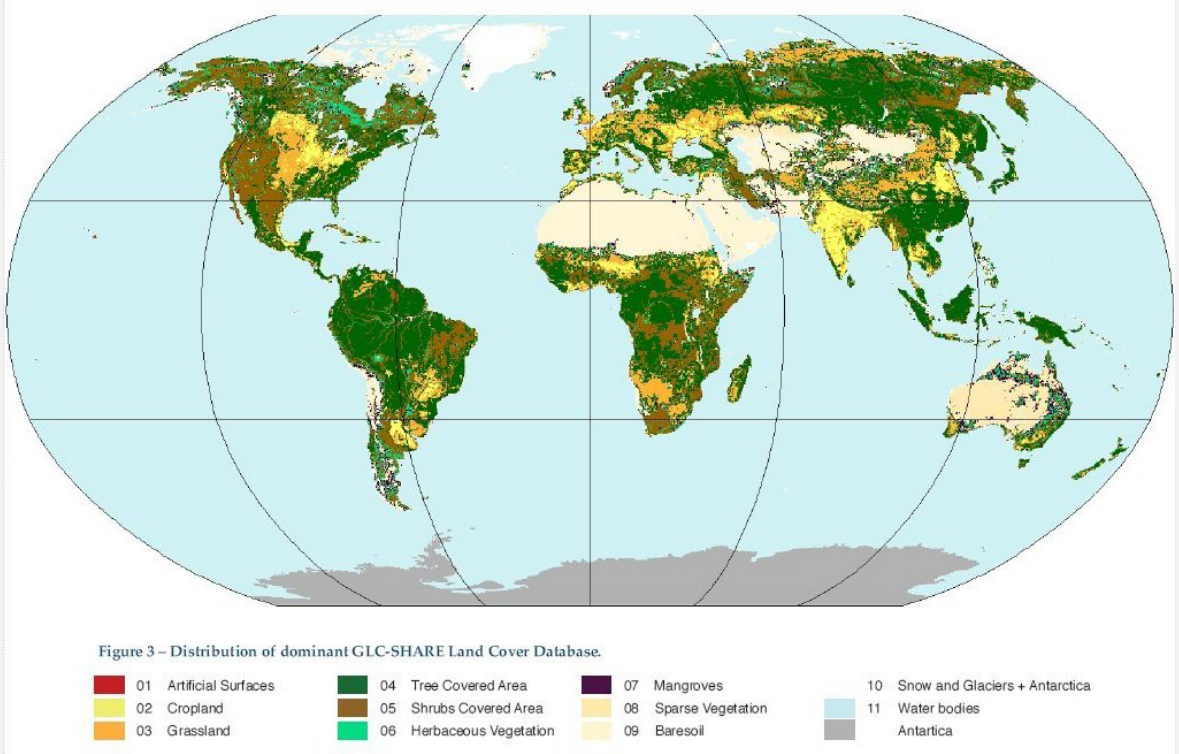
Forest Land Use Data Explorer



Forest Land Use Data Explorer



FAO Global Land Cover-SHARE



- Available for 2014
- Includes 11 land cover classes
- Available for download through FAO GeoNetwork portal: http://www.fao.org/geonetwork/srv/en/main.home
- FAO also has national and regional land cover datasets for many countries in Africa and the Himalayas: http://www.glcn.org/dat_1_en.jsp

ESA Climate Change Initiative Land Cover

http://www.esa-landcover-cci.org

- Annual global land cover time series from 1992-2015
- Spatial Resolution: 300 meters
- Remote Sensing Sources:
  – NOAA AVHRR, SPOT, ENVISAT, PROBA-V
- 22 land cover classes based on the UN Land Cover Classification System
- Visualization and download:
  – CCI Land Cover viewer: http://maps.elie.ucl.ac.be/CCI/viewer/

Land cover legend

view global (level 1)

- Cropland, rainfed
- - Herbaceous cover
- - Tree or shrub cover
- Cropland irrigated or post-flooding
- Mosaic cropland (>50%) / natural vegetation (Tree, shrub, herbaceous cover) (<50%)
- Mosaic natural vegetation (Tree, shrub, herbaceous cover) (>50%) / cropland (<50%)
- Tree cover, broadleaved, evergreen, closed to open (>15%)
- Tree cover, broadleaved, deciduous, closed to open (>15%)
- - Tree cover, broadleaved, deciduous, closed (>40%)
- - Tree cover, broadleaved, deciduous, open (15-40%)
- Tree cover, needleleaved, evergreen, closed to open (>15%)
- - Tree cover, needleleaved, evergreen, closed (>40%)
- - Tree cover, needleleaved, evergreen, open (15-40%)
- Tree cover, needleleaved, deciduous, closed to open (>15%)
- - Tree cover, needleleaved,

Long=-49.3945°, Lat=-17.1797°

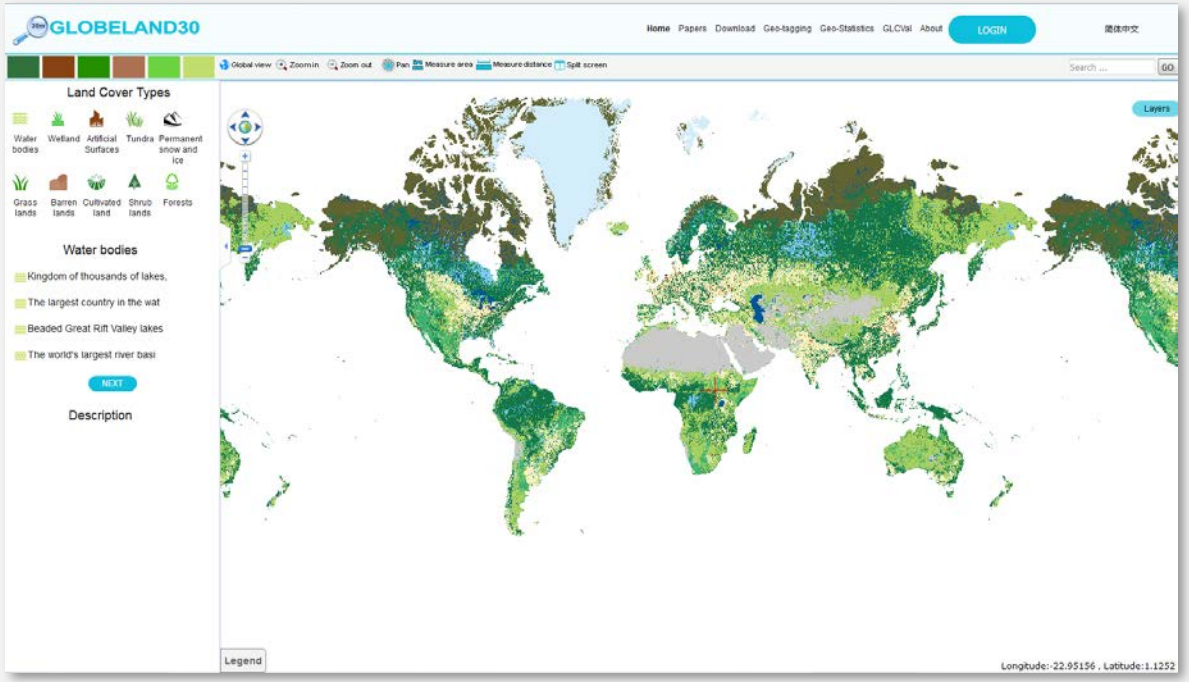
Documentation

- Product User Guide v2
- Quick User Guide for Maps v2.0.7
- Quick user guide Land Surface Seasonality products
- Legend for LC Map v2.0.7
- Preview LC Map v2.0.7 for Year 2015
- Preview MERIS SR Composite

