

## ARSET

Applied Remote Sensing Training

<http://arset.gsfc.nasa.gov>

 @NASAARSET

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

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Instructors: Cindy Schmidt and Amber McCullum

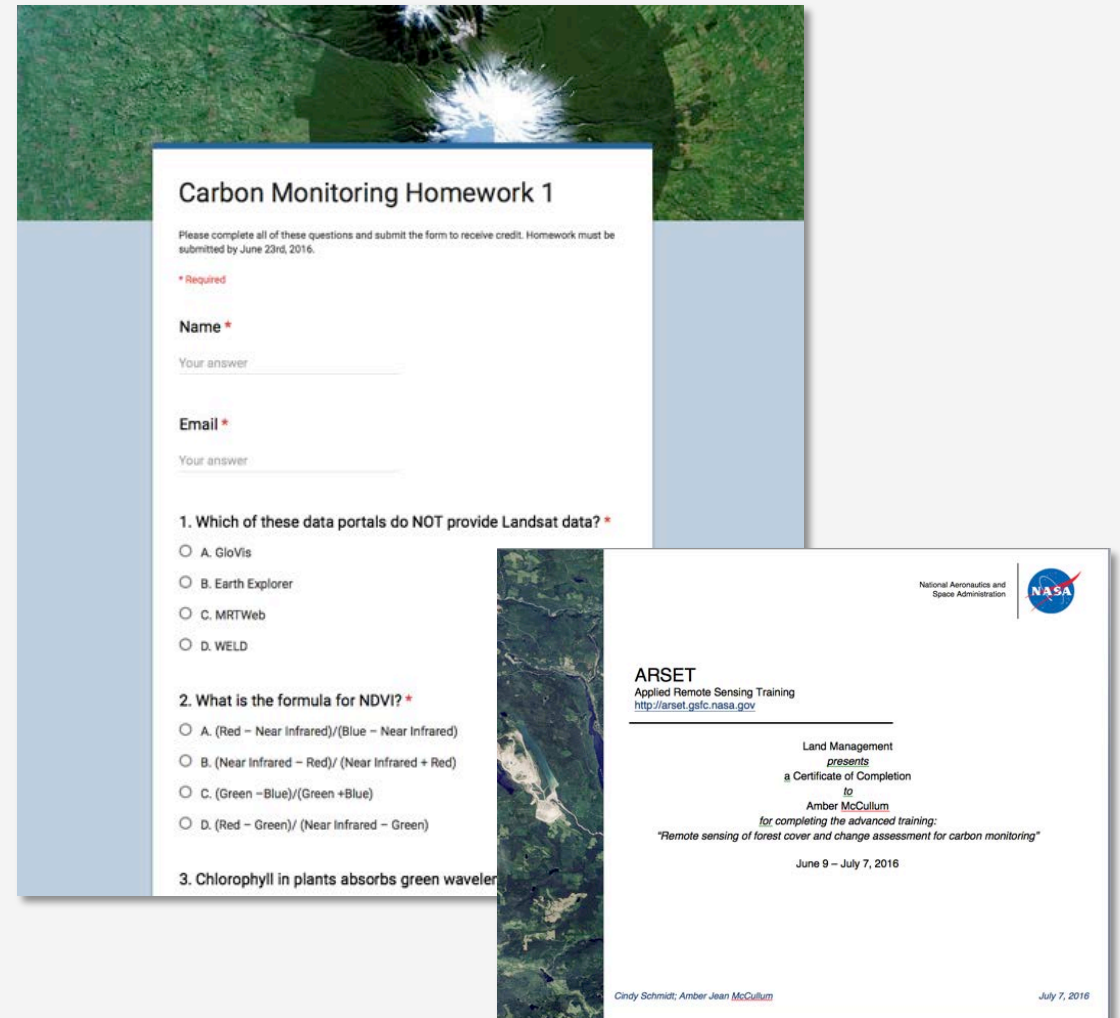
Session 3: June 22, 2017

# 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](mailto:cynthia.l.schmidt@nasa.gov), or
    - [amberjean.mccullum@nasa.gov](mailto:amberjean.mccullum@nasa.gov)

# Homework and Certificates

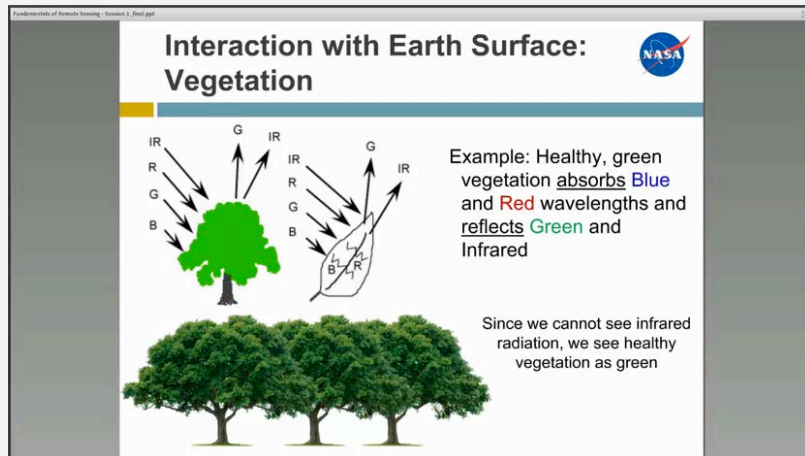
- Homework
  - Answers must be submitted via Google Form
- Certificate of Completion:
  - Attend all 3 webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
    - HW Deadline: July 6<sup>th</sup>
  - You will receive certificates approx. two months after the completion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



The image displays two documents related to the ARSET training program. The top document is a Google Form titled "Carbon Monitoring Homework 1". It includes instructions to complete all questions and submit by June 23rd, 2016. The form contains fields for "Name" and "Email", both marked as required. Below these are three multiple-choice questions: 1. Which of these data portals do NOT provide Landsat data? (Options: A. GloVis, B. Earth Explorer, C. MRTWeb, D. WELD); 2. What is the formula for NDVI? (Options: A. (Red - Near Infrared)/(Blue - Near Infrared), B. (Near Infrared - Red)/(Near Infrared + Red), C. (Green - Blue)/(Green + Blue), D. (Red - Green)/(Near Infrared - Green)); 3. Chlorophyll in plants absorbs green waveler. The bottom document is a Certificate of Completion from ARSET (Applied Remote Sensing Training) presented to Amber McCullum for completing advanced training in remote sensing of forest cover and change assessment for carbon monitoring, dated June 9 - July 7, 2016. The certificate is signed by Cindy Schmidt and Amber Jean McCullum.

# Prerequisite

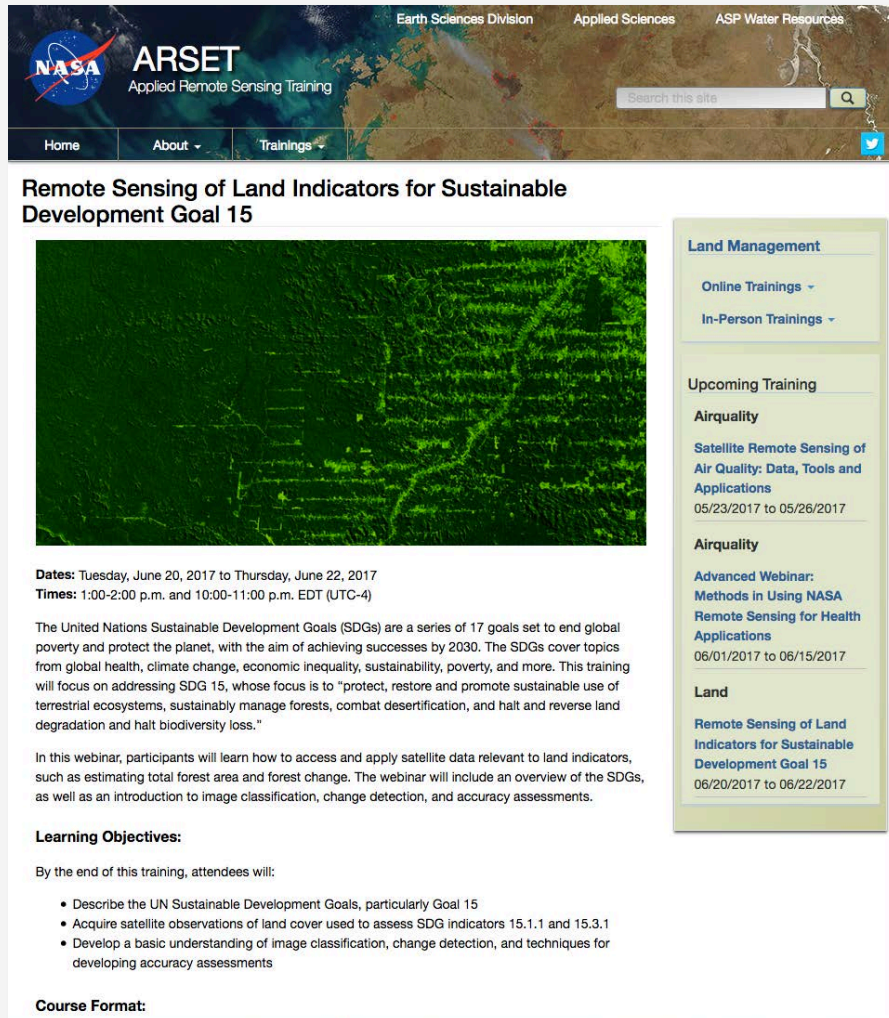
- Fundamentals of Remote Sensing
  - Sessions 1 and 2A (Land)
  - On demand webinar, available anytime
  - <http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing>



The screenshot shows the NASA ARSET website. The top navigation bar includes 'Home', 'About', and 'Trainings'. A search bar is located on the right. A dropdown menu is open under 'Trainings', with 'Fundamentals' selected. Below the menu, a large banner features a satellite image of Earth and text for an 'Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications'. The webinar is scheduled for Thursdays, June 1-15, 2017, at 10 a.m. or 3 p.m. EDT (UTC-4). A 'Register Now' button is present. The right sidebar contains sections for 'ARSET' (Webinars, Workshops, Suggest a Training, Personnel, Resources) and 'Upcoming Training' (Airquality, Satellite Remote Sensing of Air Quality: Data, Tools and Applications, Airquality, Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications, Land, Remote Sensing of Land).

# Accessing Course Materials

- <http://arset.gsfc.nasa.gov/land/webinars/sdg15/>



**Remote Sensing of Land Indicators for Sustainable Development Goal 15**

**Dates:** Tuesday, June 20, 2017 to Thursday, June 22, 2017  
**Times:** 1:00-2:00 p.m. and 10:00-11:00 p.m. EDT (UTC-4)

The United Nations Sustainable Development Goals (SDGs) are a series of 17 goals set to end global poverty and protect the planet, with the aim of achieving successes by 2030. The SDGs cover topics from global health, climate change, economic inequality, sustainability, poverty, and more. This training will focus on addressing SDG 15, whose focus is to "protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss."

