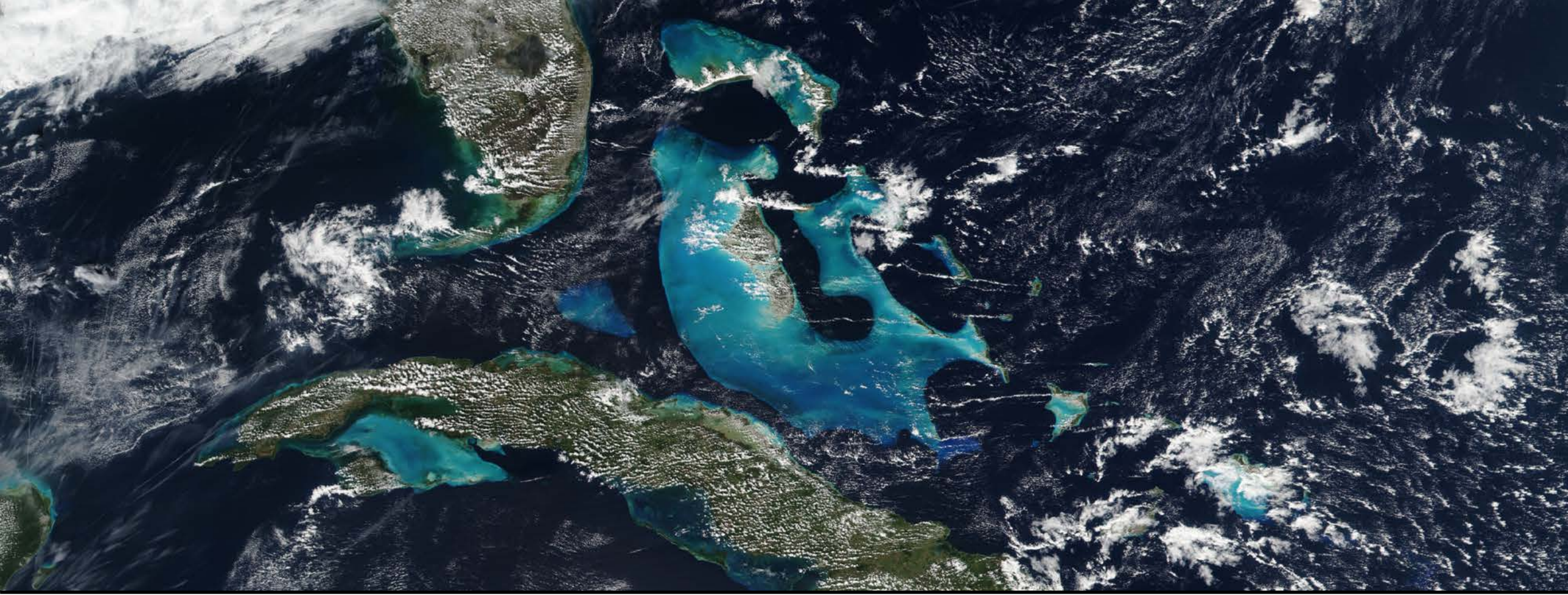# Overview of Target 15.3 and Indicator 15.3.1

Brock Blevins

Target 15.3

SDG 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

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.

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

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
  - https://knowledge.unccd.int/topics/sustainable-development-goals-sdgs/sdg-indicator-1531
- 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

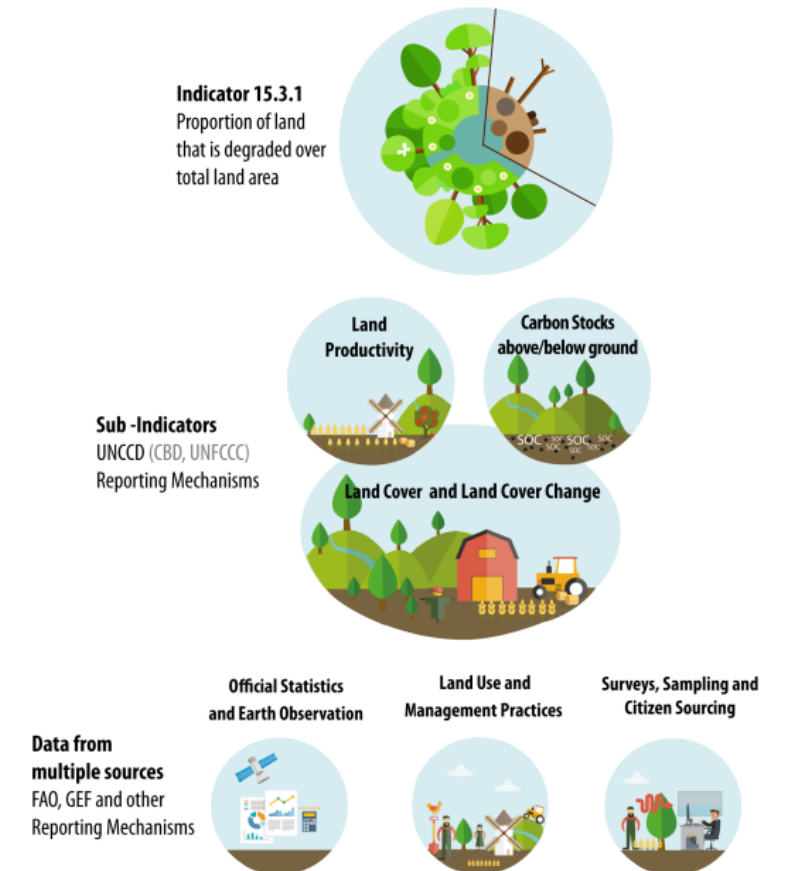Image Credit: (Top) UN Convention to Combat Desertification (Bottom) BBC

