



Welcome to Introduction to Remote Sensing for Scenario-Based Ecoforecasting

We will begin promptly at 12:00 EDT (UTC-4)

Course Format:

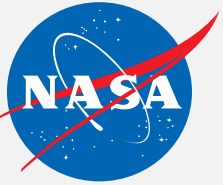
- Four, one hour sessions
- Sessions will be held each Thursday in September – 7, 14, 21, and 28
- All attendees will be muted automatically upon entry
- This session will be recorded and made available to you within two days

Please be sure you have reviewed the content within Session 1 of *Fundamentals of Remote Sensing*:

<http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing>



National Aeronautics and
Space Administration



ARSET

Applied Remote Sensing Training

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

 @NASAARSET

Introduction to Remote Sensing for Scenario- Based Ecoforecasting

Week 1

Instructors: Amber McCullum and Cindy Schmidt

Course Structure

- Four 1-hour sessions each Thursday in September (7, 14, 21 and 28) at 12:00 – 1:00 p.m. EDT (UTC-4)
- Guest speakers with the USGS North Central Climate Center
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
 - <https://arset.gsfc.nasa.gov/land/webinars/scenario-based-ecoforecasting-17>
 - Q&A: Following each lecture and/or by email
 - cynthia.l.schmidt@nasa.gov, or
 - amberjean.mccullum@nasa.gov

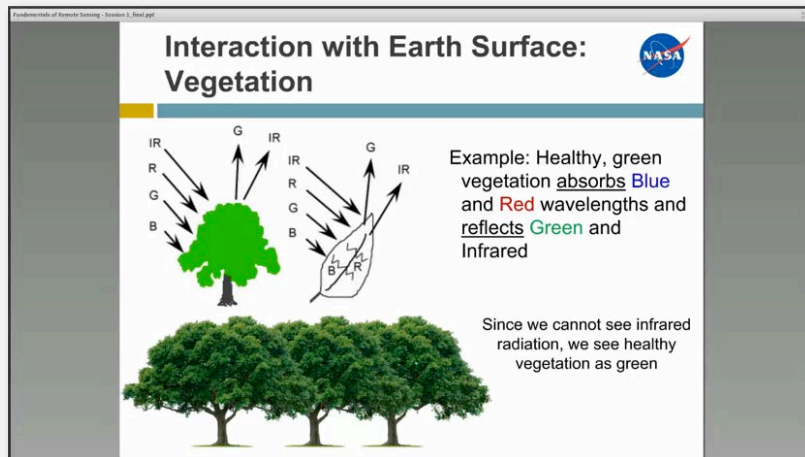
Homework and Certificates

- Homework
 - Two homework assignments
 - Answers must be submitted via Google Forms
- Certificate of Completion:
 - Attend 3 out of 4 live webinars
 - Complete the homework assignment by the deadline (access from ARSET website)
 - HW 1 Deadline: Sept 28th
 - HW2 Deadline: Oct 12th
 - You will receive certificates approx. two months after the completion of the course from: 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 questions and submit by June 23rd, 2016. The form has 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) at NASA GSFC. It is presented by Land Management to Amber McCullum for completing advanced training on "Remote sensing of forest cover and change assessment for carbon monitoring". The certificate is dated June 9 - July 7, 2016, and signed by Cindy Schmidt and Amber Jean McCullum.