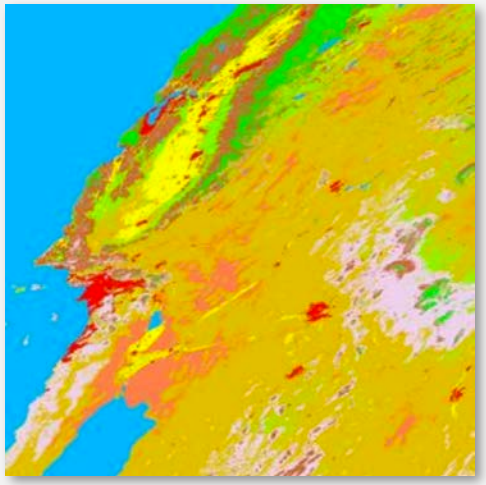
2000 km

GlobeLand30 (China)

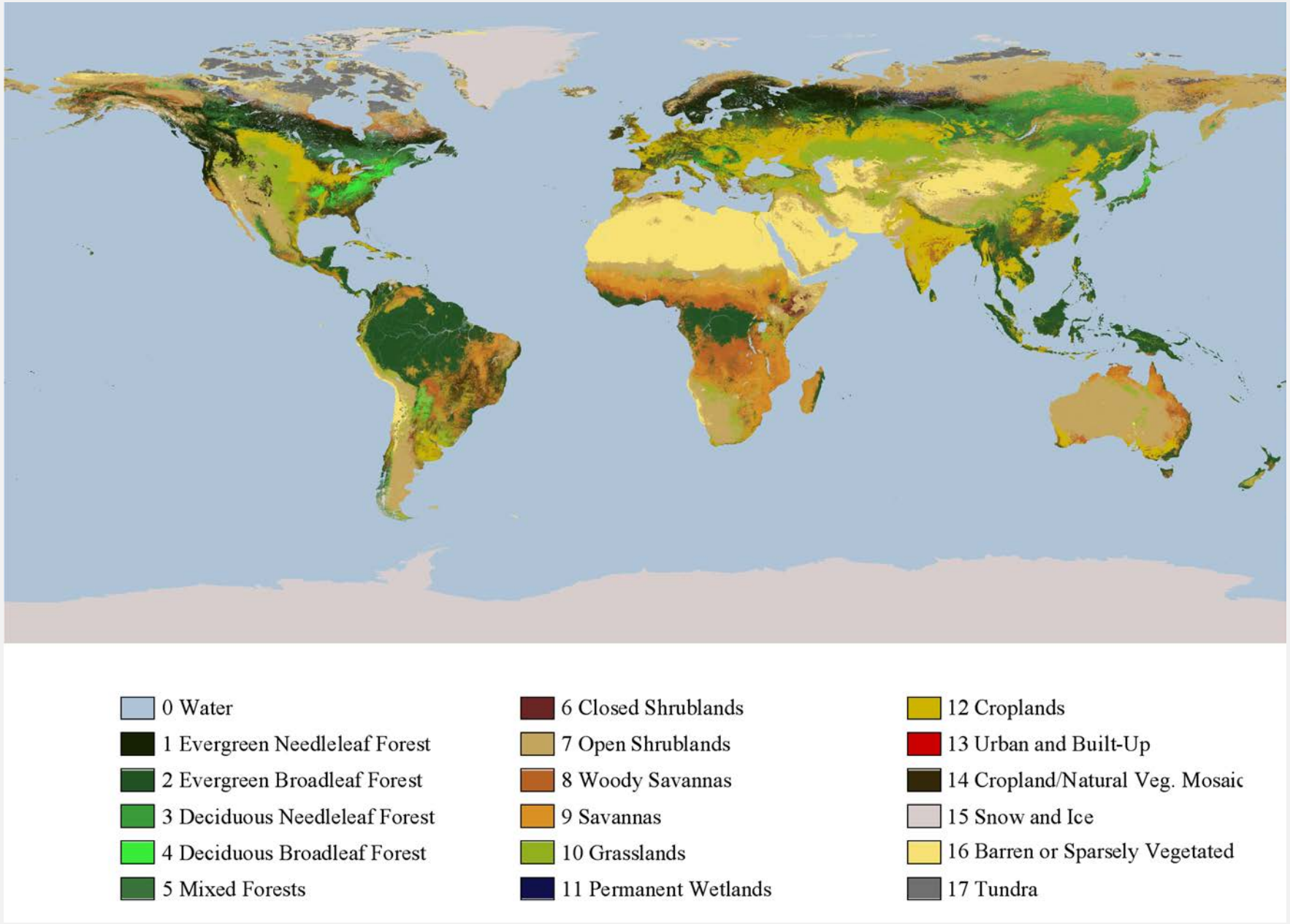
- Launched in 2010
- Spatial resolution 30 meters
- 10 land cover classes
- For years 2000 and 2010
- http://www.globallandcover.com/GLC30Download/index.aspx

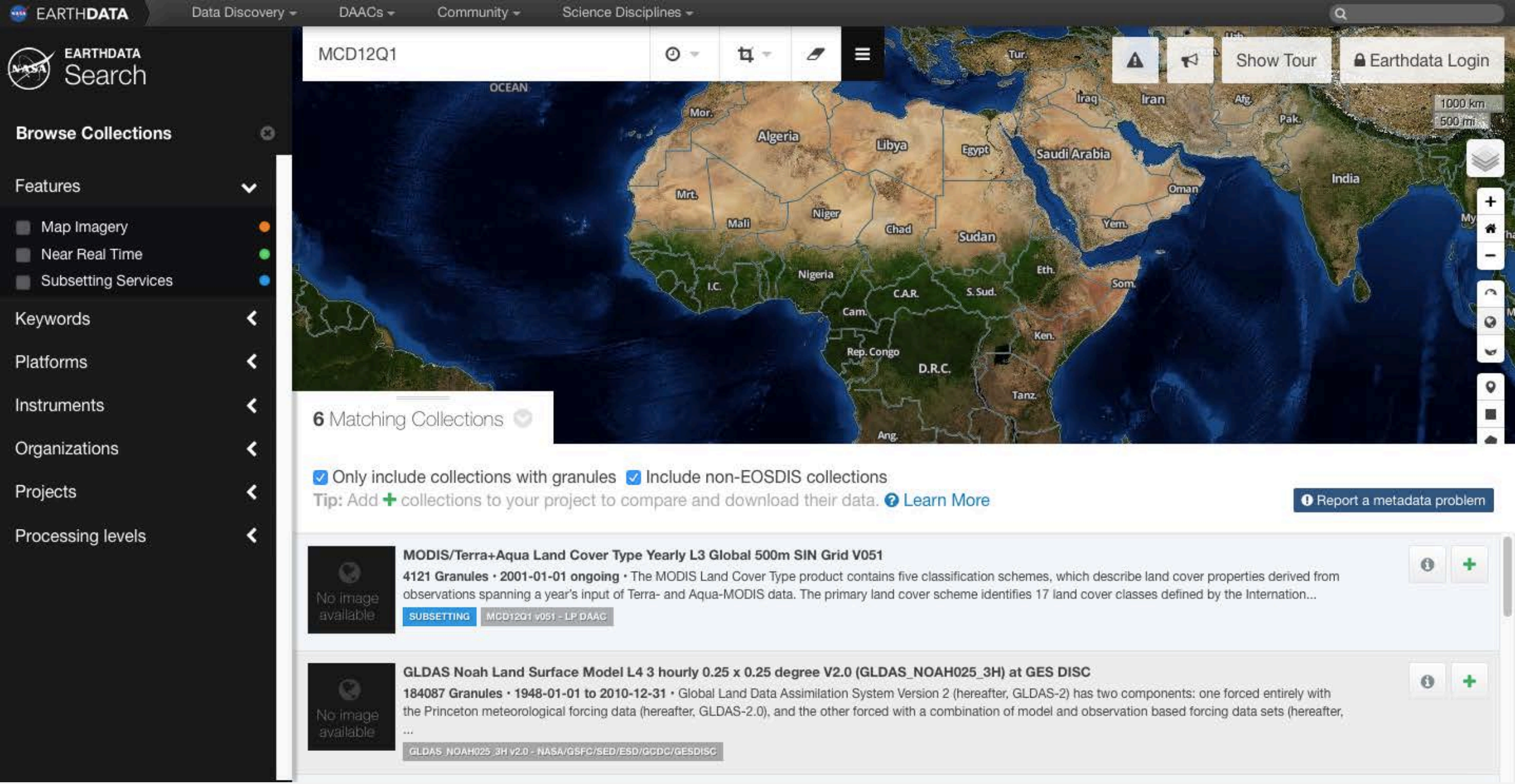


MODIS Land Cover (MCD12Q1)