In this webinar, participants will learn how to access and apply satellite data relevant to land indicators, such as estimating total forest area and forest change. The webinar will include an overview of the SDGs, as well as an introduction to image classification, change detection, and accuracy assessments.

**Learning Objectives:**

By the end of this training, attendees will:

- Describe the UN Sustainable Development Goals, particularly Goal 15
- Acquire satellite observations of land cover used to assess SDG indicators 15.1.1 and 15.3.1
- Develop a basic understanding of image classification, change detection, and techniques for developing accuracy assessments

**Course Format:**

## Audience:

Regional, state, federal, and international organizations interested in addressing monitoring requirements for the SDGs through the use of remote sensing. 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. Space is limited, and preference will be given to organizations listed above over organizations focused primarily on research. You will be notified by email if your registration has been approved on or before June 16, 2017. Please register for **only one session**.

- [Register for Session A, 1:00 - 2:00 p.m. EDT \(UTC-4\)](#) »
- [Register for Session B, 10:00 - 11:00 p.m. EDT \(UTC-4\)](#) »

## Course Agenda:

[Agenda.pdf](#)

## Session One: Overview of SDG 15

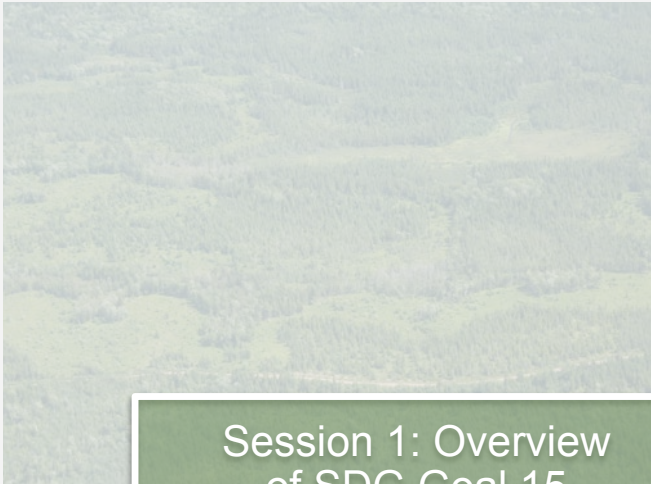
June 20, 2017

- [Presentation Slides \(English\)](#) »
- [Presentation Slides \(Spanish\)](#) »
- [View the recording](#) »

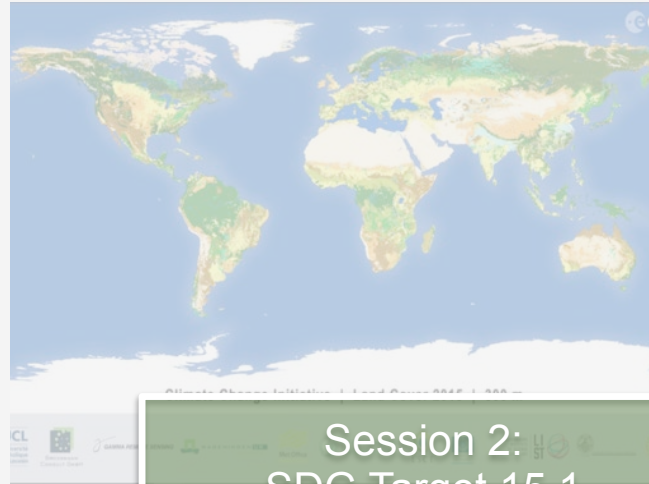
- Introduction to the Sustainable Goals Framework
  - Overview of SDG 15
  - International Institute for Sustainable Development's (IISD's) SDG Knowledge Hub
  - Group on Earth Observations (GEO) and the SDGs
- State of the World's Forests
- Introduction to the role of land-based remote sensing for targets and indicators
- Remote sensing data sources for assessment of land cover
  - Landsat
  - MODIS
  - VIIRS
  - Sentinel

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

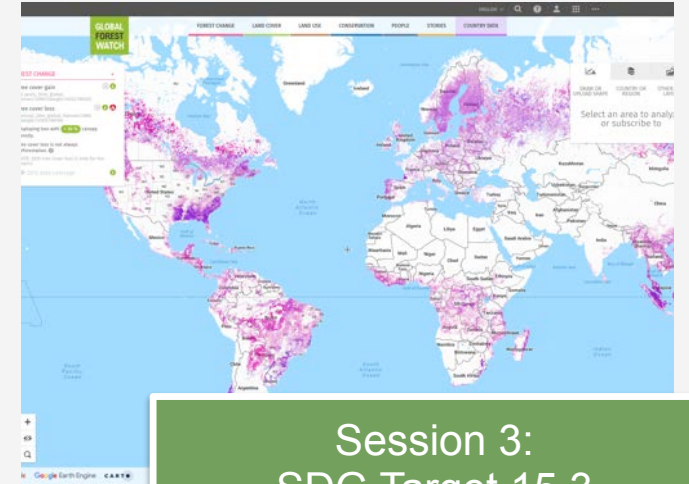
# Course Outline



Session 1: Overview  
of SDG Goal 15



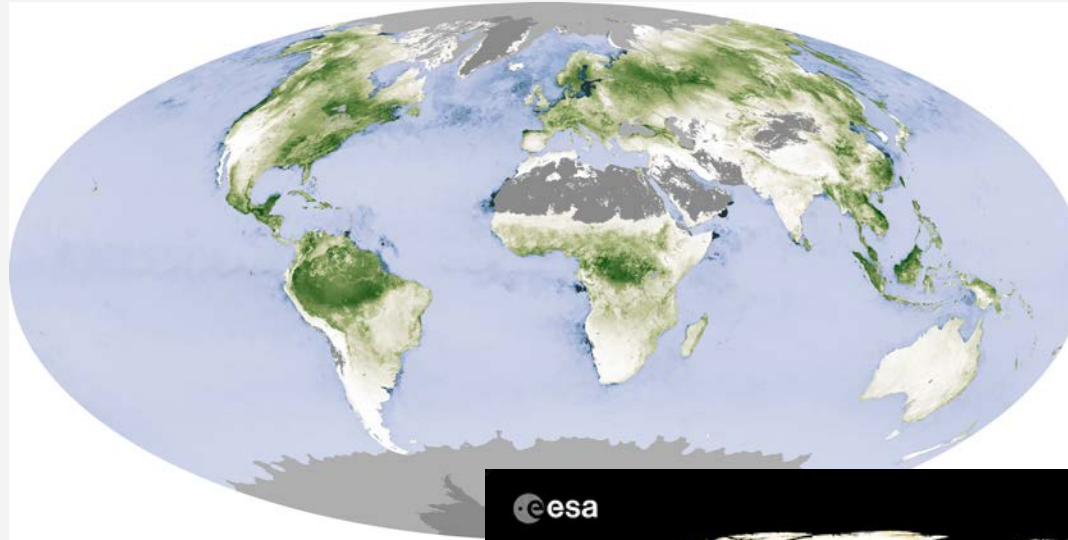
Session 2:  
SDG Target 15.1



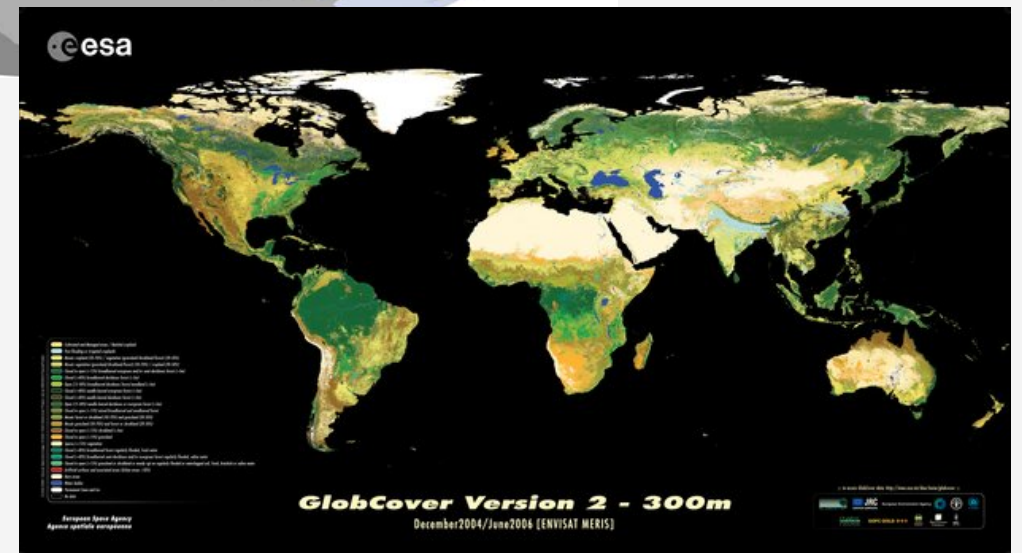
Session 3:  
SDG Target 15.3

## Session 3 Agenda

- Overview of Target 15.3 and Indicator 15.3.1
- Vegetation definitions relevant to land productivity and health
- Global satellite-derived vegetation products
- Land cover change detection methods with satellite imagery



Net Primary Productivity (NPP) from MODIS in 2009 (Earth Observatory) (Top); Global land cover map, 2008 via ESA (right).



Target 15.3

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## SDG: Target 15.3

- Target 15.3: By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
  - Indicator 15.3.1: Proportion of land that is degraded over total land area

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“Land degradation is the reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes arising from human activities.”