Prerequisite

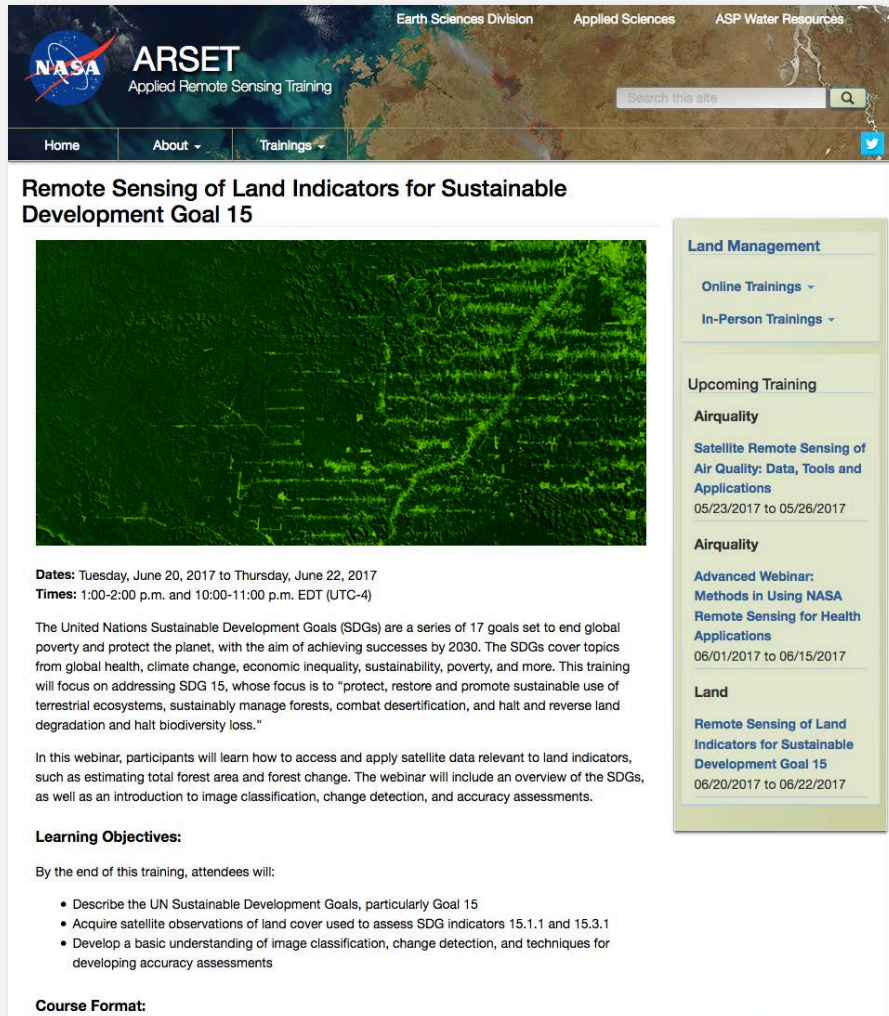
- Fundamentals of Remote Sensing
 - Sessions 1 and 2A (Land)
 - On demand webinar, available anytime
 - <http://arset.gsfc.nasa.gov/webinars/fundamentals-remote-sensing>



The screenshot shows the NASA ARSET website. The header includes the NASA logo and 'ARSET Applied Remote Sensing Training'. A search bar is present. The main navigation menu has 'Home', 'About', and 'Trainings'. The 'Trainings' dropdown menu is open, showing 'Fundamentals', 'Disasters', 'Health & Air Quality', 'Land', and 'Water Resources'. The 'Fundamentals' option is highlighted. To the right, there is a promotional banner for an 'Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications' scheduled for Thursdays, June 1-15, 2017, at 10 a.m. or 3 p.m. EDT (UTC-4). A 'Register Now' button is visible. On the far right, a sidebar lists 'ARSET' resources: 'Webinars', 'Workshops', 'Suggest a Training', 'Personnel', and 'Resources'. Below this, 'Upcoming Training' is listed, including 'Airquality' and 'Satellite Remote Sensing of Air Quality: Data, Tools and Applications' (05/23/2017 to 05/26/2017) and 'Airquality' and 'Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications' (06/01/2017 to 06/15/2017). At the bottom, there is a 'Land' section with 'Remote Sensing of Land'.

Accessing Course Materials

<https://arset.gsfc.nasa.gov/land/webinars/scenario-based-ecoforecasting-17>



The screenshot shows the ARSET website interface. At the top, there is a navigation bar with the NASA logo, the text 'ARSET Applied Remote Sensing Training', and links for 'Home', 'About', and 'Trainings'. Below the navigation bar, the main heading reads 'Remote Sensing of Land Indicators for Sustainable Development Goal 15'. A large satellite image of a forest is displayed. To the right of the image is a sidebar with a 'Land Management' section containing links for 'Online Trainings' and 'In-Person Trainings'. Below that is an 'Upcoming Training' section with two entries: 'Satellite Remote Sensing of Air Quality: Data, Tools and Applications' (05/23/2017 to 05/26/2017) and 'Air Quality: Advanced Webinar: Methods in Using NASA Remote Sensing for Health Applications' (06/01/2017 to 06/15/2017). Underneath is a 'Land' section with an entry for 'Remote Sensing of Land Indicators for Sustainable Development Goal 15' (06/20/2017 to 06/22/2017). The main content area below the image contains the following text:

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

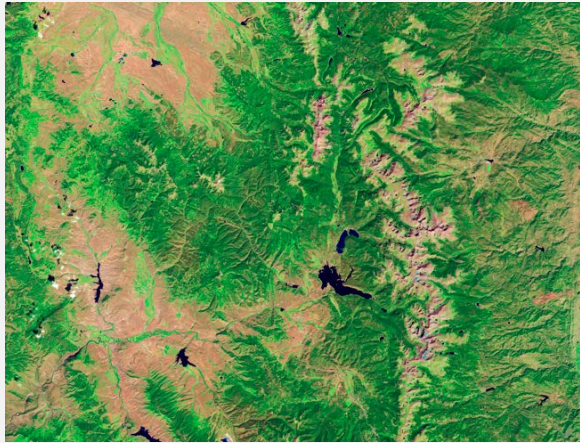
June 20, 2017

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

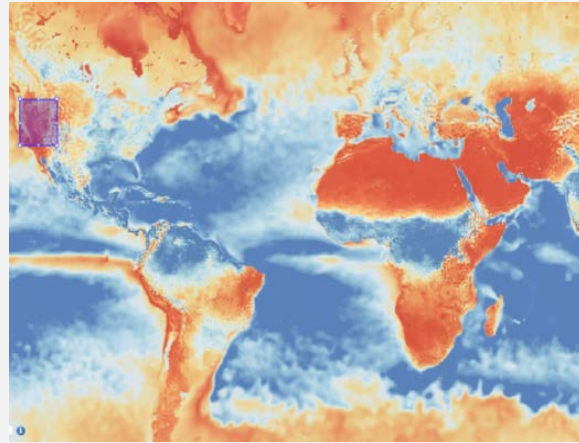
- Introduction to the Sustainable Goals Framework
 - Overview of SDG 15
 - International Institute for Sustainable Development's (IISD's) SDG Knowledge Hub
 - Group on Earth Observations (GEO) and the SDGs
- State of the World's Forests
- Introduction to the role of land-based remote sensing for targets 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

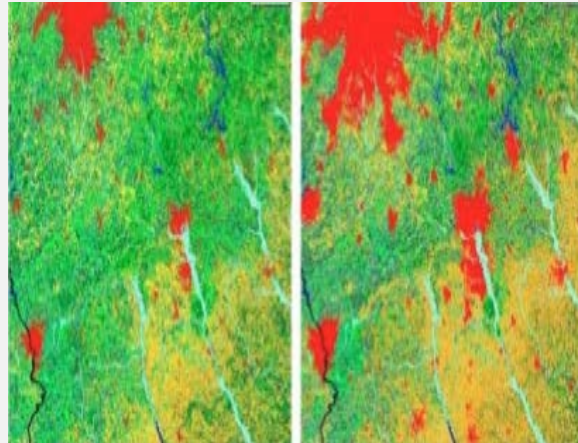
Course Outline



Session 1: Overview of Ecological Forecasting



Session 2: Overview of Climate Science and Data



Session 3: Overview of Scenario Planning



Session 4: Overview of Species Distribution and Simulation Modeling

Session 1 Agenda

- About ARSET
- Introduction to Scenario Planning
- Land Cover Products
- Phenology
- Burn Severity
- Tree Mortality
- Land Cover Data Access and Tools
 - AppEEARS
 - Earthdata Search



USGS National Gap Analysis Program (Left); NDVI images in summer and winter (Below)



Gombe
National Park

About ARSET

NASA's Applied Remote Sensing Training Program (ARSET)

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

- Empowering the global community through remote sensing training
- Part of NASA's Applied Sciences Capacity Building Program
- Goal: increase the use of Earth Science in decision-making through training for:
 - policy makers
 - environmental managers
 - other professionals in the public and private sector
- Trainings offered focusing on applications in:



Disasters



Land



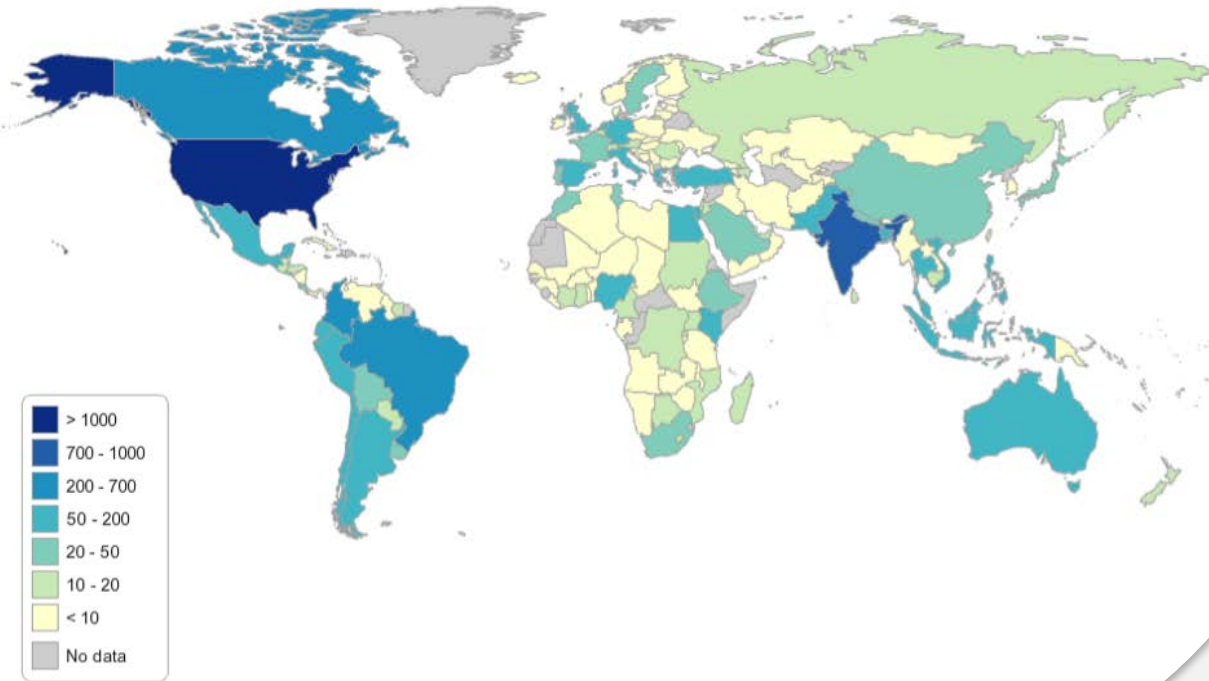
Health & Air Quality



Water Resources

ARSET's Global Footprint

**ARSET Participants by Country
2009 – 2016**



96 ARSET Trainings

11,000+ participants reached

2,500+ organizations reached

150+ countries reached

55 U.S. States, Territories, and D.C. reached

ARSET Training Levels

Fundamentals


- Online only
- Assumes no prior knowledge of remote sensing

Basic Training

- Online and in-person
- Requires fundamentals training or equivalent knowledge
- Specific applications

Advanced Training

- Online and in-person
- Requires basic training or equivalent knowledge
- More in-depth or focused topics



Fundamentals of Remote Sensing: Satellites, Sensors, Data, and Tools for Land Management & Wildfire Applications

Basic Training: Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring

Advanced Training: Advanced Webinar: Land Cover Classification with Satellite Data

ARSET Website: View Webinars

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

ARSET-Dev
Applied Remote Sensing Training

Home About Trainings

Applied Remote Sensing Training

Using NASA Remote Sensing for Disaster Management

June 9-30, 2016
Thursdays
11:00 a.m. - 12:00 p.m. and 6:00-7:00 p.m. EDT

Learn More

ARSET

- Webinars**
- Workshops
- Suggest a Training
- Personnel
- Resources

Upcoming Training

Disasters

Using NASA Remote Sensing for Disaster Management
06/09/2016 to 06/30/2016

Airquality

Fundamentals of Satellite Remote Sensing for Health Monitoring
06/02/2016 to 06/30/2016

Land

Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring
06/09/2016 to 07/07/2016

Webinars

ARSET offers online webinars throughout the year. Each training lasts four to five weeks, one hour per week, and are often offered twice a day to accommodate attendees in different time zones. Webinars are appropriate for professionals engaged in applied environmental management.