- Contains five classification schemes
  - Identifies 17 land cover classes identified by the International Geosphere Biosphere Programme, which includes 11 natural vegetation classes, 3 developed and mosaicked land classes, and 3 non-vegetated land classes
- Spatial Resolution: 500 meters
- Temporal Coverage: 2001-2013 annually
- *Note:* MODIS Version 5 processing has ended so years after 2013 will not be processed. The new suite of Version 6 land cover products are *expected* to be complete by end of 2017.
- Download data from NASA's Earthdata: http://search.earthdata.nasa.gov

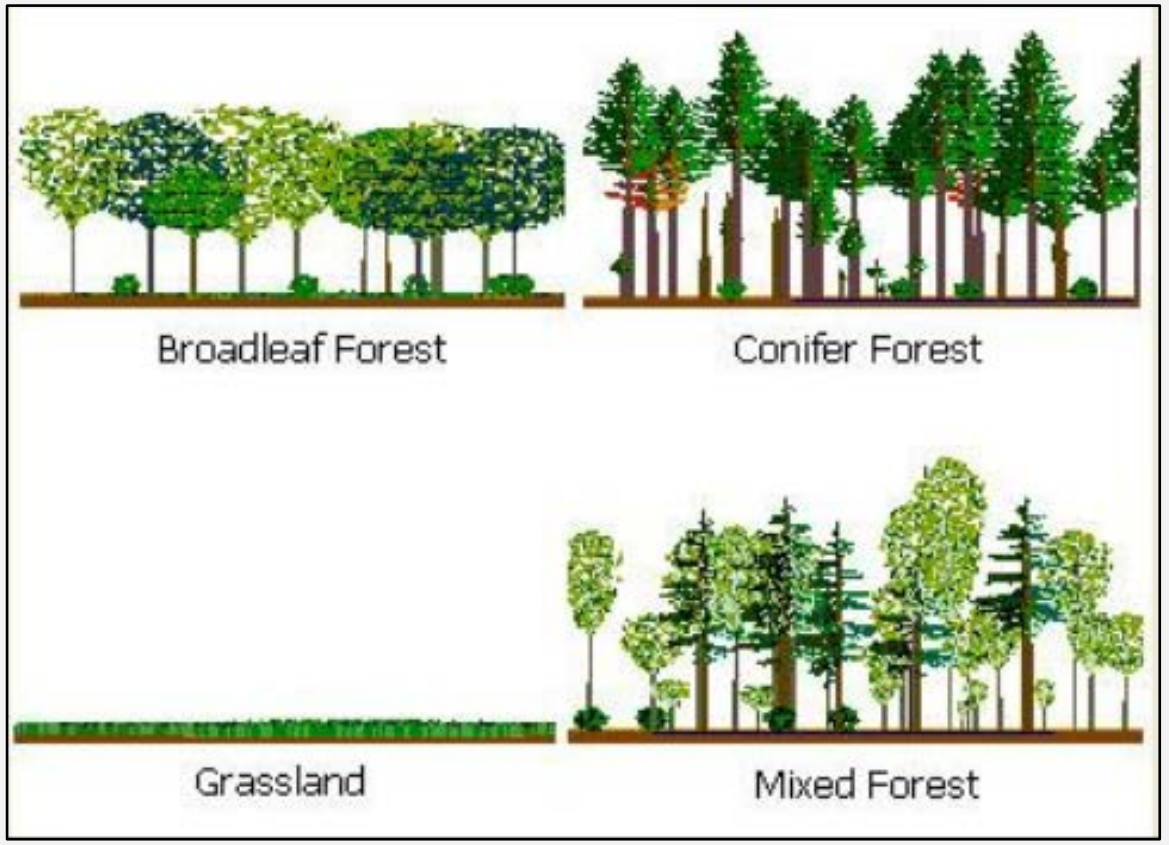

0 Water
1 Evergreen Needleleaf Forest
2 Evergreen Broadleaf Forest
3 Deciduous Needleleaf Forest
4 Deciduous Broadleaf Forest
5 Mixed Forests
6 Closed Shrublands
7 Open Shrublands
8 Woody Savannas
9 Savannas
10 Grasslands
11 Permanent Wetlands
12 Croplands
13 Urban and Built-Up
14 Cropland/Natural Veg. Mosaic
15 Snow and Ice
16 Barren or Sparsely Vegetated
17 Tundra


EARTHDATA
Data Discovery
DAACs
Community
Science Disciplines
EARTHDATA Search
MCD12Q1
Show Tour
Earthdata Login
Browse Collections
Features
Map Imagery
Near Real Time
Subsetting Services
Keywords
Platforms
Instruments
Organizations
Projects
Processing levels
OCEAN
Mor.
Algeria
Libya
Egypt
Saudi Arabia
Iraq
Iran
Afg.
Pak.
India
Oman
Yem.
Mrt.
Mali
Niger
Chad
Sudan
Nigeria
I.C.
C.A.R.
S.Sud.
Eth.
Som.
Cam.
Ken.
Rep. Congo
D.R.C.
Tanz.
Ang.
1000 km
500 mi
6 Matching Collections
Only include collections with granules
Include non-EOSDIS collections
Tip: Add + collections to your project to compare and download their data.
Learn More
Report a metadata problem
No image available
MODIS/Terra+Aqua Land Cover Type Yearly L3 Global 500m SIN Grid V051
4121 Granules · 2001-01-01 ongoing · The MODIS Land Cover Type product contains five classification schemes, which describe land cover properties derived from observations spanning a year's input of Terra- and Aqua-MODIS data. The primary land cover scheme identifies 17 land cover classes defined by the Internation...
SUBSETTING
MCD12Q1 v051 - LP DAAC
No image available
GLDAS Noah Land Surface Model L4 3 hourly 0.25 x 0.25 degree V2.0 (GLDAS_NOAH025_3H) at GES DISC
184087 Granules · 1948-01-01 to 2010-12-31 · Global Land Data Assimilation System Version 2 (hereafter, GLDAS-2) has two components: one forced entirely with the Princeton meteorological forcing data (hereafter, GLDAS-2.0), and the other forced with a combination of model and observation based forcing data sets (hereafter, ...
GLDAS_NOAH025_3H v2.0 - NASA/GSFC/SED/ESD/GCDC/GESDISC

Land Cover Classification from Satellite Imagery

Classification Scheme

- The schema is used to categorize and label land cover
- A well designed classification scheme is critical to deriving useful information
- Rules:
  - Must be exhaustive: all land cover in image must be included
  - Must be mutually exclusive: no overlap between classes
  - Must be based on what can be interpreted in the imagery



Classification Scheme

More Considerations

- Schemes should be:
  - Hierarchical
    - Forest
      - Hardwood
      - Softwood
  - Based on measurable land cover characteristics
    - Size class, percent canopy cover, etc.
- Avoid subjective, interpretive classes, such as “old growth”