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 for Monitoring and Reporting on SDG Target 15.3

Indicator 15.3.1
Proportion of land that is degraded over total land area

Land Productivity

Carbon Stocks above/below ground

Sub -Indicators
UNCCD (CBD, UNFCCC)
Reporting Mechanisms

Land Cover and Land Cover Change

Official Statistics and Earth Observation

Land Use and Management Practices

Surveys, Sampling and Citizen Sourcing

Data from multiple sources
FAO, GEF and other Reporting Mechanisms

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

Indicator 15.3.1

Definitions:

- *Land degradation* is defined as the reduction or loss of the biological or economic productivity and complexity of rain fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from a combination of pressures, including land use and management practices. This definition was adopted by and is used by the 196 countries that are Party to the UNCCD.1 (see also Figure 1)

- *Land Degradation Neutrality* (LDN) is defined as a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems (decision 3/COP12).2
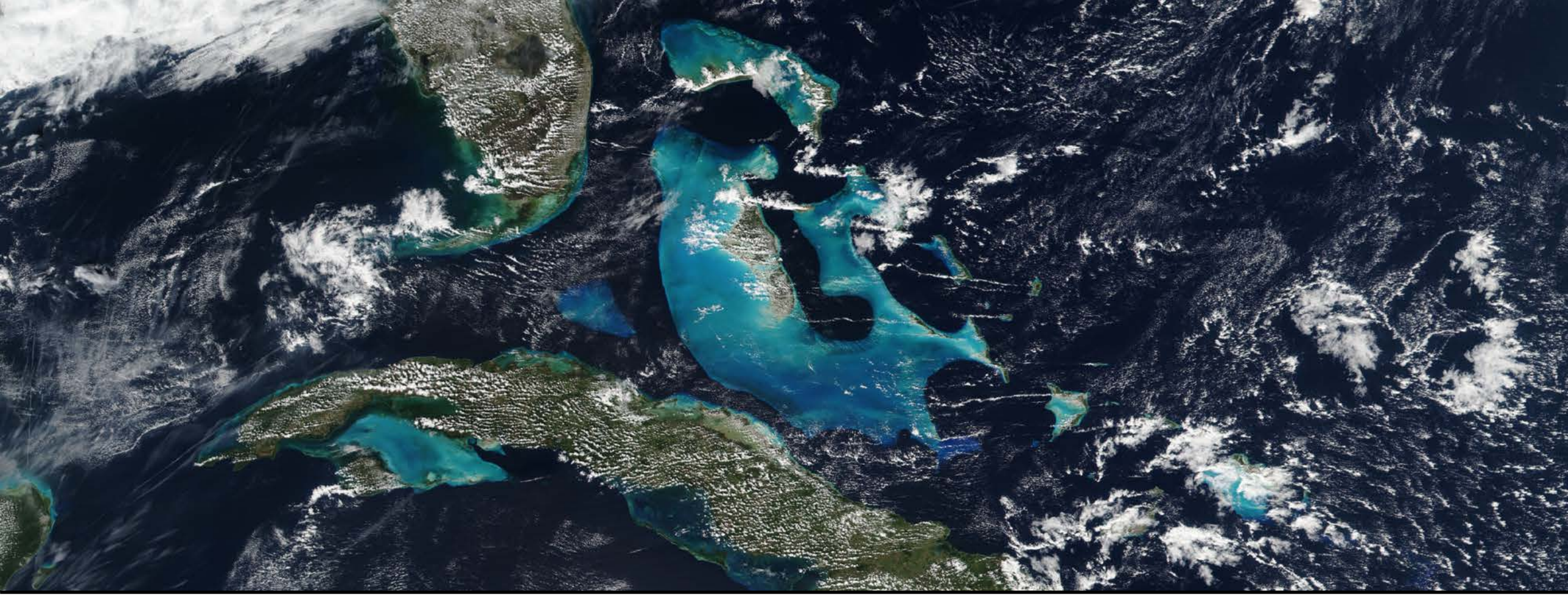
Framework and Guiding Principles for a Land Degradation Indicator, United Nations Convention to Combat Desertification

Indicator 15.3.1

The measurement unit for this indicator is the spatial extent (hectares or km2) expressed as the proportion (percentage or %) of land that is degraded over total land area.

SDG indicator 15.3.1 is a binary - degraded/not degraded - quantification based on the analysis of available data for three sub-indicators to be validated and reported by national authorities. The sub-indicators (Trends in Land Cover, Land Productivity and Carbon Stocks) were adopted by the UNCCD's governing body in 2013 as part of its monitoring and evaluation approach.

https://arset.gsfc.nasa.gov/sites/default/files/users/sdgs/Metadata-15-03-01_20180123_1.pdf

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

Indicator 15.3.1

- **Data collection:** The data collection process for UNCCD reporting has begun with the first reporting period scheduled for 2018 and subsequent reporting every four years.

- **Data release:** Data from the 2018 reporting period will be released by February 2019 in national, sub-regional, regional and global formats.