These online courses help beginners and advanced professionals use NASA Earth science data and modeling in areas of air quality, disaster management, land management, water resources, and wildfire detection and modeling.

ARSET hosts both introductory and advanced webinars. Check the individual webinar page for its level and more information. Most webinars have materials available in English and Spanish.

Introductory Webinars

Trainings are appropriate for applied professionals with no remote sensing experience.

Advanced Webinars

Trainings are appropriate for professionals with experience in remote sensing or NASA data and resources. Advanced topics will detail specific data or applications by region or discipline. These advanced trainings have case studies and hands-on exercises for participants on data access and processing.

Introduction to Satellite Remote Sensing for Air Quality Applications

Wednesday, July 6, 2016 to Wednesday, August 3, 2016
8:00 - 9:00 a.m. EDT (UTC-4)

Application Area: Airquality

Instruments/Missions: Aqua, Aura, CALIPSO, MISR, MODIS, NPP, Terra

Keywords: Aerosols, Air Pollution, Pollution Transport, Satellite Imagery, Tools, Trace Gases

Read more

Introduction to Remote Sensing for Coastal and Ocean Applications

Wednesday, July 6, 2016 to Wednesday, July 27, 2016
1:00-2:00 p.m. EDT (UTC-4)

Application Area: Land, Water

Instruments/Missions: Aqua, MODIS, NPP, Terra, VIIRS

Keywords: Satellite Imagery, Tools, Water Quality

Read more

Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring

Thursday, June 9, 2016 to Thursday, July 7, 2016

ARSET

- Webinars**
- Workshops
- Suggest a Training
- Personnel
- Resources

Upcoming Training

Disasters

Using NASA Remote Sensing for Disaster Management
06/09/2016 to 06/30/2016

Airquality

Fundamentals of Satellite Remote Sensing for Health Monitoring
06/02/2016 to 06/30/2016

Land

Remote Sensing of Forest Cover and Change Assessment for Carbon Monitoring
06/09/2016 to 07/07/2016

Last updated: May 06, 2016
NASA Official: Kenneth Pickering
Webmaster: Susannah Pearce