Classification Scheme: Example

- Water
- Non-Vegetated: <20% vegetated
- Rangeland: <10% tree crown closure
- Forest: >10% tree crown closure (CC)
  - Hardwood: 65% hardwood trees
    - sparse (10% to <30% CC)
    - medium density (30% to <66% CC)
    - dense (66% CC)
  - Softwood: 65% softwood trees
    - sparse (10% to <30% CC)
    - medium density (30% to <66% CC)
    - dense (66% CC)
- Other

Classification Schemes

Classification Schemes	Purpose	Description	Minimum Mapping Unit	Temporal Product Frequency
Forest/Non-Forest	Trend analysis, basis for other products	Extent of all forest types	< 0.5 ha	Annual
Forest Stratification	Provide consistency in biomass density with a stratum for more accurate estimates	Suggested primary stratification: primary forest, modified natural forest, planted forest	< 0.5 ha	Annual
All Land Use Categories	National baseline mapping	For example, the UN-FAO Land Cover Classification System	< 0.5 ha	Annual

Turning Data Into Information

Spectral vs. Informational Classes

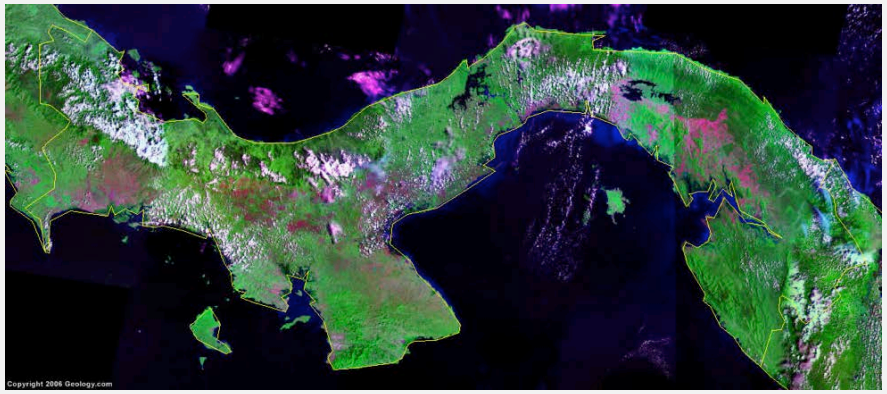
Spectral Classes

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

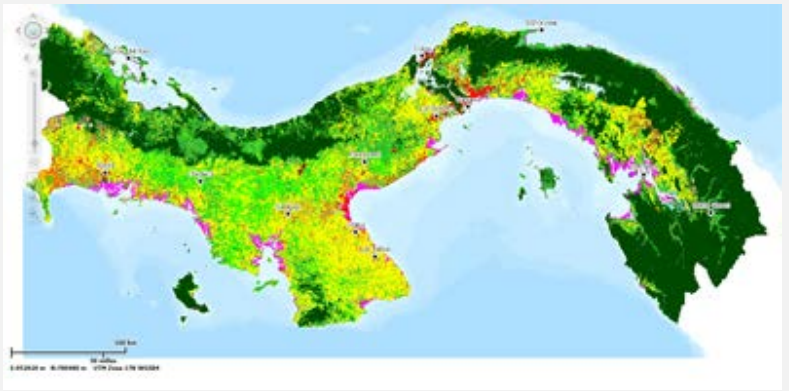
Informational Classes

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

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



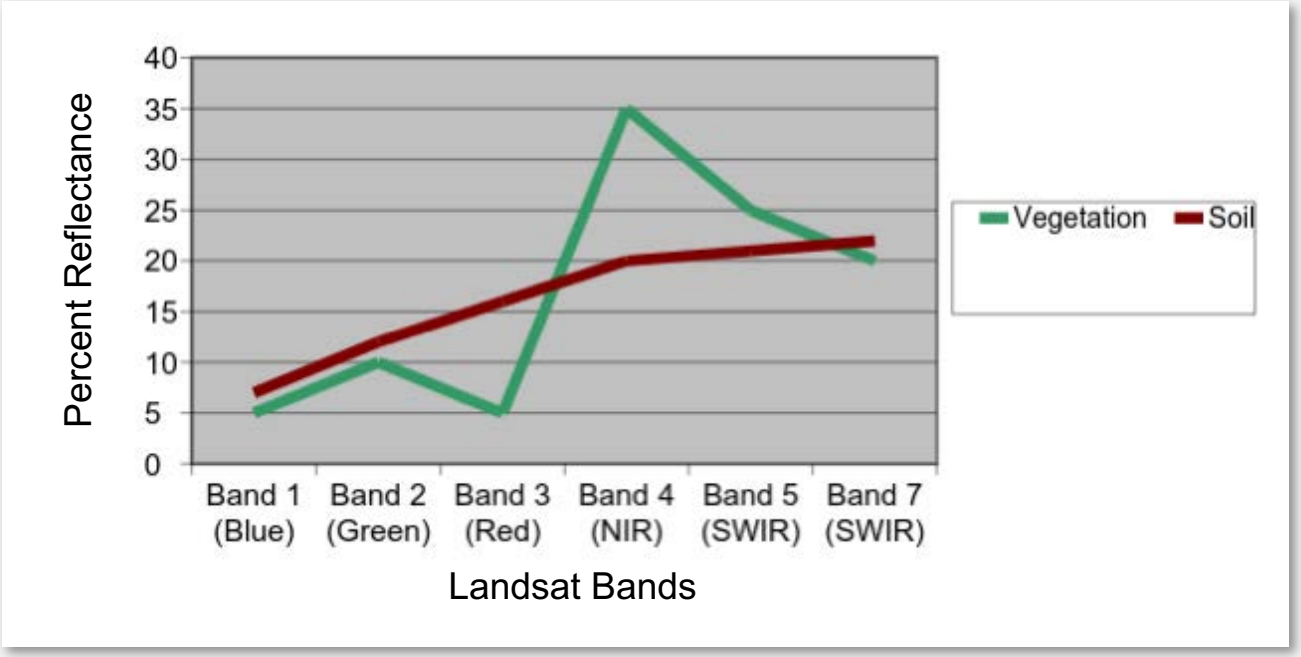
Satellite image of Panama



Land cover map of Panama

Land Cover Mapping Basics

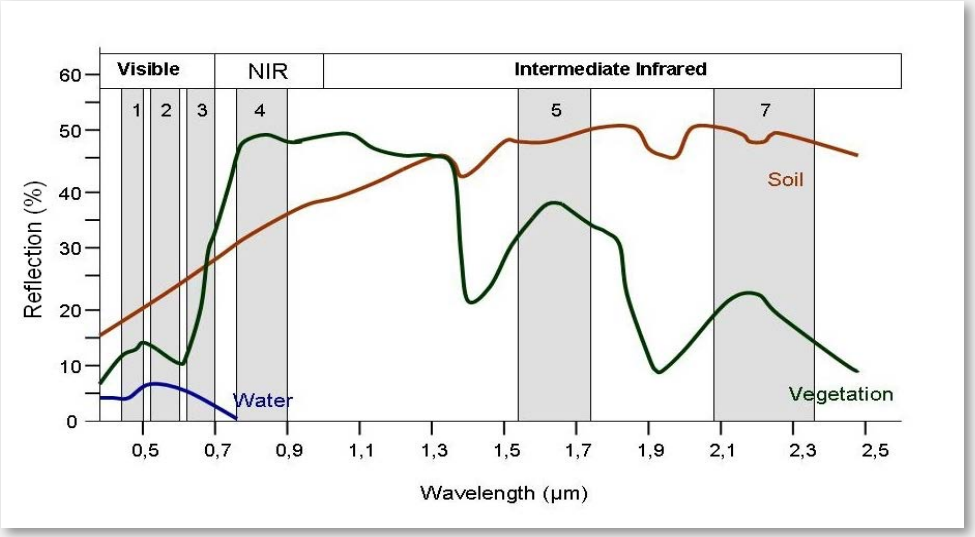
- Remember that objects on the ground reflect electromagnetic radiation differently in different wavelengths
- That is called the object's **spectral signature**
- Example: Green vegetation absorbs Red wavelengths but reflects NIR wavelengths