- **Data providers** The ministries or agencies ("main reporting entity") that host the UNCCD National Focal Points, in conjunction with National Statistical Offices and specialized agencies, will prepare UNCCD national reports that include indicator 15.3.1 and the sub-indicators. Otherwise national data will be procured through national data platforms and mechanisms endorsed by the UN Statistical Commission

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

Vegetation Definitions

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)
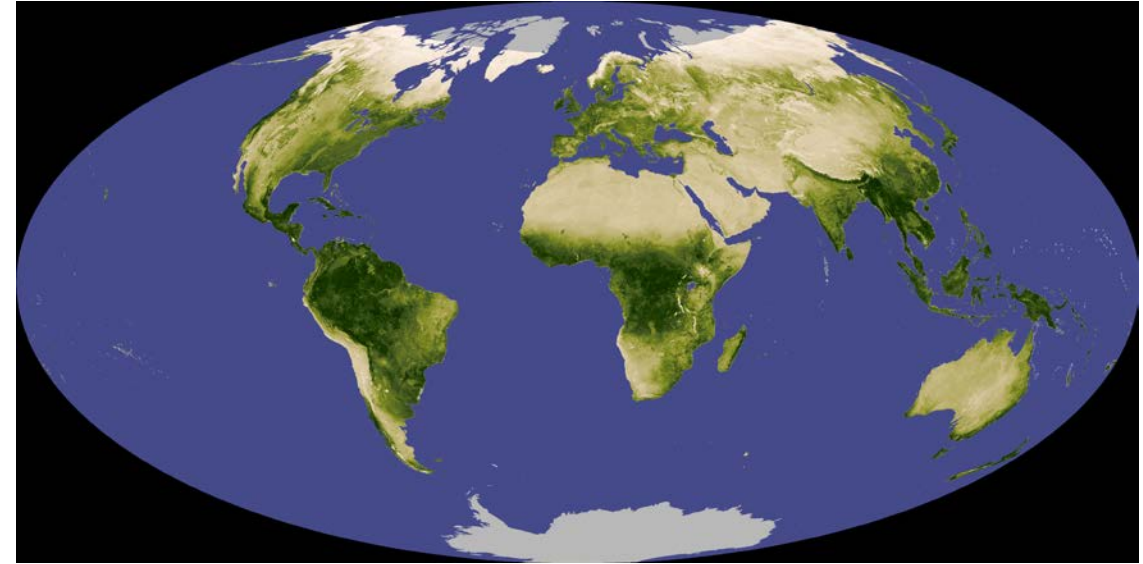
MODIS NDVI

Vegetation Definitions: Carbon Pools and Fluxes

- **Gross Primary Productivity (GPP)**: total of all carbon fixed through photosynthesis
- **Autotrophic Respiration (Ra)**: the carbon that a plant uses and loses in the process of constructing and maintaining its biomass (above & below ground)
- **Heterotrophic Respiration (Rh)**: 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
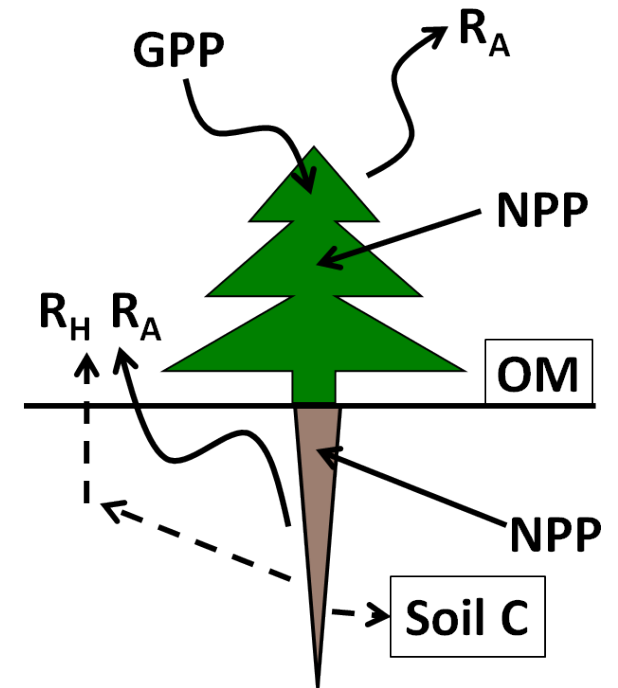
Image Credit: Silviculture and Applied Forest Ecology at Stephen F. Austin State University

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

NDVI equation and schematic (right); Leaf Area Index Depiction (bottom)

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

Ground area covered by plant

Plant A:
Leaf area = 40% of ground area (LAF = 0.4)