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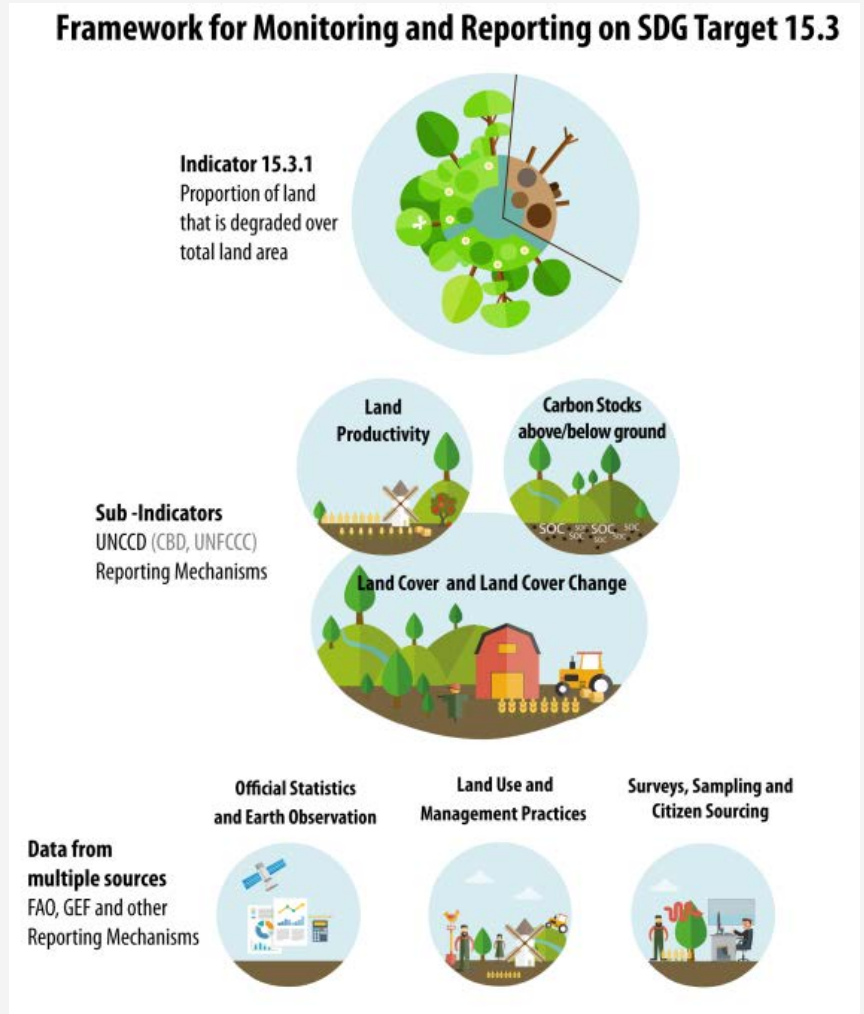
*Elaboration of an international convention to combat desertification in countries experiencing serious drought and/or desertification, particularly in Africa* (1994, September 12).  
<http://www.unccd.int/Lists/SiteDocumentLibrary/conventionText/conv-eng.pdf>

# Indicator 15.3.1

## Sub-indicators

- Land cover and land cover change
- Land productivity
- Carbon stocks above and below ground
- A combination of satellite Earth observations and site-based data will be needed to
  - set baselines to determine the initial status of the sub-indicators
  - detect change in each of the sub-indicators
  - derive the indicator by determining what areas of change are considered land degradation

Framework and Guiding Principles for a Land Degradation Indicator, United Nations Convention to Combat Desertification



# United Nations Convention to Combat Desertification

<http://www2.unccd.int/>

- Focus on Target 15.3 in effort for land degradation neutrality
  - <http://www2.unccd.int/land-degradation-neutrality>
- Links environment and development to sustainable land management
- Specifically addresses arid, semi-arid, and dryland ecosystems
- Works to:
  - improve living conditions in drylands
  - maintain and restore land & soil productivity
  - mitigate drought
  - combat desertification and land degradation

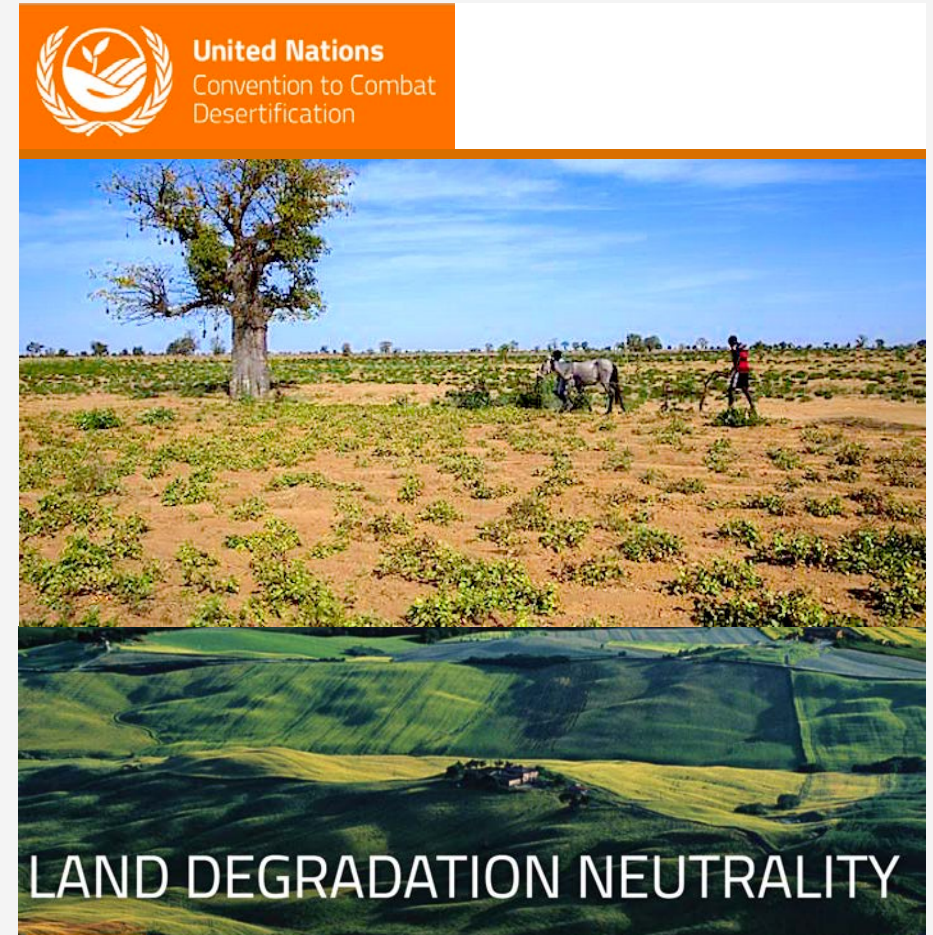


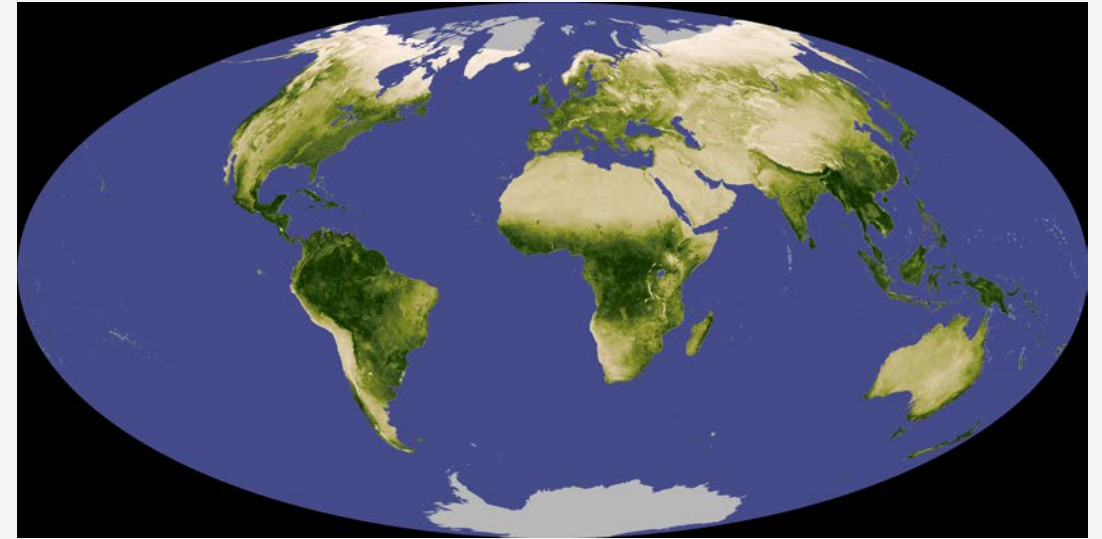
Image Credit: (Top) BBC (Bottom) UN Convention to Combat Desertification

# Vegetation Definitions

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# Land Productivity

- For plants, productivity, or primary production is the production of chemical energy in organic compounds by living organisms, usually through photosynthesis
- Reflects the net effects of changes in ecosystem functioning on plant and biomass growth
- Can be monitored by Earth Observation proxies of above-ground net primary productivity (NPP) such as:
  - Spectral Indices (e.g. NDVI)
  - Biophysical retrievals (e.g. fraction of absorbed photosynthetically active radiation, fAPAR)



MODIS NDVI

# Vegetation Definitions: Carbon Pools and Fluxes

- **Gross Primary Productivity (GPP)**: total of all carbon fixed through photosynthesis
- **Autotrophic Respiration ( $R_A$ )**: the carbon that a plant uses and loses in the process of constructing and maintaining its biomass (above & below ground)
- **Heterotrophic Respiration ( $R_H$ )**: carbon that is released to the atmosphere by consumers or decomposers that are breaking down organic matter (OM)
- **Net Primary Productivity (NPP)**: the amount of carbon uptake after subtracting plant respiration from GPP

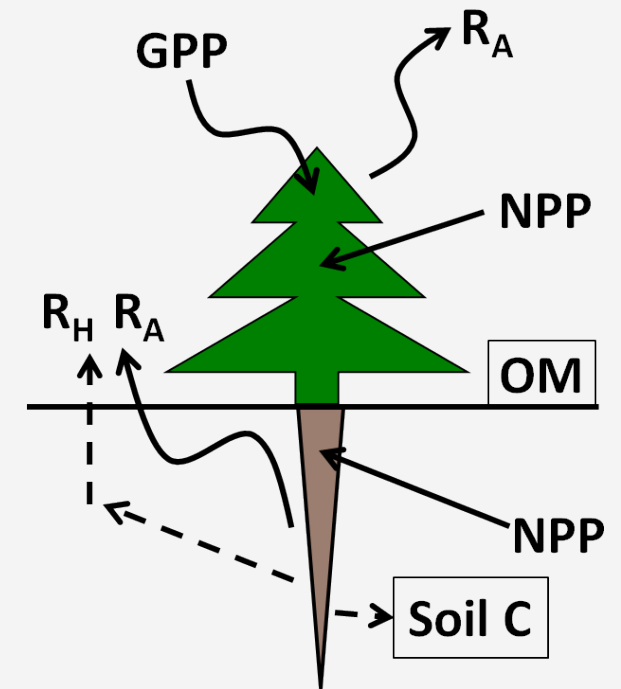
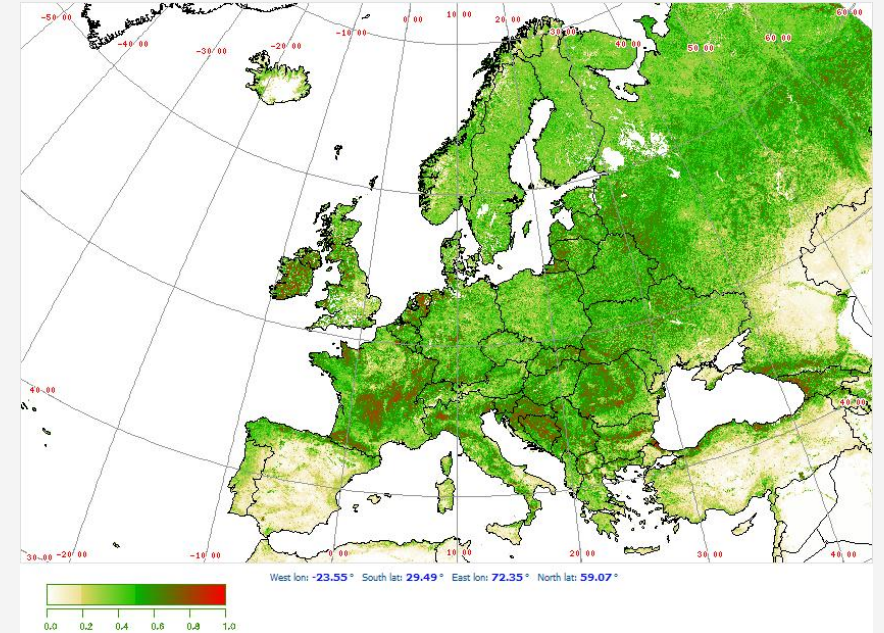