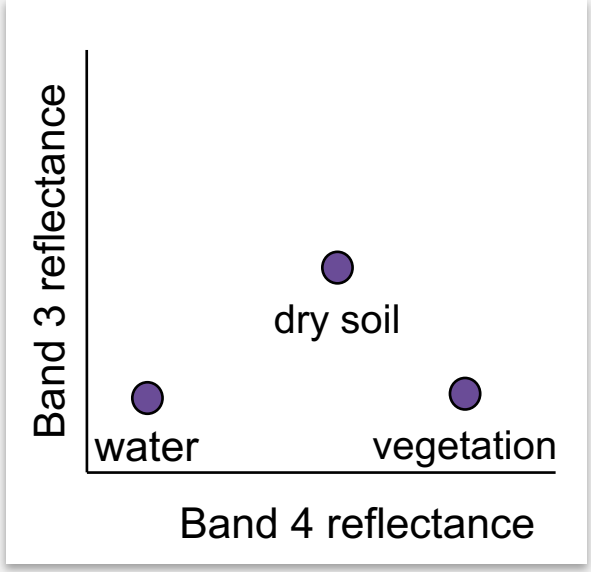
Land Cover Mapping Basics

Spectral Plots

- Look at spectral signatures by plotting Band 3 (Red) vs. Band 4 (NIR) reflectance values

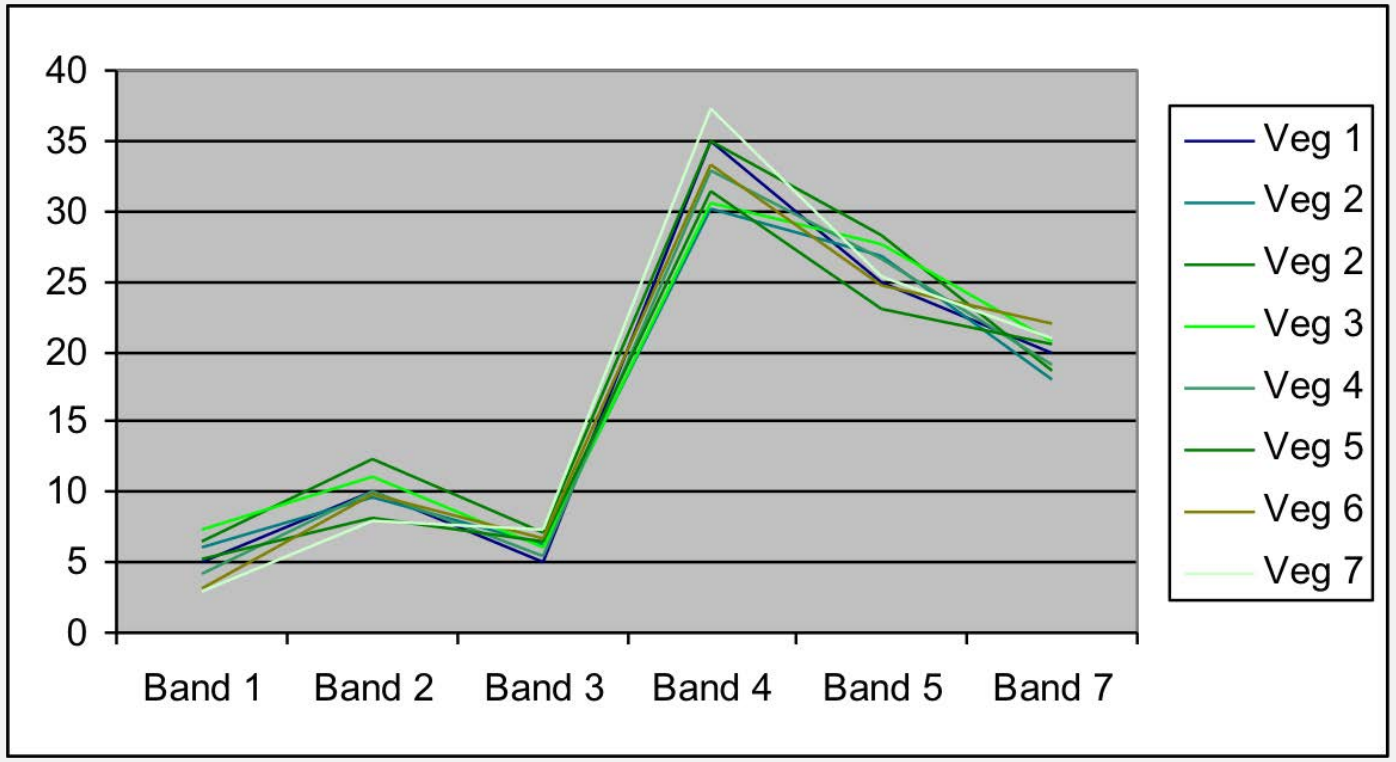


- Objects (soil, water, and vegetation) fall in different places in the plot
- The software uses this to distinguish between different land cover types



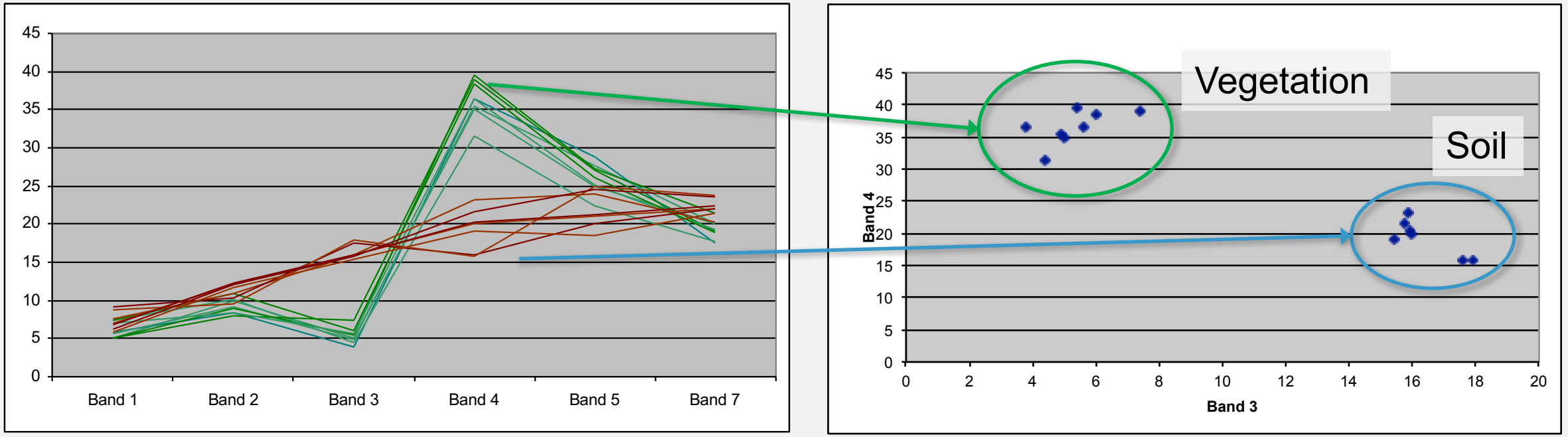
Spectral Signatures

- 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

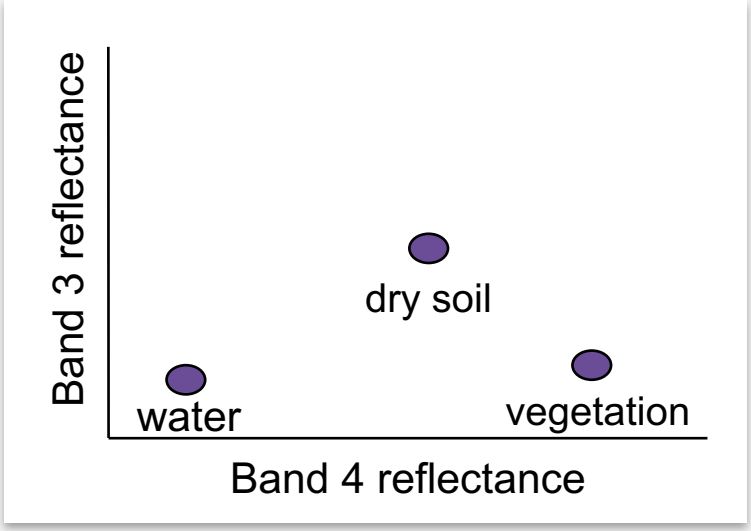
- Easier: distinguishing between broad classes (e.g. vegetation and soil)
- Harder: distinguishing *within* broad classes (e.g. vegetation types)
- Variation within and between type (broad classes) is below