Plant B:
Leaf area = 80% of ground area (LAF = 0.8)
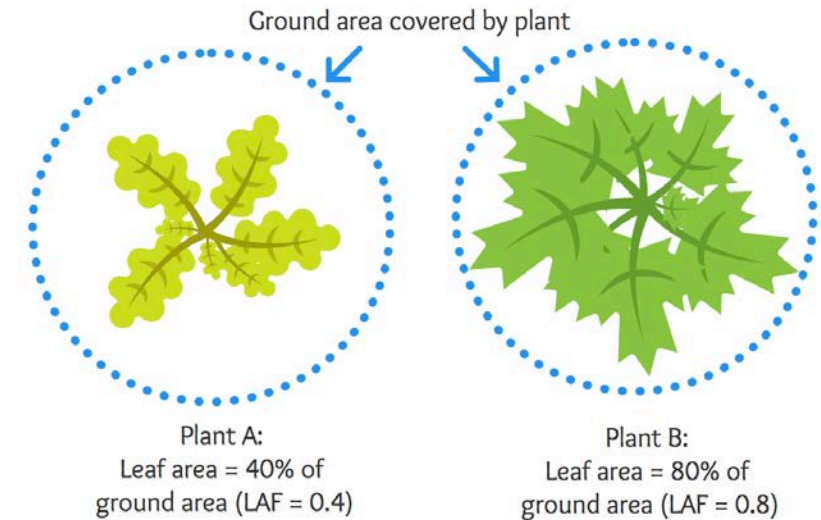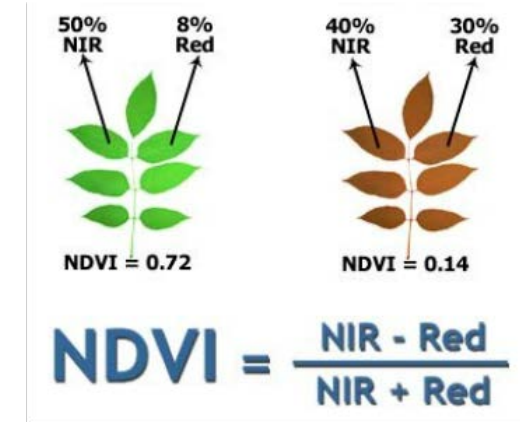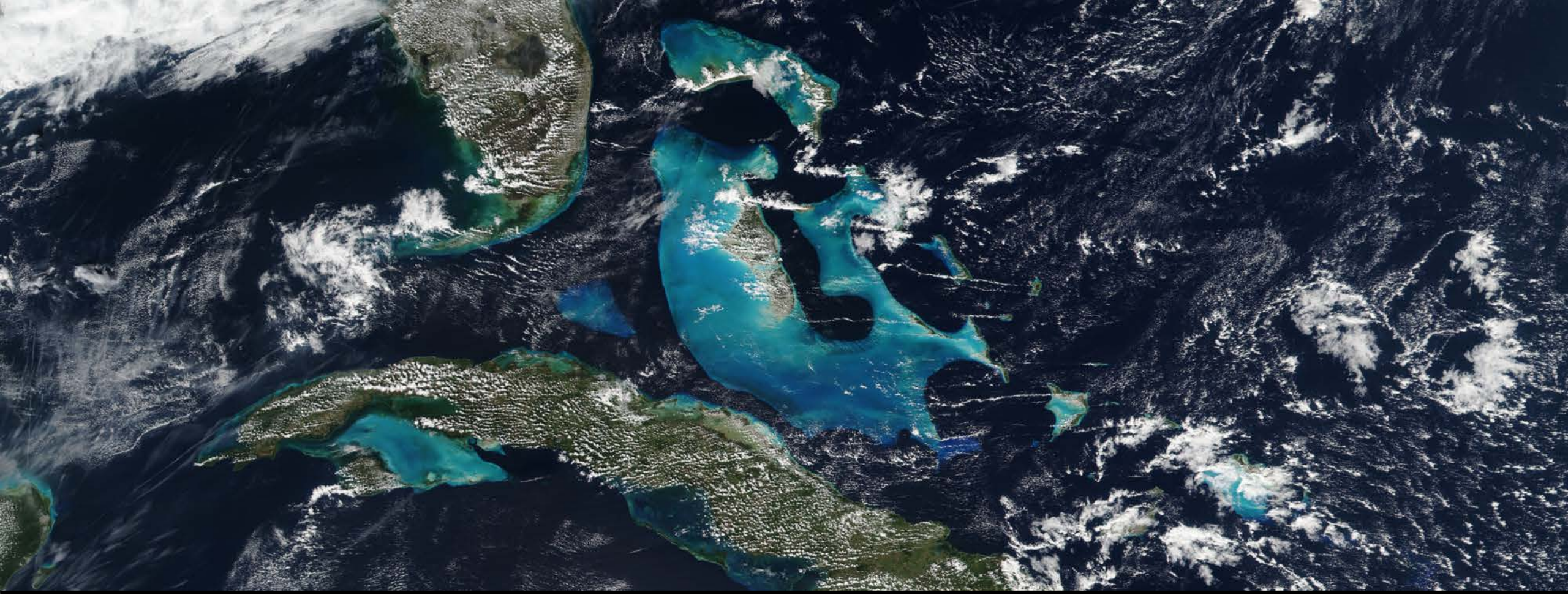
Vegetation Products

Global Land Cover Maps

- 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/
- MODIS Land Cover
  - https://search.earthdata.nasa.gov

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

Copernicus Global Land Service for Productivity Products

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

MODIS Vegetation Productivity Datasets

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

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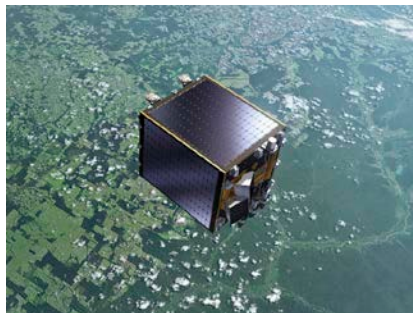
Product	Spatial Resolution	Temporal
Top of Atmosphere/ Top of Canopy	100 meter	Daily, 5-day composite
NDVI	100 meter	Daily, 5-day composite
Top of Atmosphere/Top of Canopy	300 meter	Daily, 10-day composite
NDVI	300 meter	10-day composite
Top of Atmosphere/Top of Canopy	1 kilometer	Daily, 10-day composite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

ESA Product Distribution Portal

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

SPOT and Proba-V products through the ESA product distribution portal

ESA Product Distribution Portal

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

Land Cover Change from Satellite Imagery

Land cover change is an essential component for the assessment of trends in land degradation, restoration and carbon stocks

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?