Image Credit: [Silviculture and Applied Forest Ecology](#) at Stephen F. Austin State University

## More Definitions

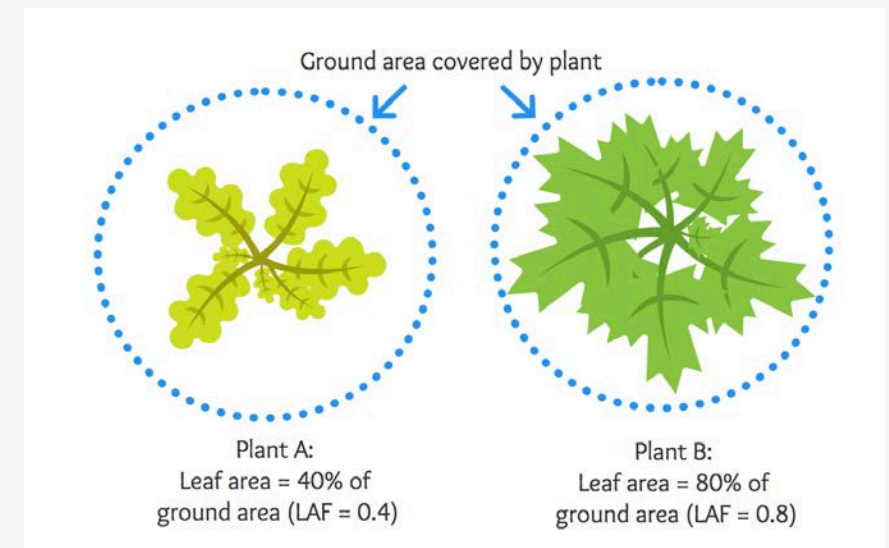
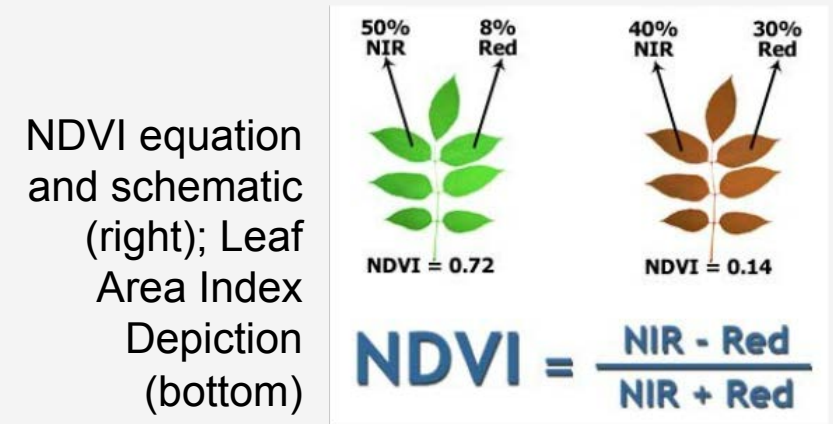
- **Photosynthetically active radiation (PAR):** the spectral range from 400-700 nm that is used by plants in photosynthesis
- **Fraction of Absorbed Photosynthetically Active Radiation (fPAR or fAPAR):** the portion of PAR used by plants
  - Precipitation and temperature are two of the major determining factors
  - Important parameter in measuring biomass production
  - fPAR can be measured on the ground or inferred from satellite imagery



fAPAR in Europe, August 2011 from European Space Agency (ESA)

# Vegetation Indices

- **Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI):** relationship between visible and near-infrared radiation to compare the photosynthetic capacity of vegetation per pixel
  - *These are not quantifiable measurements*
- **Leaf Area Index (LAI):** the leaf area per unit ground area
  - The one-sided green leaf area per unit ground area in broadleaf canopies and ½ the total needle surface area per unit ground area in coniferous canopies
- LAI is related to, but not directly proportional to, NDVI





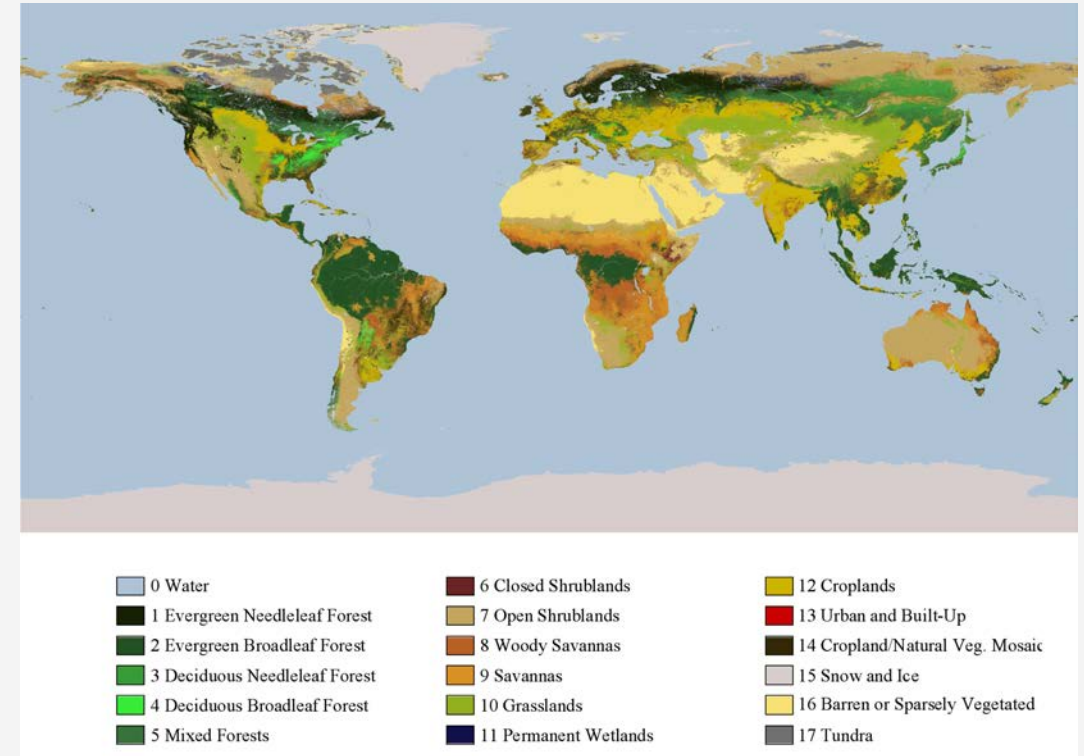


# Vegetation Products

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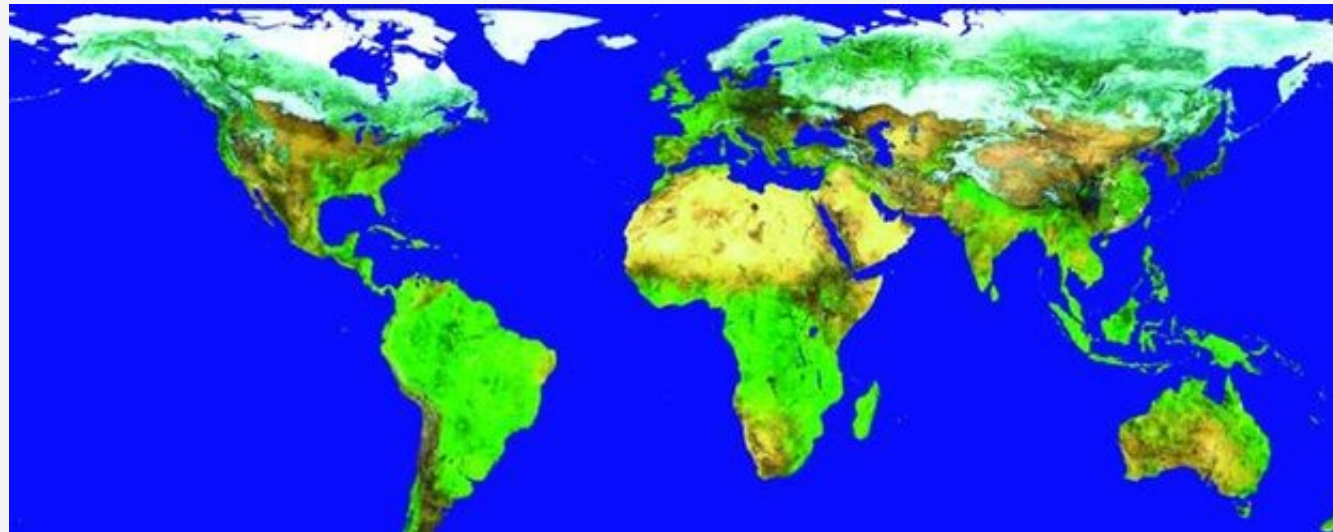
# Global Land Cover Maps (from session 2)

- FAO Global Land Cover SHARE (GLC-SHARE)
  - <http://www.fao.org/geonetwork/srv/en/main.home>
- European Space Agency Climate Change Initiative Land Cover
  - <http://maps.elie.ucl.ac.be/CCI/viewer/>
- GlobeLand30 (China)
  - <http://www.globallandcover.com/GLC30Download/index.aspx>
- MODIS Land Cover
  - <https://search.earthdata.nasa.gov>



# Global Productivity Data

- Copernicus Global Land Service vegetation products
- MODIS vegetation products
- European Space Agency Vegetation Product (SPOT – Vito viewing portal)  
[www.vito-eodata.be](http://www.vito-eodata.be)