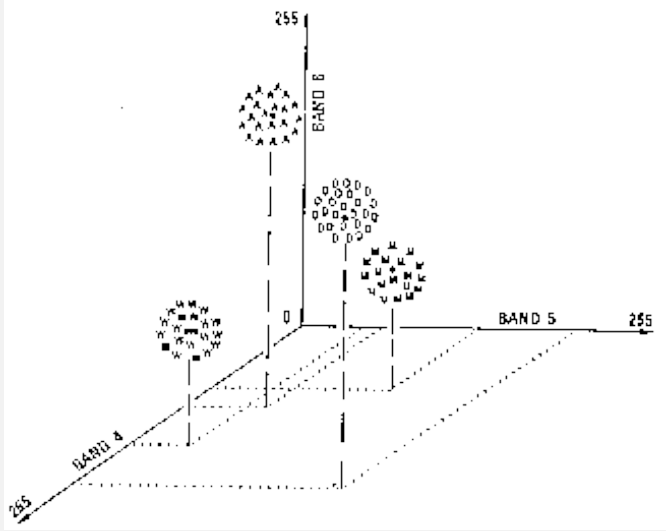
Multi-Dimensional Spectral Plots

To make things even more confusing…

- When looking at spectral plots, each band represents a different dimension
- 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 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

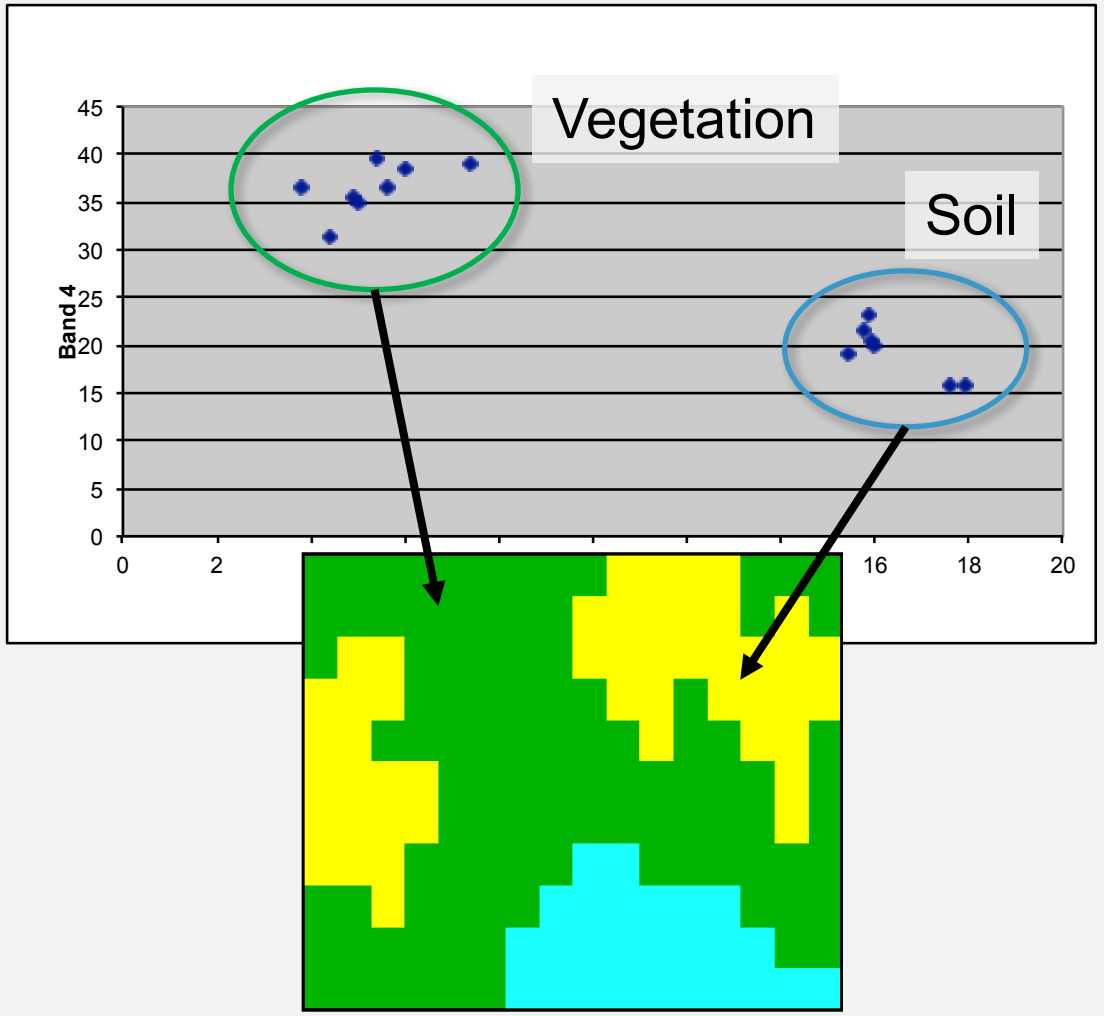
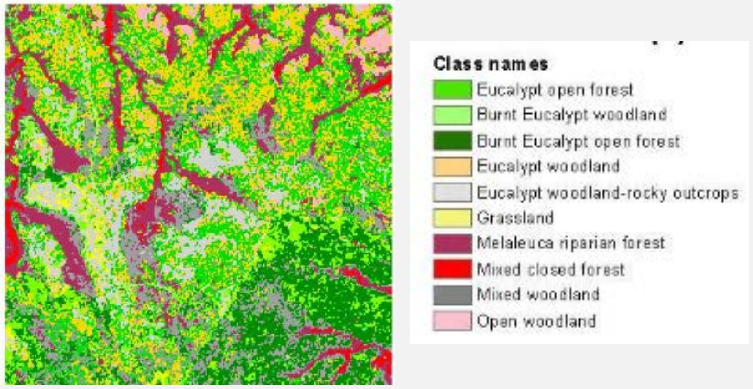