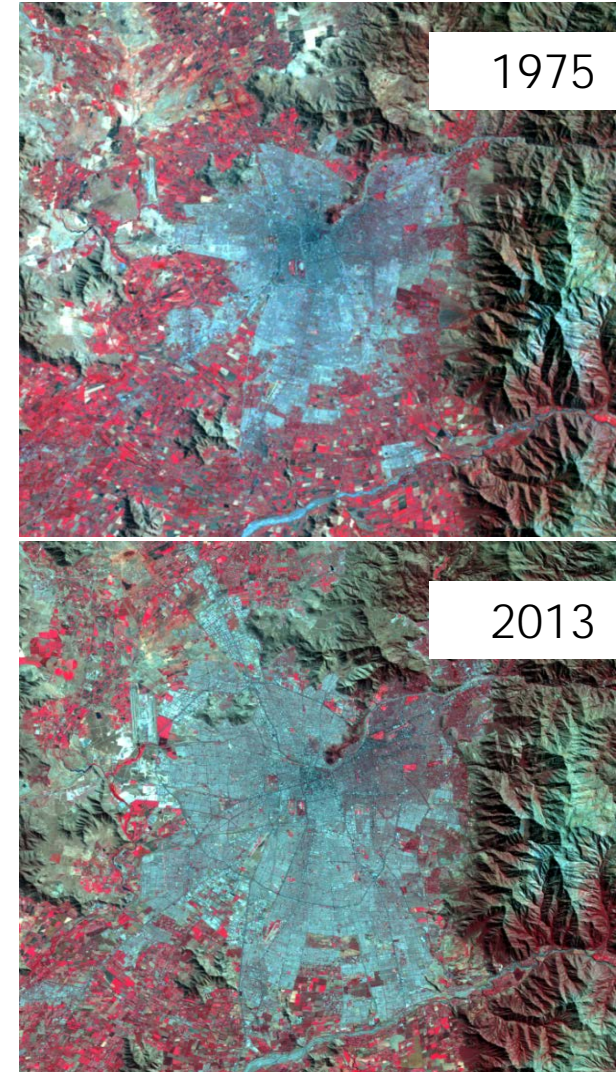 - increase of urban growth in Santiago, Chile from 1975 to 2013 (right)

Image: Urban growth in Santiago, Chile. Credit: USGS

1975

2013

Broad Categories of Change

- Change in shape or size of patches of land cover types (urbanization)
- You can have 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)
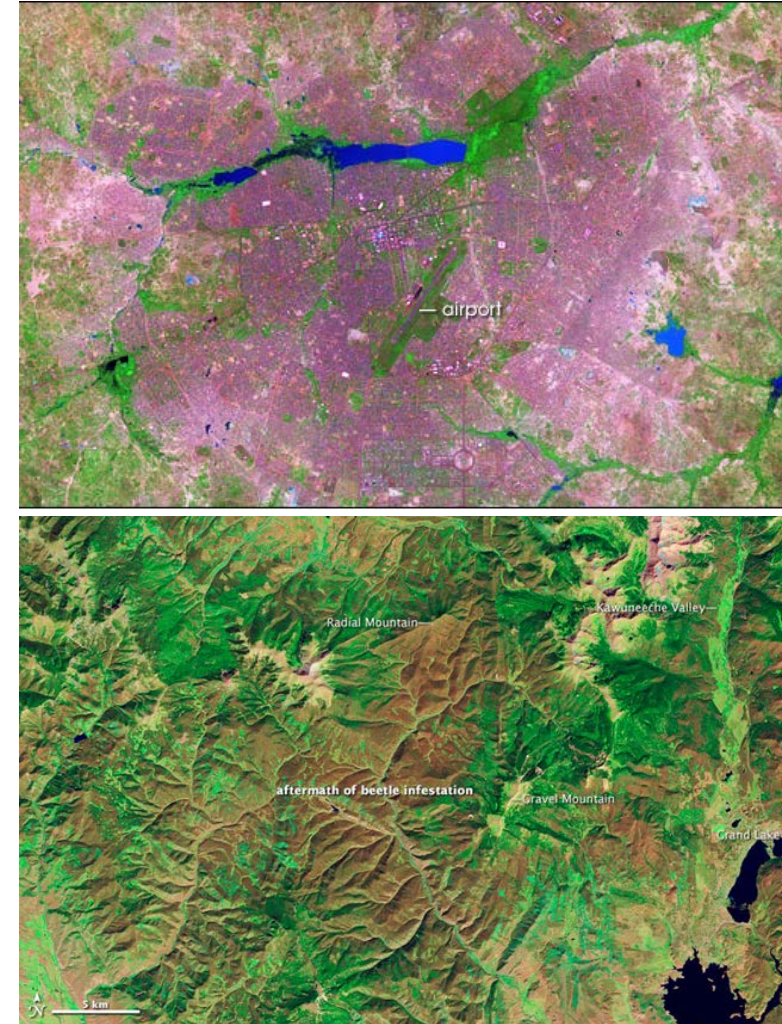- Changes in timing of extent of seasonal processes (drought monitoring)