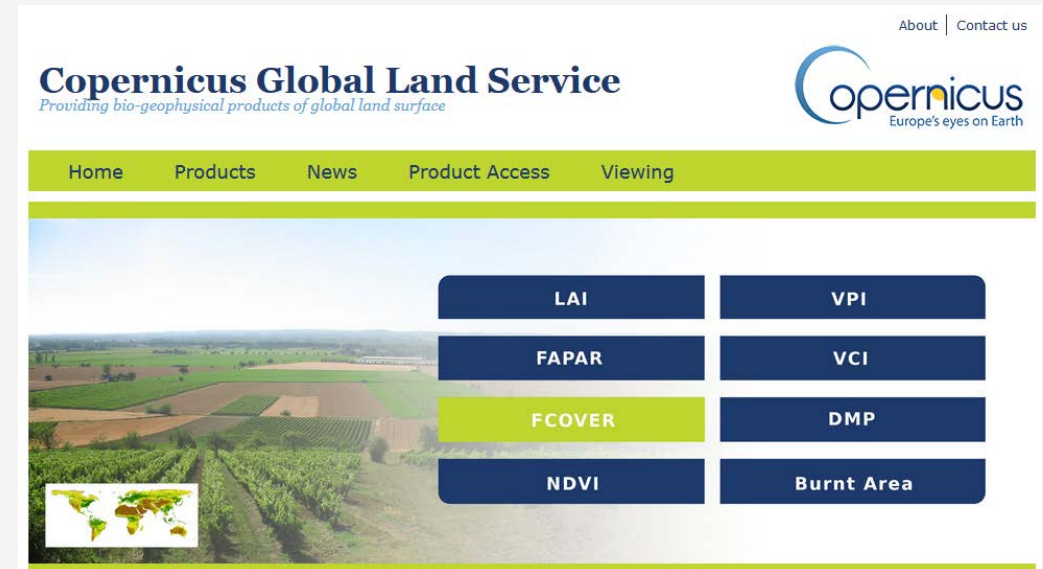


ESA 10-dat vegetation product via SPOT

# Copernicus Global Land Service

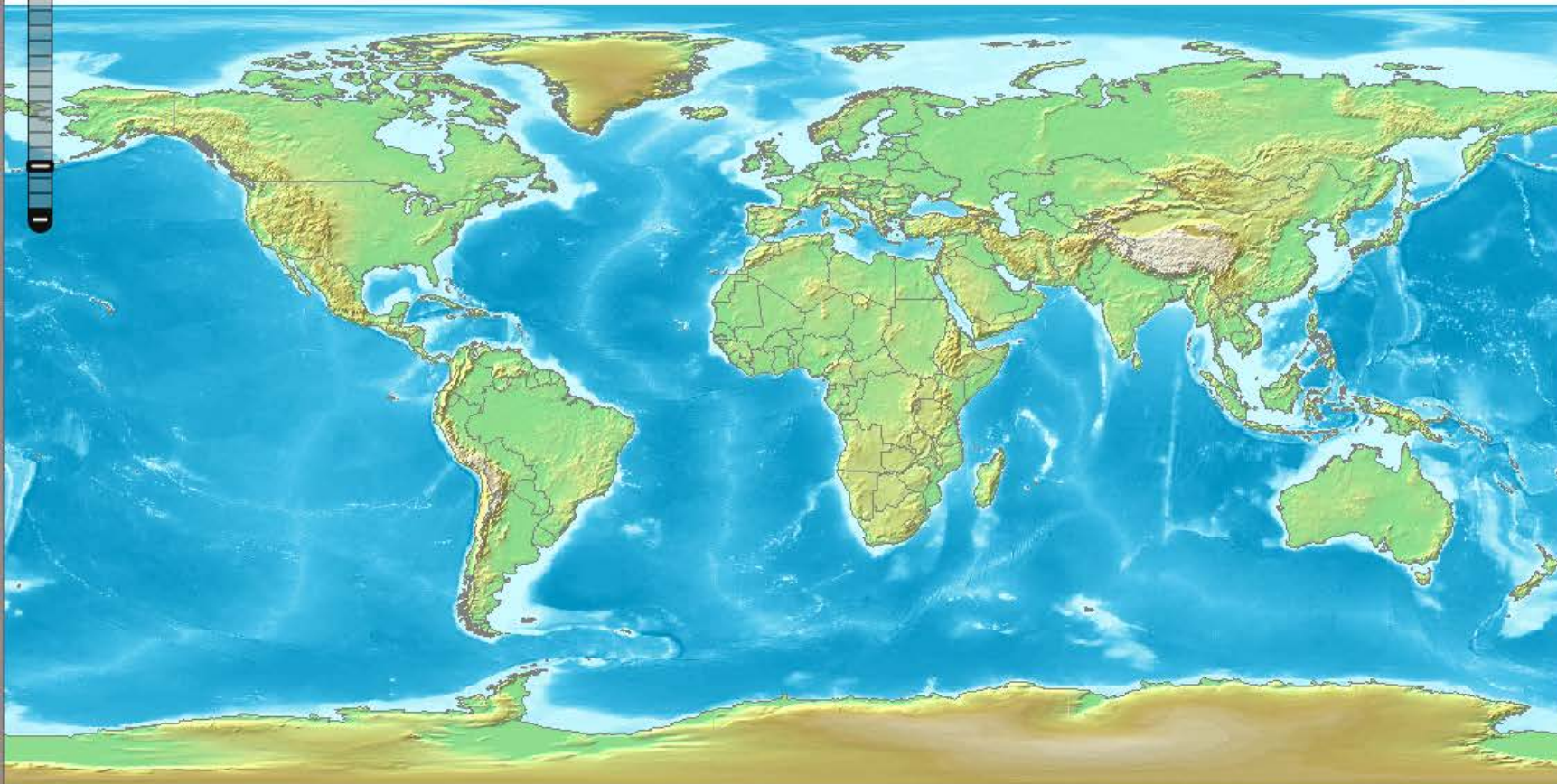
<http://land.copernicus.eu/global/themes/Vegetation>

- **LAI:** Leaf Area Index
- **FAPAR:** Fraction of Absorbed Photosynthetic Active Radiation
- **FCOVER:** Fraction of green vegetation cover
- **NDVI:** Normalized Difference Vegetation Index
- **VPI:** Vegetation Productivity Index
- **VCI:** Vegetation Condition Index
- **DMP:** Dry Matter Productivity



- Spatial Resolution: 300 m/ 1 km
- Temporal Coverage: ranges depending on the product
- Available through product portal

[Watch our video tutorials](#)



[Catalogue search](#)

[Subscription](#)

## Vegetation Properties - FCOVER 1km V2

[Help](#)

**Collection**

- LAI 300m V1 (118 products) [i](#) [e](#)
- LAI 1km V2 (659 products) [i](#) [e](#)
- LAI 1km V1 (4617 products) [i](#) [e](#)
- FCOVER 300m V1 (118 products) [i](#) [e](#)
- FCOVER 1km V2 (659 products)** [i](#) [e](#)
- FCOVER 1km V1 (4619 products) [i](#) [e](#)
- FAPAR 300m V1 (118 products) [i](#) [e](#)
- FAPAR 1km V2 (659 products) [i](#) [e](#)
- FAPAR 1km V1 (4618 products) [i](#) [e](#)

**Basic**

**Date**

**Slot**

Start date

End date

ROI

**Advanced**



Number of results per page

# MODIS Vegetation Products

Product	Spatial	Temporal
FPAR*/ LAI**	500 m	8-day composite
NDVI/EVI	250, 500, 1000, 5600 m	monthly, 16-day composites
GPP	500 m	8-day composite
NPP	500 m	8-day composite

\*FPAR (Fraction of Photosynthetically Active Radiation): The fraction of incident photosynthetically active radiation (400-700 nm) absorbed by the green elements of a vegetation canopy

\*\*LAI (Leaf Area Index): The one-sided green leaf area per unit ground area in broadleaf canopies and half the total needle surface area per unit ground area in coniferous canopies

# MODIS Vegetation Products

<https://earthdata.nasa.gov>

The screenshot displays the EarthData Search interface. At the top, the search bar contains the text "MOD13Q1 V006". Below the search bar, there are filters for "Temporal", "Spatial", and "Clear Filters". The left sidebar shows "Browse Collections" with various categories like Features, Keywords, Platforms, Instruments, Organizations, and Processing levels. The main content area shows "1 Matching Collections" with a search time of 0.4s. A collection card is displayed for "MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006", which is a MOD13Q1 v006 - LP DAAC product, ongoing from 1999-12-18, with 114934 Granules. The right side of the interface features a satellite map of the world, with a scale bar indicating 1000 km and 500 mi.

# European Space Agency Vegetation Product

## SPOT Vegetation Programme (1998-2014)

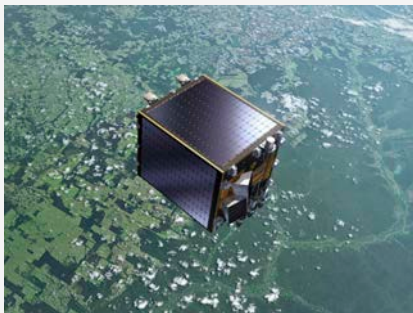
- Consists of two instruments:
  - VEG 1: aboard the SPOT 4 satellite, launched 1998
  - VEG 2: aboard the SPOT 5 satellite, launched in 2002
- Overall objective: To provide accurate measurements of the basic characteristics of vegetation canopies on an operational basis
- Two types of products:
  - VGT-DS: a daily synthesis product (between the two instruments) with ground reflectance and NDVI computed from those reflectance values
  - VGT-PS: a 10-day period synthesis of NDVI maximum values
  - Spatial resolution of 1.15 km
- Mission ended in 2013 but has been replaced by the PROBA-V mission



# European Space Agency Vegetation Product

## PROBA-V

- Preparation for the ESA Sentinel-3 satellite mission
- Spectral channels are similar to SPOT-VGT
- Platform is smaller than a cubic meter



Product	Spatial Resolution	Temporal
Top of Atmosphere/ Top of Canopy	100 meter	Daily, 5-day composite
NDVI	100 meter	Daily, 5-day composite
Top of Atmosphere/Top of Canopy	300 meter	Daily, 10-day composite
NDVI	300 meter	10-day composite
Top of Atmosphere/Top of Canopy	1 kilometer	Daily, 10-day composite
NDVI	1 kilometer	10-day composite

# ESA Product Distribution Portal

<http://www.vito-eodata.be/>

**vito**  
vision on technology

belspo **esa**

## PRODUCT DISTRIBUTION PORTAL

Free Satellite Imagery

**PROBA-V 1 KM SYNTHESSES NEAR REAL-TIME** Collections

**PROBA-V SEGMENTS** Collections

**PROBA-V 300 M SYNTHESSES (OLDER THAN 1 MONTH)** Collections

**PROBA-V 100 M SYNTHESSES (OLDER THAN 1 MONTH)** Collections

**SPOT-VEGETATION** Collections

**METOP-AVHRR S10 SYNTHESSES** Collections

**ENVISAT-MERIS S10 SYNTHESSES** Collections

Fast HTTP Access

PROBA-V User Manual Product Customization Tool

View the PDF instruction movie

### News

**1 May 2017**  
PROBA-V mission extended to 2019!

**1 May 2017**  
New PROBA-V website launched!

**14 February 2017**  
New collections for PROBA-V and SPOT VEGETATION

### PROBA-V's Image of the Week

Subscribe

View previous images of the week

Version 2.1.15-20161004 About us Terms of use Feedback

# ESA Product Distribution Portal

<http://www.vito-eodata.be/>

The screenshot displays the ESA Product Distribution Portal interface. At the top left is the VITO logo with the tagline "vision on technology". To the right are logos for BELSPo and ESA. Further right are navigation links for "Login", "Help", "Register", "FAQ", and "Contact". Below these are icons for home, search, and other functions. The main area features a world map with a legend and a search panel on the right. The search panel is titled "SPOT-VEGETATION - S10 NDVI - continental extracts" and includes a "Collection" section with the following items:

- FreeP (level2) (177287 products)
- S1 products (5925 products)
- S10 NDVI - continental extracts (5860 products)
- S10 Radiometric- continental extracts (5860 products)
- Global S10 (586 products)

The "Basic" section contains search filters:

Date	Slot			
Start date	Dekad 1	January	2013	
End date	Dekad 3	May	2014	

Below the date filters are input fields for "ROI" and a "Search" button. The "Advanced" section is currently empty. At the bottom of the search panel, there is a "Number of results per page" dropdown set to 100.