Image Classification

Approaches

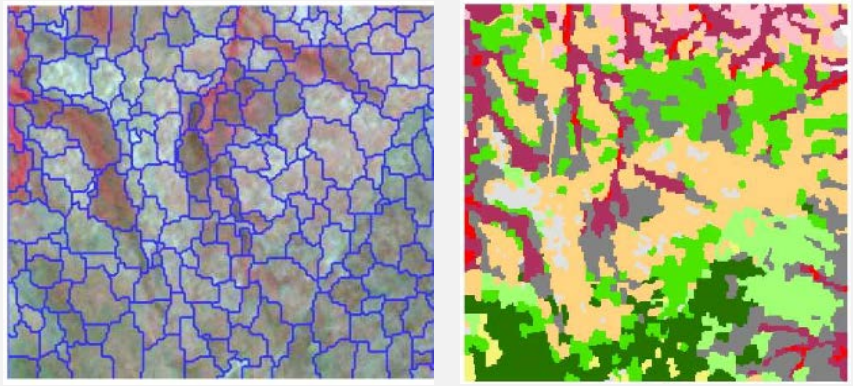
Pixel-Based

- 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

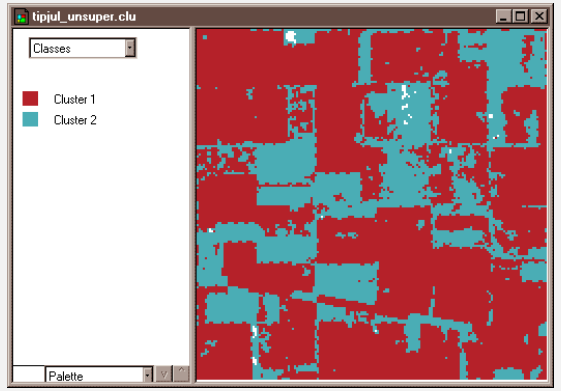
Methods

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

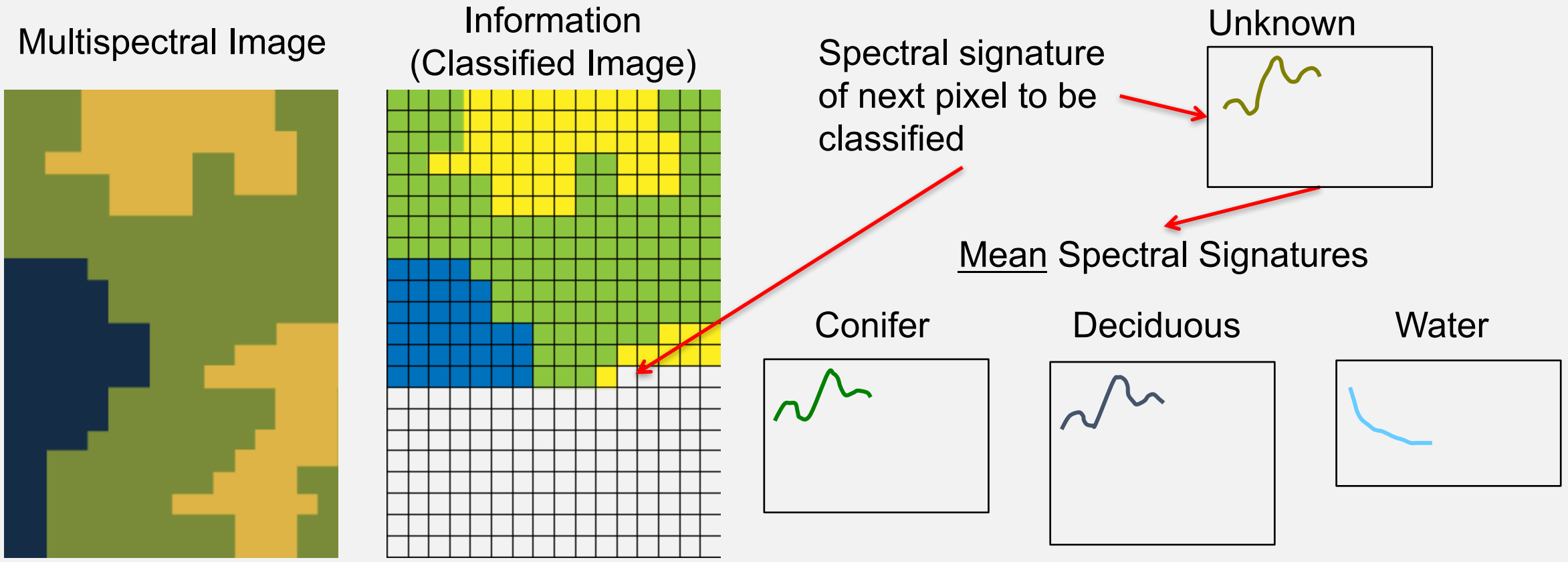


Credit: David DiBiase, Penn State Department of Geography

Image Classification

Supervised Method

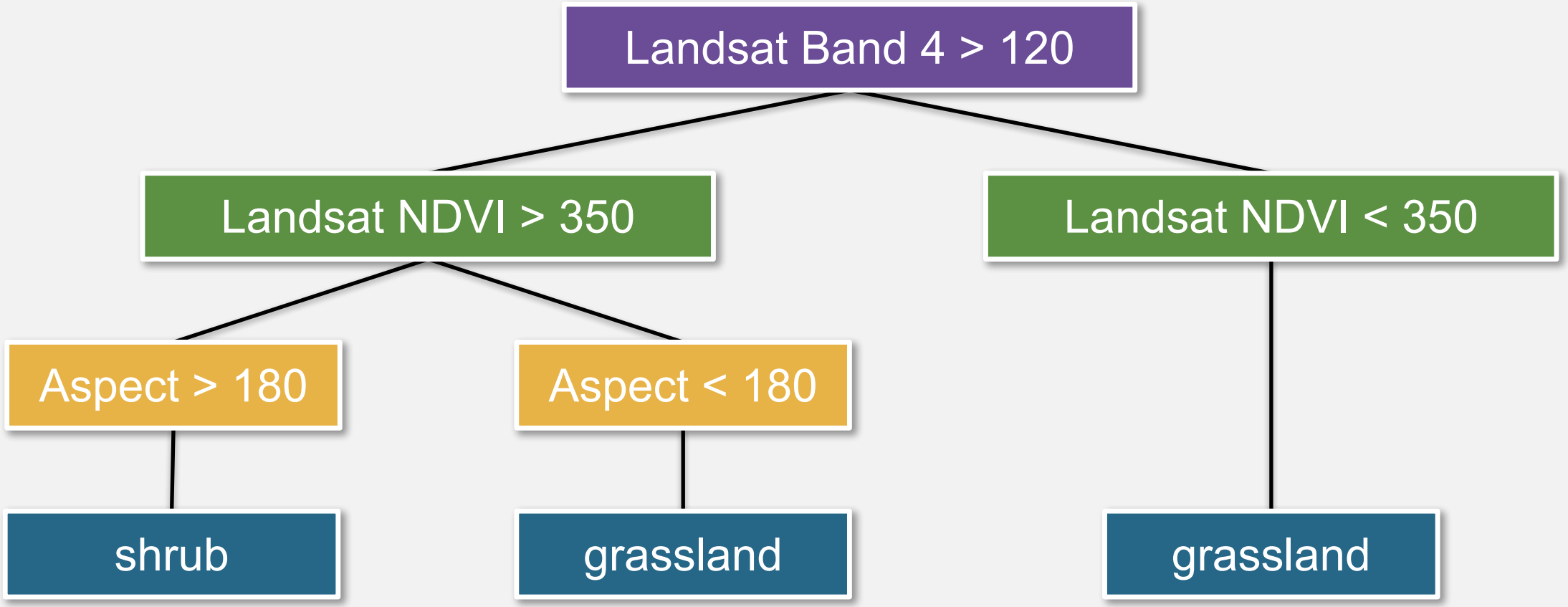
The spectral signature of each pixel in the image gets matched with the training signatures and the image is classified accordingly