Image: 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

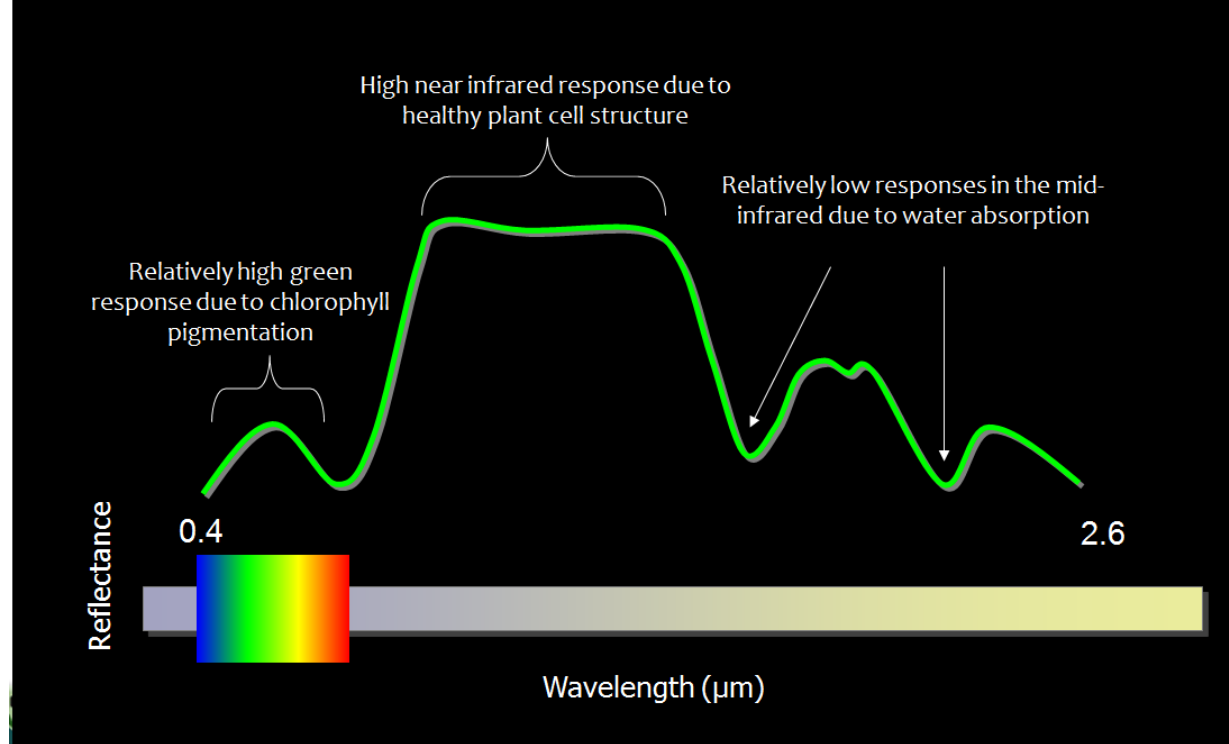Spectral response curve of typical vegetation from 0.4 to 2.6 μm

High near infrared response due to healthy plant cell structure

Relatively low responses in the mid-infrared due to water absorption

Relatively high green response due to chlorophyll pigmentation

Reflectance

0.4

2.6

Wavelength (μm)

Image Credit: RSAC, USFS

Land Cover Change Detection

- Changes on the landscape can be detected as changes in the spectral value of pixels