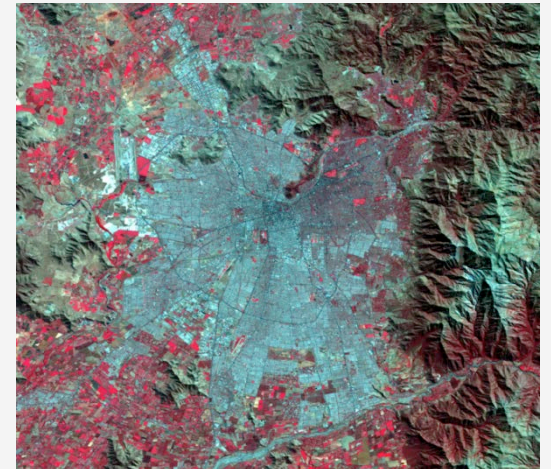
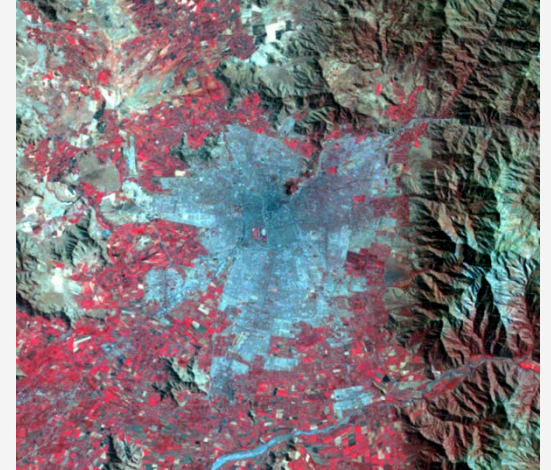
The background of the slide is an aerial satellite image of a forested area. The forest is dense and green, with some lighter green patches indicating different types of vegetation or perhaps a clearing. A semi-transparent white rectangular box is centered on the image, containing the title text. Below the title, a thin black horizontal line is drawn across the width of the text box.

# Land Cover Change from Satellite Imagery

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# Land Cover Change: What is it?

- The conversion of the landscape from one dominant feature type to another
- Examples:
  - Changes in tree cover due to wildfire or land clearing
  - Urbanization
- Information that can be derived from satellites:
  - Where and when has change taken place?
  - How much and what type of change has occurred?
  - What are the cycles and trends in the change?

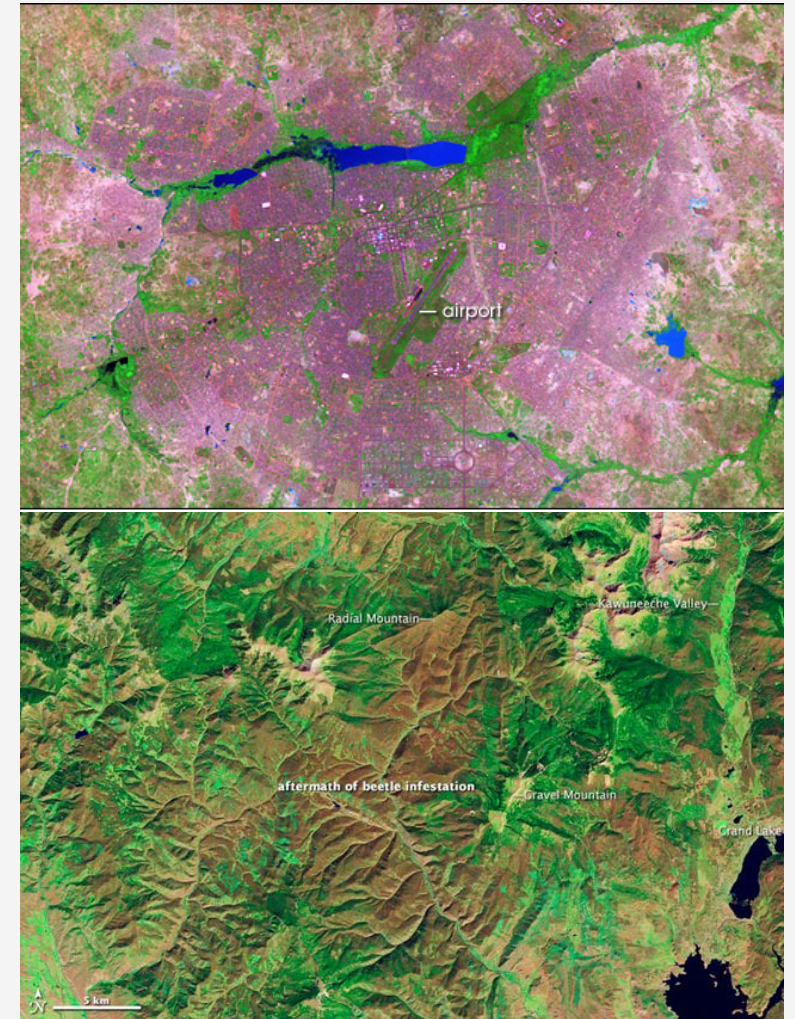


Santiago, Chile urban growth from 1975 (top) to 2013 (bottom) from Landsat  
Source: USGS

# Broad Categories of Change

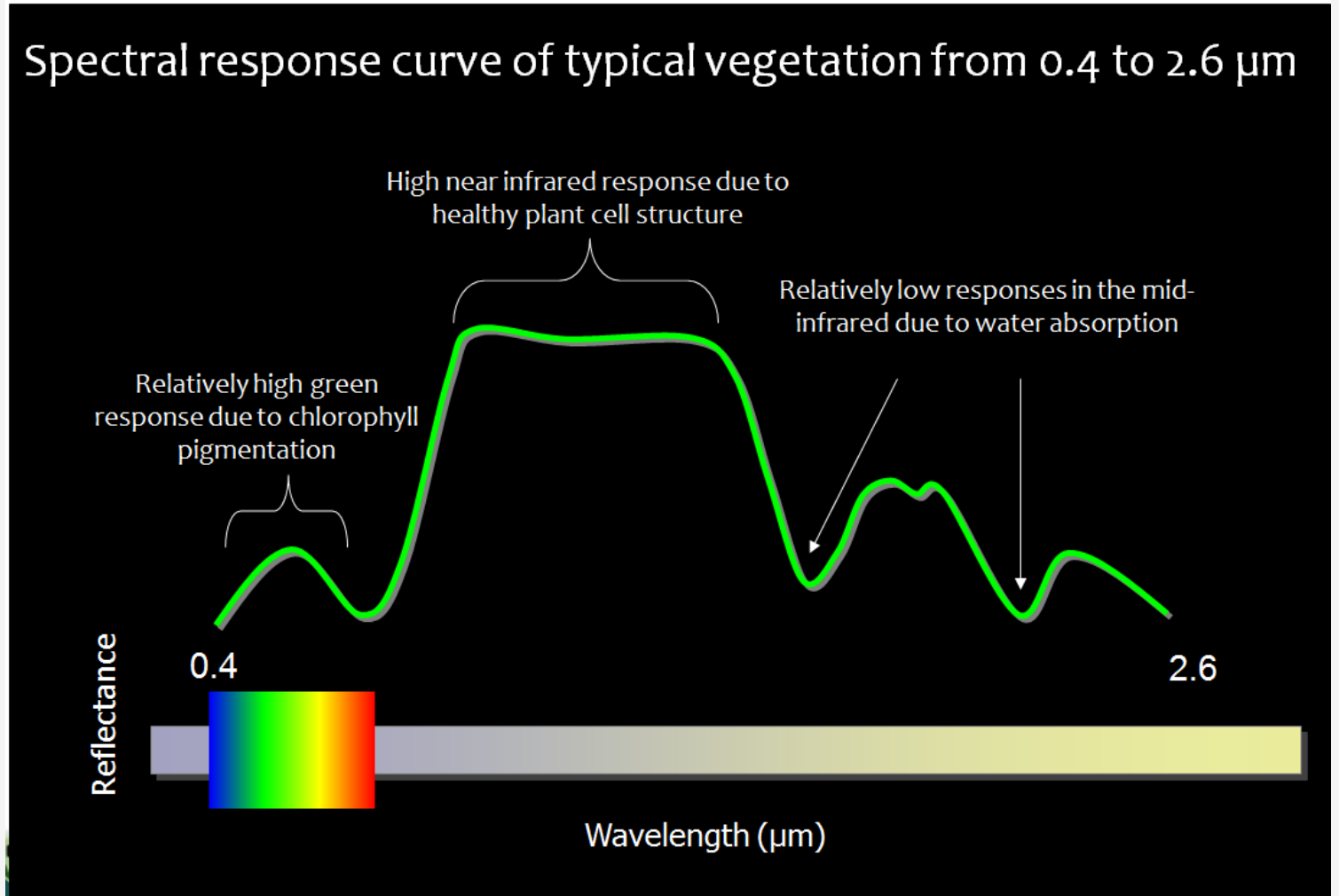
- Change in shape or size of patches of land cover types (urbanization)
- Slow changes in cover type or species composition (succession) vs. abrupt land cover transitions (wildfire, deforestation)
- Slow changes in condition of a single cover type (forest degradation due to insect or disease)
- Changes in timing of extent of seasonal processes (drought monitoring)

(Top) Urbanization in Burkina Faso, 2006  
(Bottom) Bark Beetle Infestation: Colorado, 2011