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Gombe
National Park

Introduction to Scenario Planning

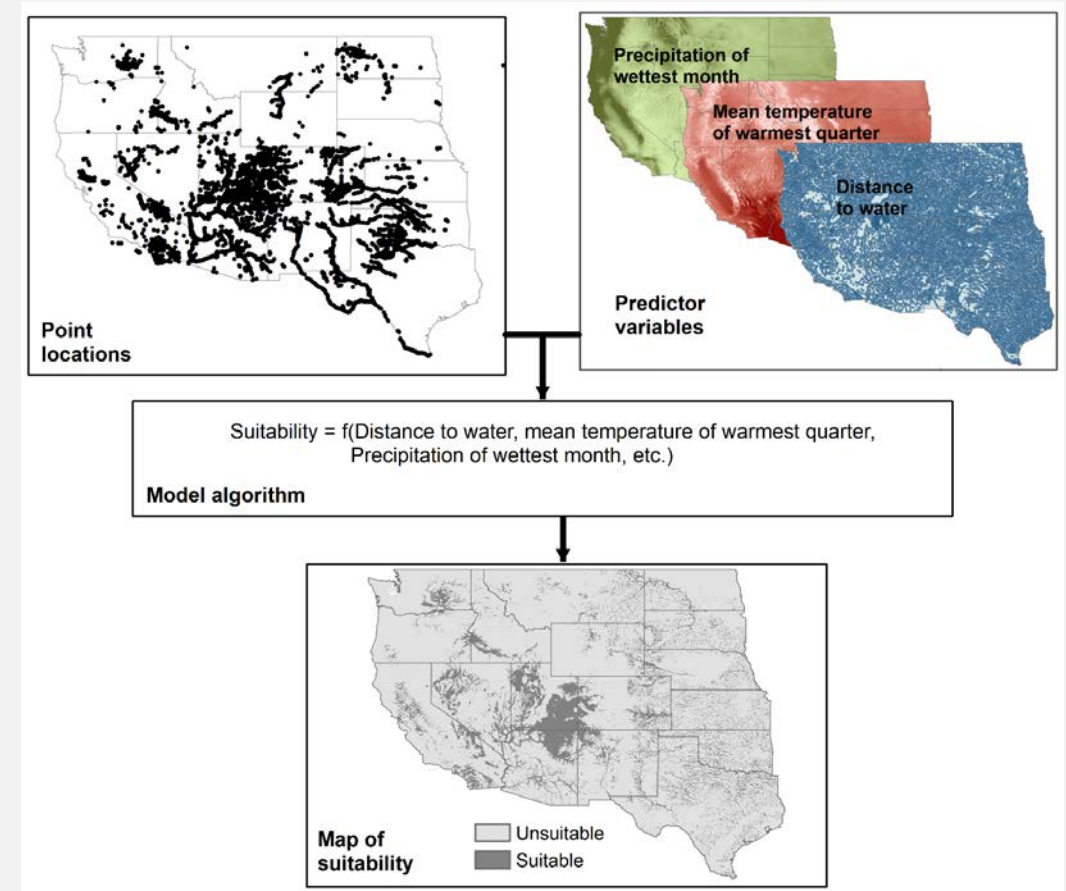
Definitions

- **Scenario Planning:** a “*systematic method for thinking creatively about possible complex and uncertain futures. The central idea of scenario planning is to consider a variety of possible futures that include many of the important uncertainties in the system rather than to focus on the accurate prediction of a single outcome.*” Peterson, G.D. et al. (2003)
- **Ecological Forecasting:** a prediction of how ecosystems will change in the future in response to environmental factors
- **Species Ecological Niche:** a set of conditions necessary for a species survival and reproduction. Those conditions can be external (e.g. environmental) or internal (e.g. density dependency).

Peterson, G. D., Cumming, G. S. and Carpenter, S. R. (2003), Scenario Planning: a Tool for Conservation in an Uncertain World. *Conservation Biology*, 17: 358–366.

Species Distribution Models

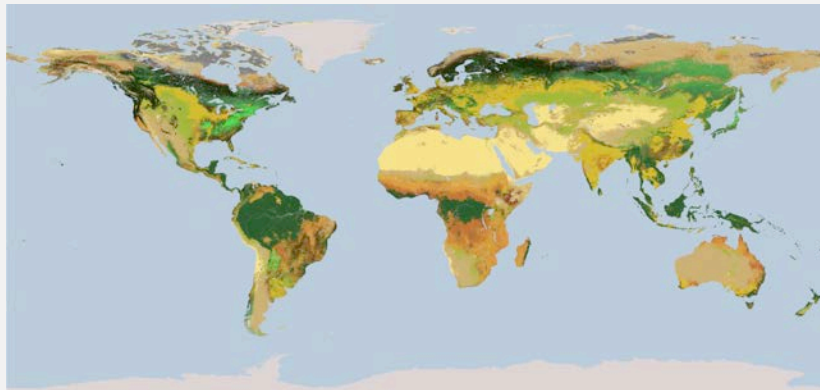
- Species Distribution Models allow you to assess the suitability of a habitat for a species
- The models use raster-based layers such as land use/land cover, elevation, and others as predictors of suitable habitats
- The predictor data is combined with ground-collected presence-absence or abundance data in empirical statistical models



Jarnevich, C. S., T. J. Stohlgren, S. Kumar, J. T. Morrisette, and T. R. Holcombe, 2015, Caveats for Correlative Species Distribution Modeling: Ecological informatics, v. 29, p. 6-15.