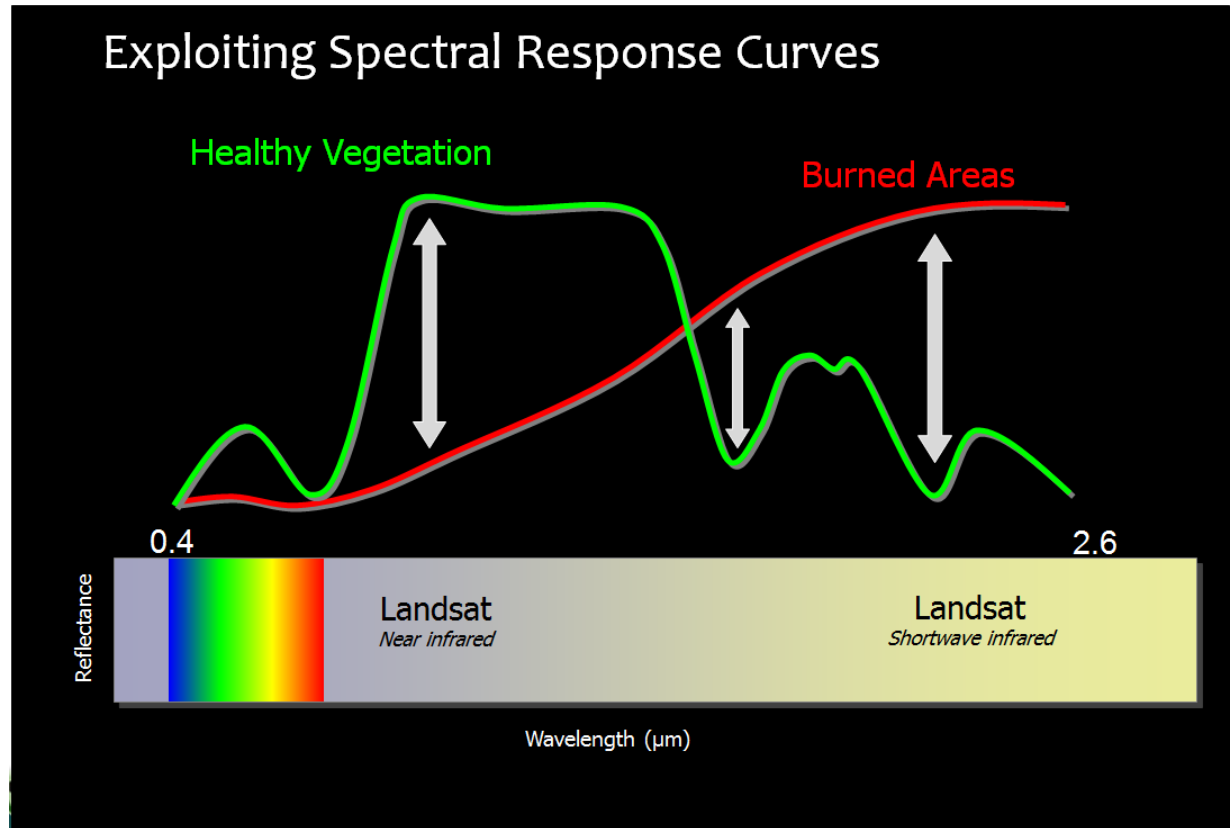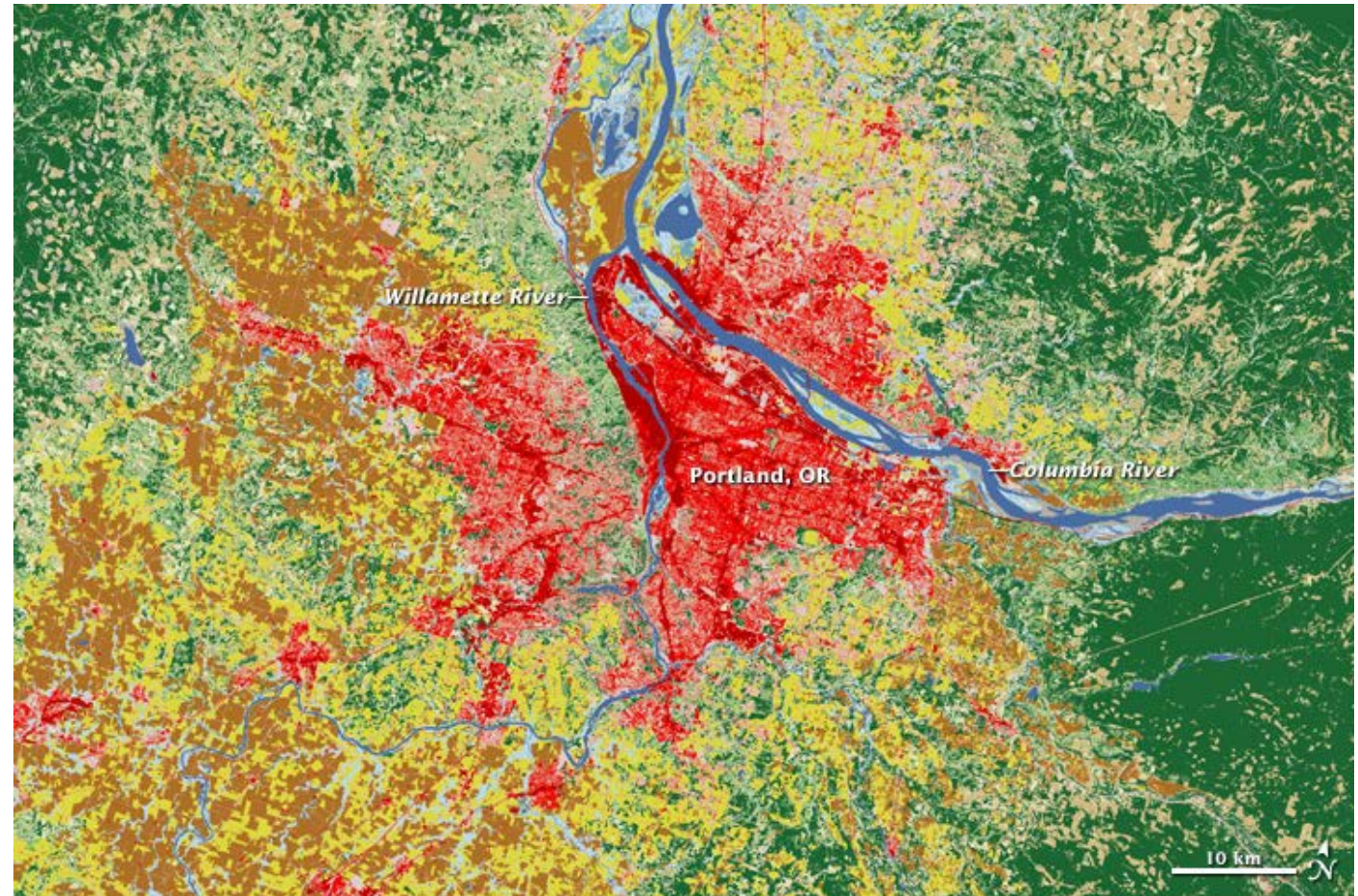- Burned areas have low reflectance in the G and NIR but high in the SWIR


Image Credit: RSAC, USFS

Change Detection Methods

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

Land Cover Classes

water | ice | urban | bare | forest | scrub | grass | crops | wetlands

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)