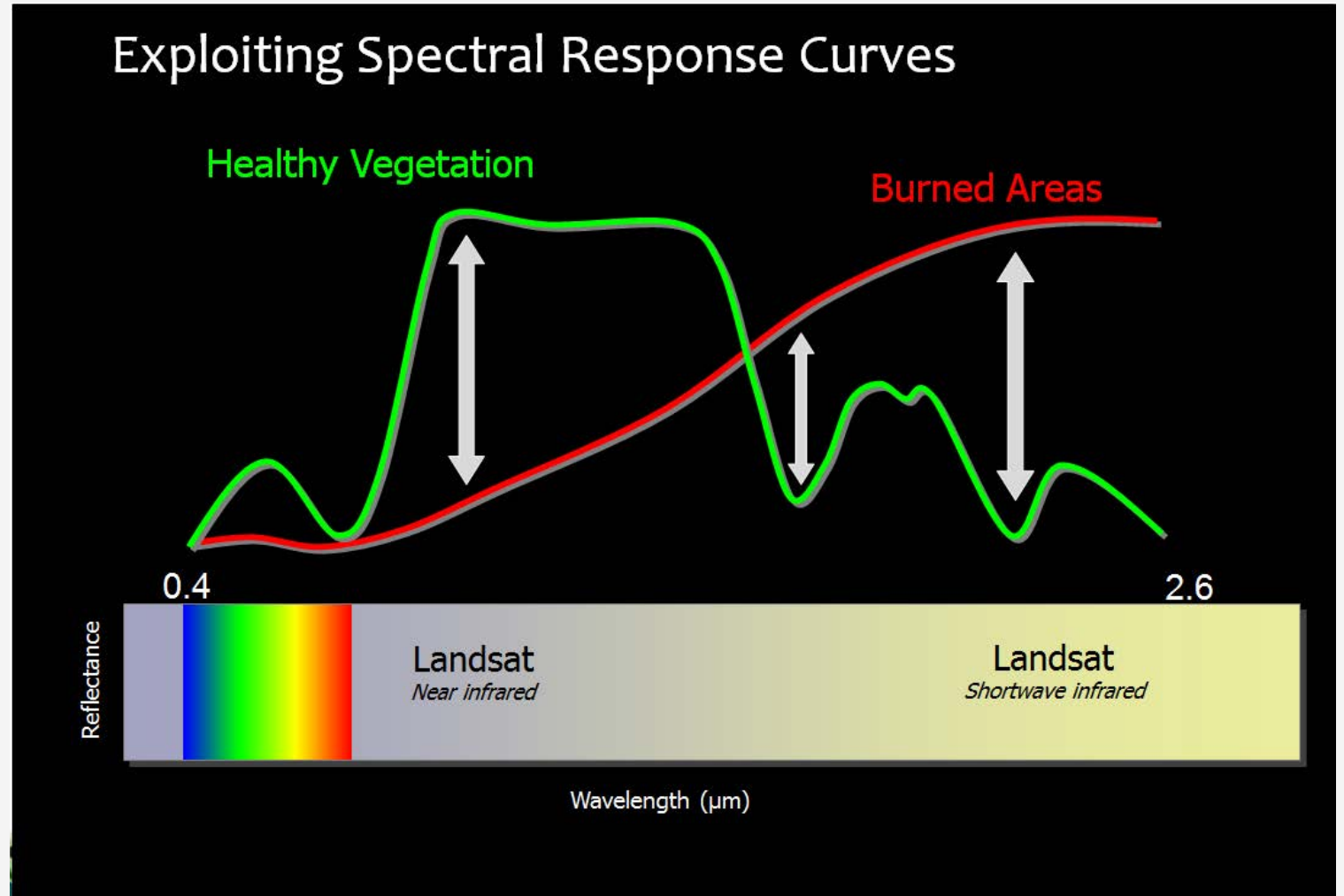
# Land Cover Change Detection

- Typical spectral response of healthy, green vegetation
- Some reflectance in the green wavelengths, very high reflectance in the Near-Infrared wavelengths
- Absorption in the Shortwave-infrared wavelengths



# Land Cover Change Detection

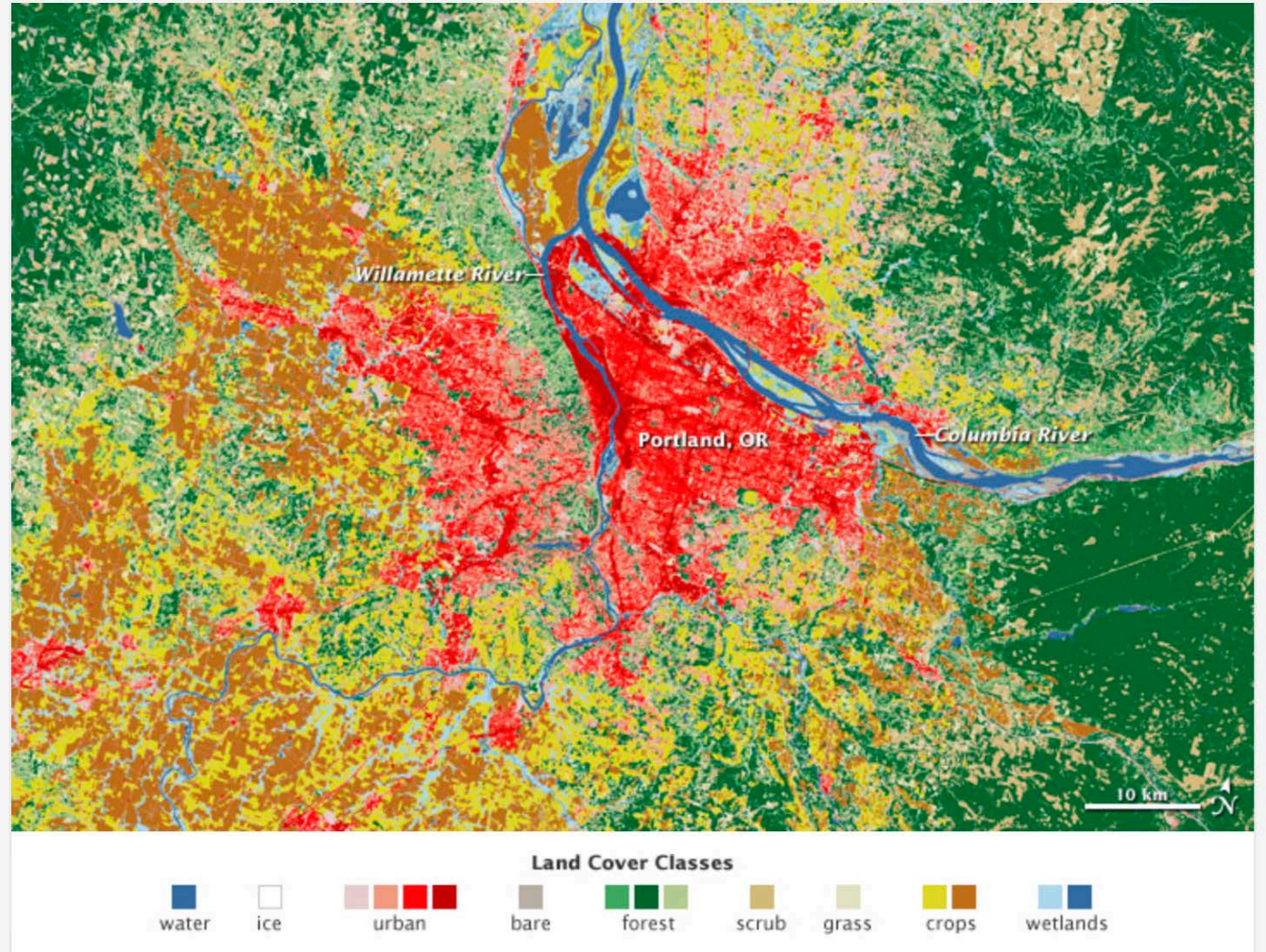
- Changes on the landscape can be detected as changes in the spectral value of pixels
- Burned areas have low reflectance in the G and NIR but high in the SWIR





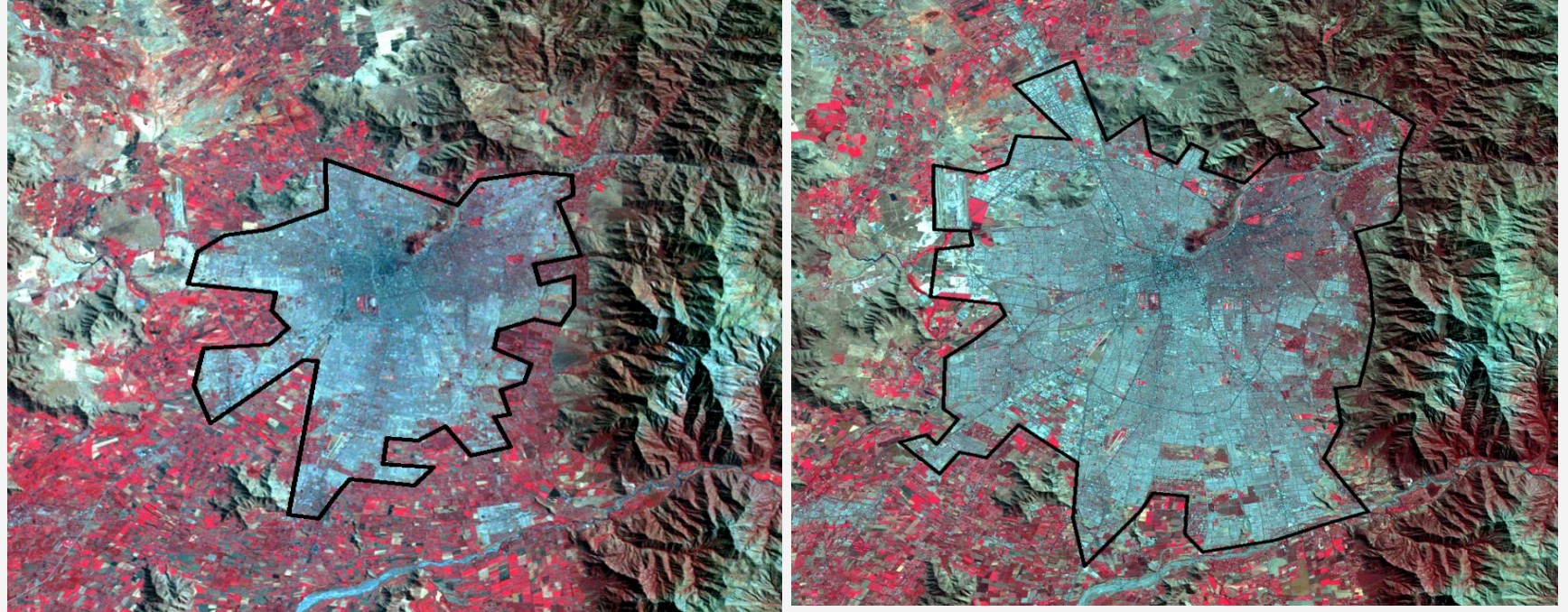
# Change Detection Methods

- Visual Analysis
- Classification Approaches
- Image Differencing
- Temporal Trajectories



# Change Detection: Visual Analysis

- Heads-up digitizing
- Good for large changes like shape or size of patches
- Not as good for subtle changes (land degradation)