Classification Methods

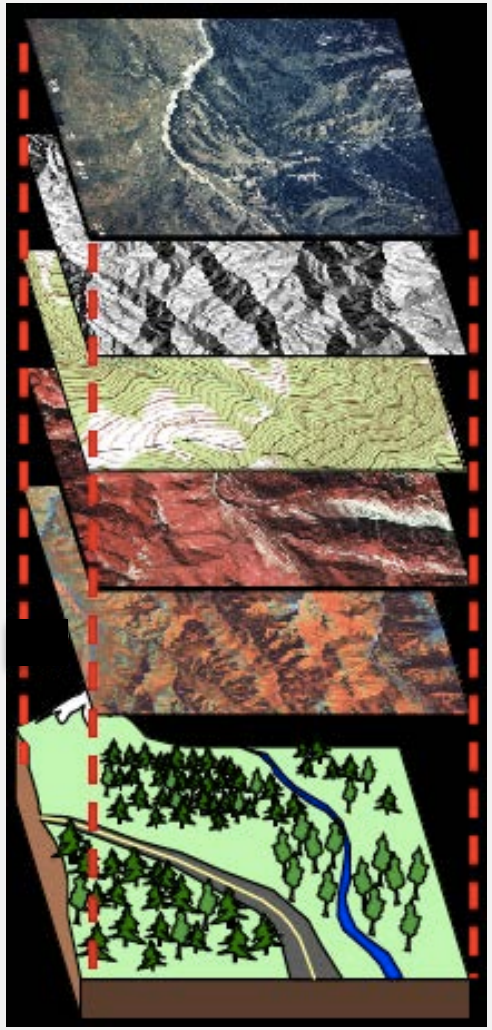
- **Classification Algorithms**: classifies the whole image by comparing the spectral characteristics of each pixel to the spectral characteristics of the training sites
  - Example: QGIS, Semi-Automated Classification Plugin has three: minimum distance, maximum likelihood, and spectral angle mapping
- **Decision Tree** (Classification and Regression Tree or CART): uses training data to develop a tree-like set of rules to determine the class for certain combinations of input data
  - Then every pixel is labeled with a class utilizing the decision rules of the classification tree
- **Random Forest**: Creates many decision trees based on predictor variables

Decision Tree Using Landsat bands, NDVI and Digital Elevation Model Data



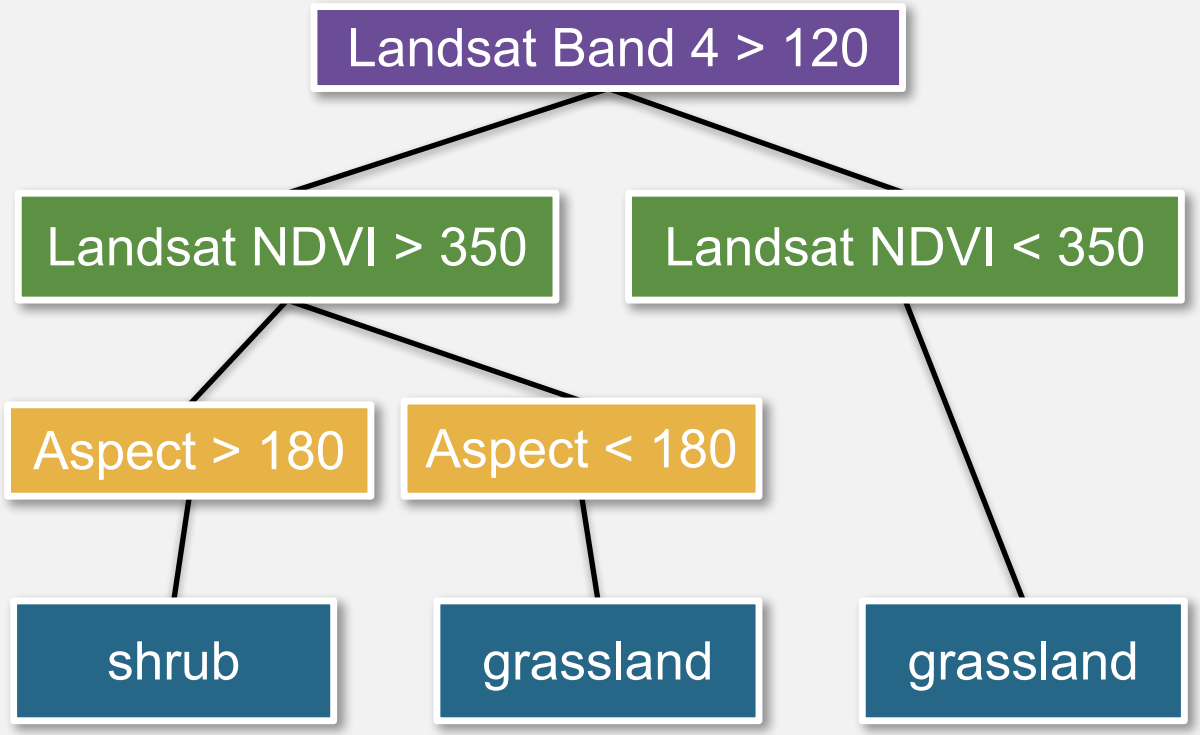
Random Forest Inputs

- Training or reference data for each class
- Predictor variables such as:
  - Multispectral image bands
  - Topographic variables: slope, elevation, aspect
  - Bioclimatic variables: temperature, precipitation, etc.
- Derived predictor variables such as:
  - NDVI
  - Other transformations (tasseled cap, etc.)



Random Forest Classification

- Random input variables are selected and used on the training data to make trees
- The image on the right is an example of one decision tree. Hundreds are created randomly using the training and reference data and built for your various classes.
- The decision trees, or random forest model, are used to classify the whole image



Summary

- Indicator 15.1.1: Forest area as a proportion of total land area
- Satellite imagery can be used to derive forest area in several ways
  - Existing forest maps (e.g. Global Forest Watch)
  - Existing land cover maps (e.g. ESA Climate Change Initiative Land Cover)
  - Create your own land cover map

MODIS and GFW Demo

Contacts

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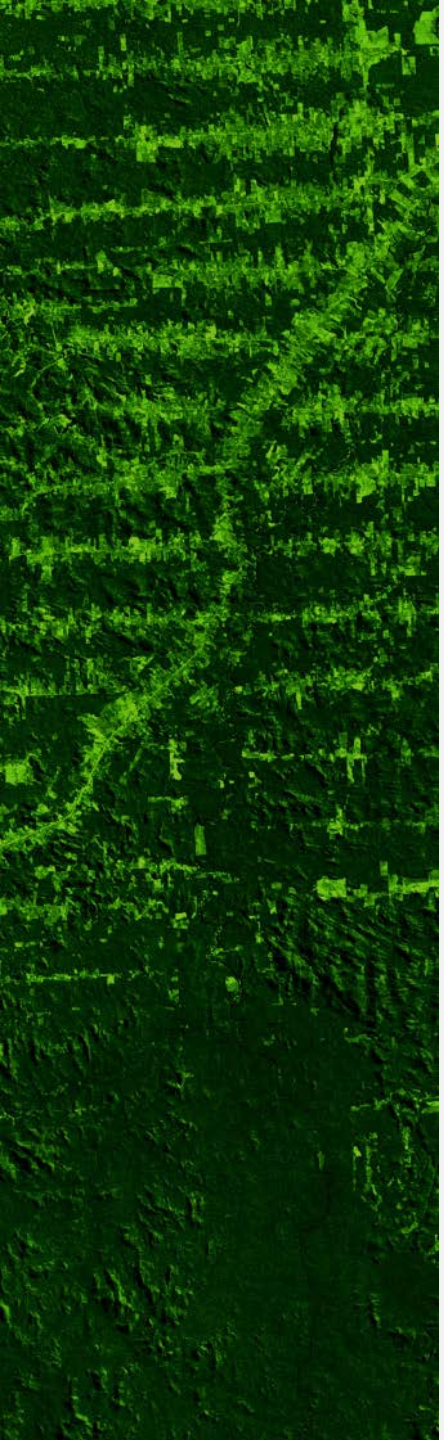
  - http://arset.gsfc.nasa.gov



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Thank You

Next Session (tomorrow):

SDG Target 15.3