1975

2013
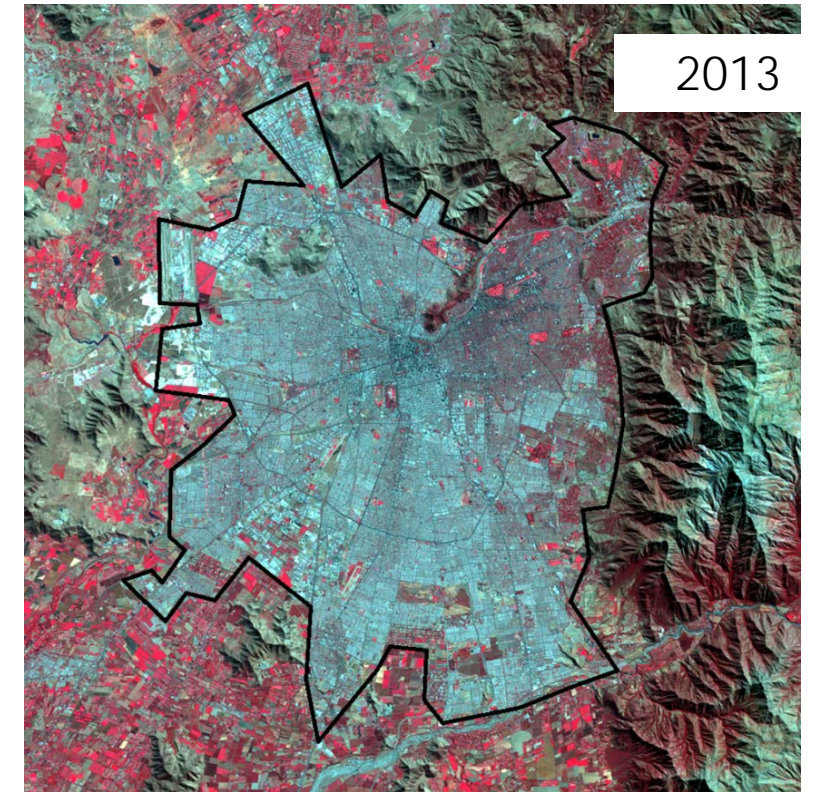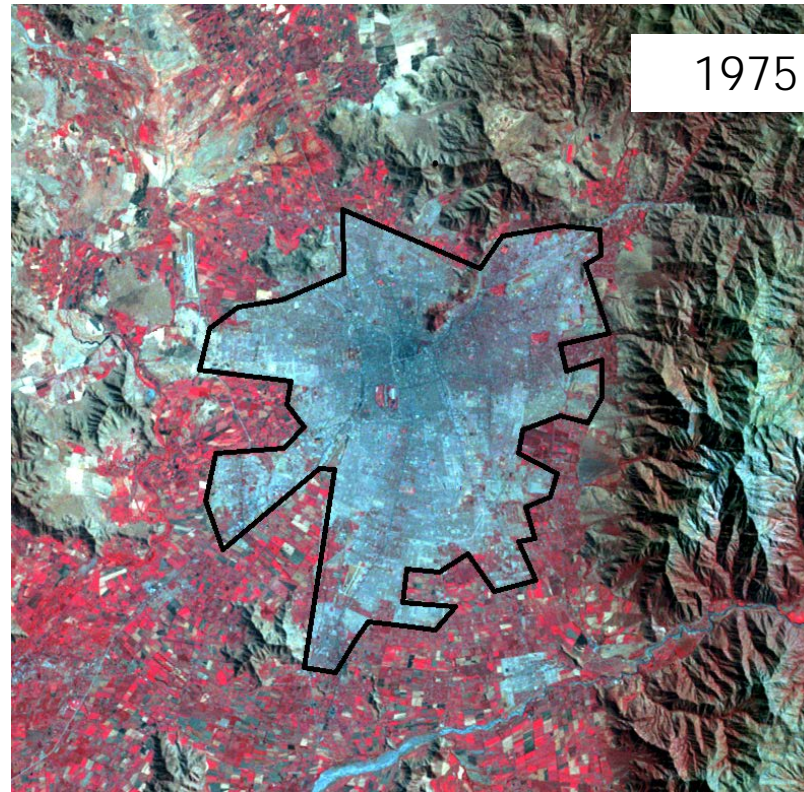
Urban growth in Santiago, Chile, captured by Landsat

Image Credit: USGS

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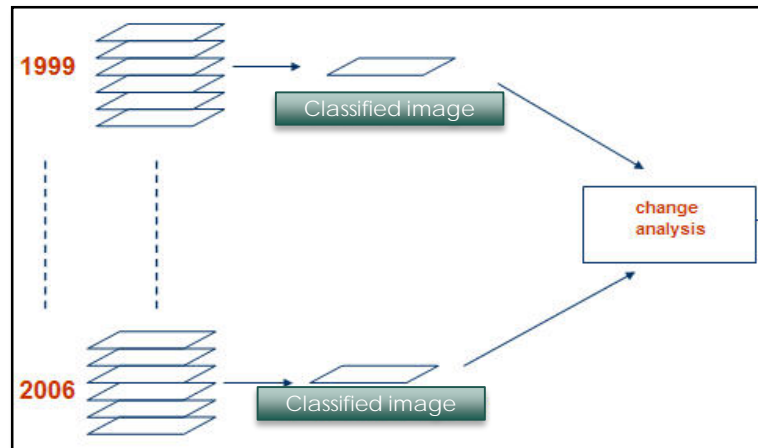
2003 and 2007 Land cover classifications of Dalian, China; Credit: Dr. Ni-Bin Chang, University of Central Florida

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
  - 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

GFW Demo

In an effort to evaluate and improve the training offered by the NASA Applied Remote Sensing Training (ARSET) program, we have created a survey to collect information from everyone who has participated. All survey responses are anonymous. The survey should take only a few minutes to complete, and we truly value your honest, constructive input.

https://www.surveymonkey.com/r/ARSET_2018_EndofTrainingSurvey

Thank you!