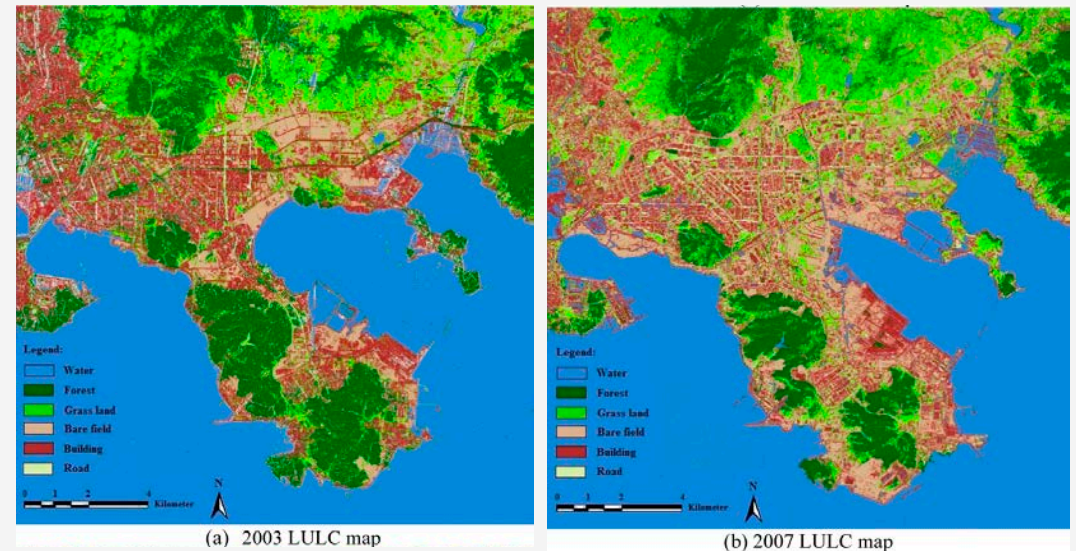
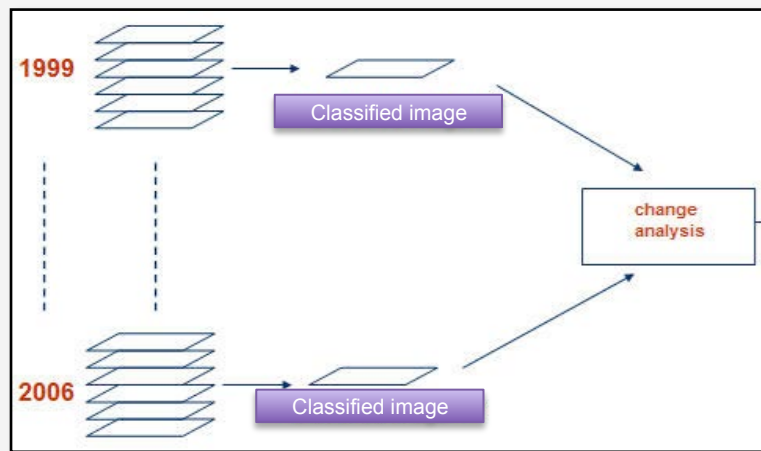


*Santiago, Chile urban growth from 1975 to 2013 from Landsat  
Source: earthshots.usgs.gov*

# Change Detection: Classification Approaches

- Need two dates of imagery
- Image classification
- Quantify land cover types in each image and compare (tabular), or
- Subtract one image from another to identify change

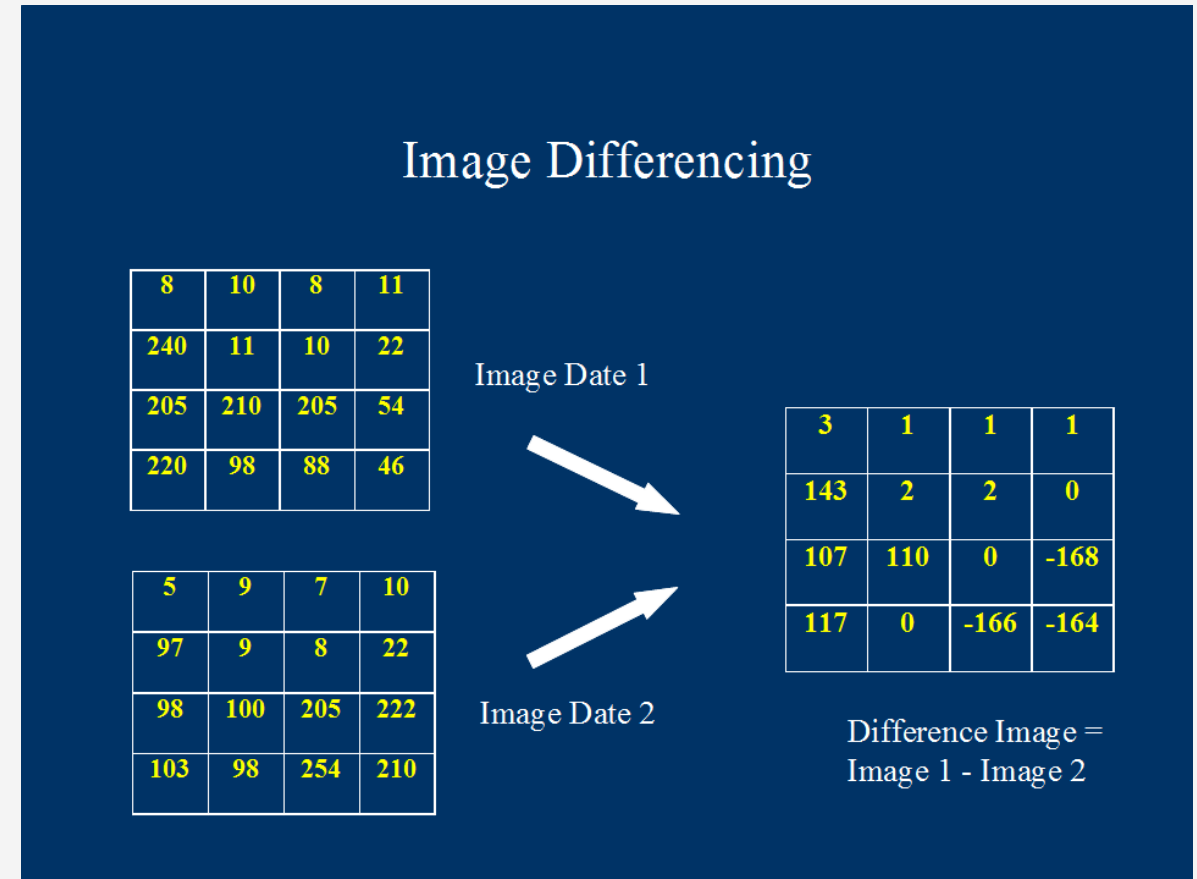
- Advantage: Easy to compute
- Disadvantage: Errors in classification will result in errors in detecting change



2003 and 2007 Land cover classifications of Dalian, China  
Credit: Dr. Ni-Bin Chang, University of Central Florida

# Change Detection: Image Differencing

- Subtract image date 1 from image date 2
- 0 means no change; positive or negative values indicate change
- Advantage: Can be used to detect subtle changes
- Disadvantage: Can be difficult to interpret



# Change Detection: Temporal Trajectories

- Takes advantage of the entire satellite image archive (i.e. Landsat: 1985-current) by using an annual time series to examine changes/trends
- Example: Landtrendr (Kennedy et al., 2010) products include:
  - Magnitude of change: 1-100% tree cover loss
  - Duration: 1-25 years
  - Year of onset of disturbance

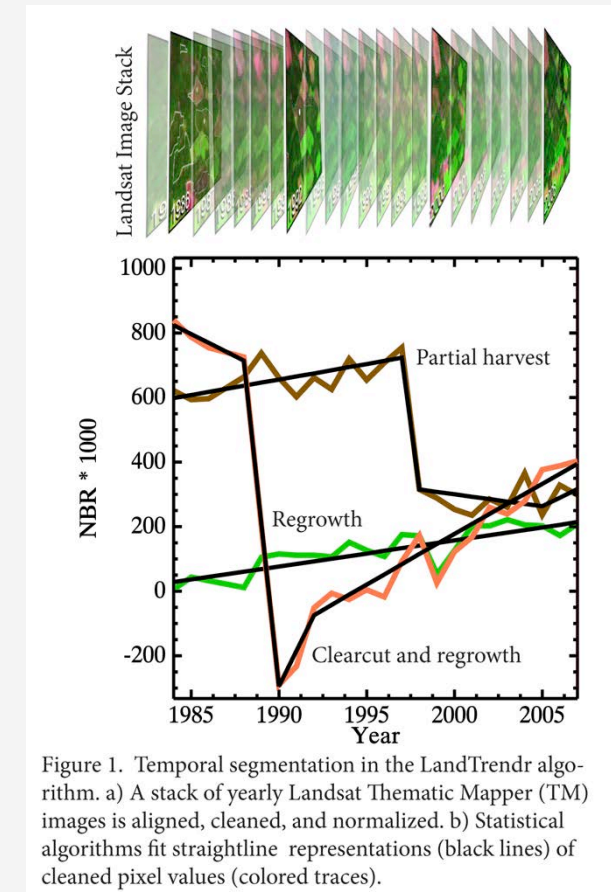
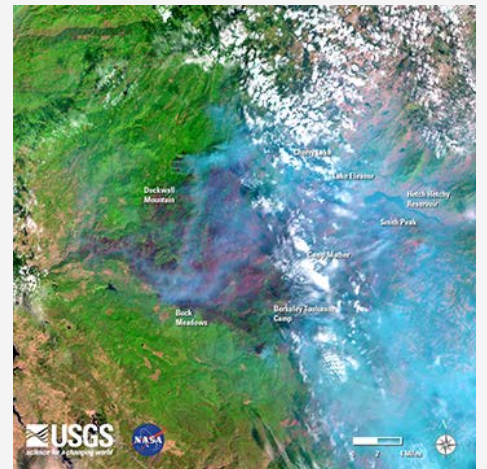


Figure 1. Temporal segmentation in the LandTrendr algorithm. a) A stack of yearly Landsat Thematic Mapper (TM) images is aligned, cleaned, and normalized. b) Statistical algorithms fit straightline representations (black lines) of cleaned pixel values (colored traces).

# Change Detection: Important Considerations

- Need to minimize the amount of spectral change caused by:
  - Seasonal variation and phenology
  - Image mis-registration
  - Clouds and shadows
  - Radiometric inconsistencies (atmospheric effects, etc.)
- Images must have atmospheric/radiometric correction.
- Images must be precisely registered to each other
- Choose images from approximately the same time of year



## Summary

- Indicator 15.3.1: Proportion of land that is degraded over total land area
  - Land productivity and health can be measured using multiple parameters
    - For example: NPP, NDVI, fAPAR
  - There are various global products available for land productivity and health parameters
    - For Example: MODIS Vegetation Products, ESA Vegetation Products
  - Change detection can be assessed via remotely-sensed imagery
  - There are a variety of change detection methods

An aerial photograph of a forested landscape, showing a dense canopy of trees in various shades of green. A semi-transparent white rectangular box is overlaid on the center of the image, containing the title text. Below the title, a thin black horizontal line is drawn across the width of the text.

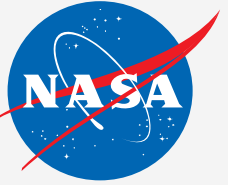
# MODIS Land Cover and GFW Demo

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# Contacts

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# Thank You

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