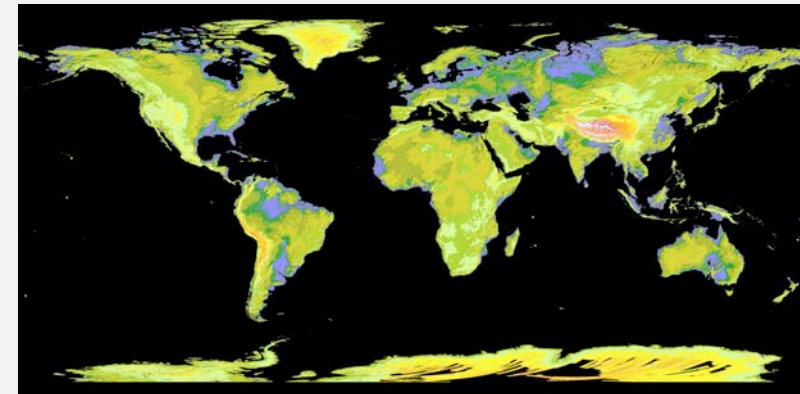
Predictor Variables

- Remote sensing products
 - Land Cover
 - NDVI/phenology
 - Burn severity
 - Tree mortality (insect/disease)



MODIS Land Cover Product

- Topography
 - Elevation, slope, aspect
- Climatology
 - Temperature (min., max., mean, etc.)
 - Precipitation (min., max., etc.)



ASTER Digital Elevation Model (DEM)

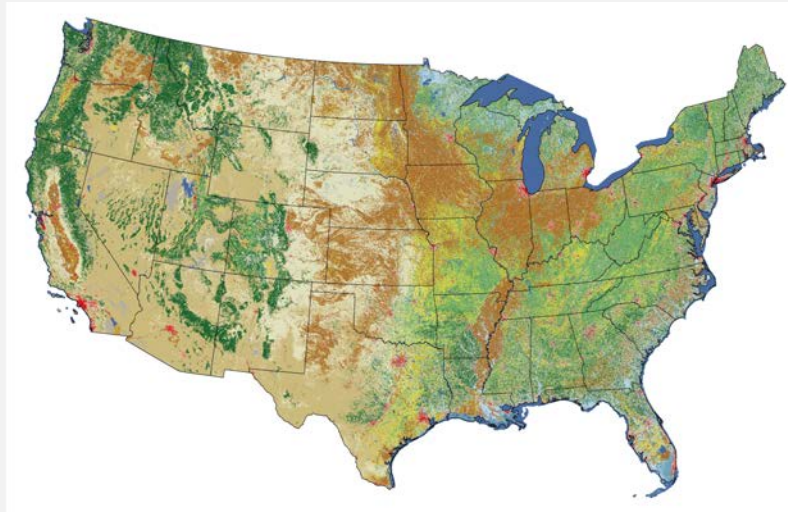
A satellite-style map of Gombe National Park. A red line traces a boundary across the terrain, which is a mix of green forested areas and brownish, cleared or agricultural land. A semi-transparent grey rectangle is overlaid on the map, containing text and a horizontal line.

Gombe
National Park

Land Cover Products

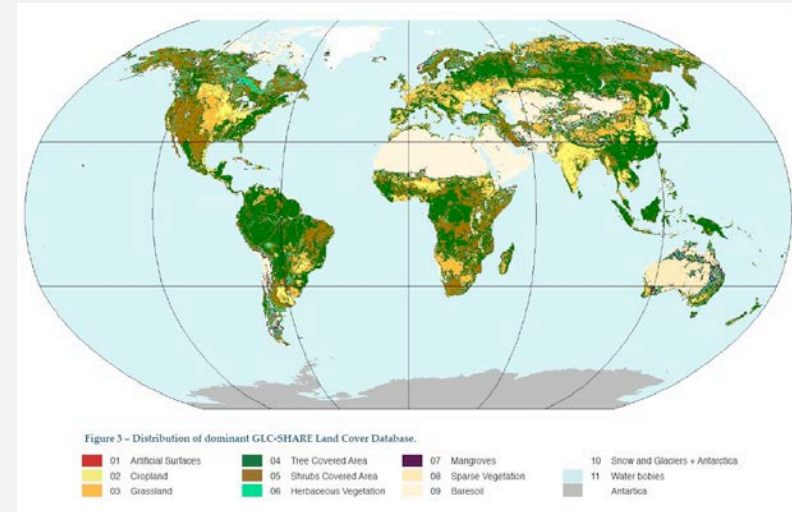
Land Cover Products

- United States
 - National Land Cover Database (NLCD)
 - GAP Analysis
 - Landfire



National Land Cover Database 2011

- Global
 - MODIS Land cover product
 - FAO Global Land Cover-SHARE
 - ESA Climate Change Initiative Land Cover

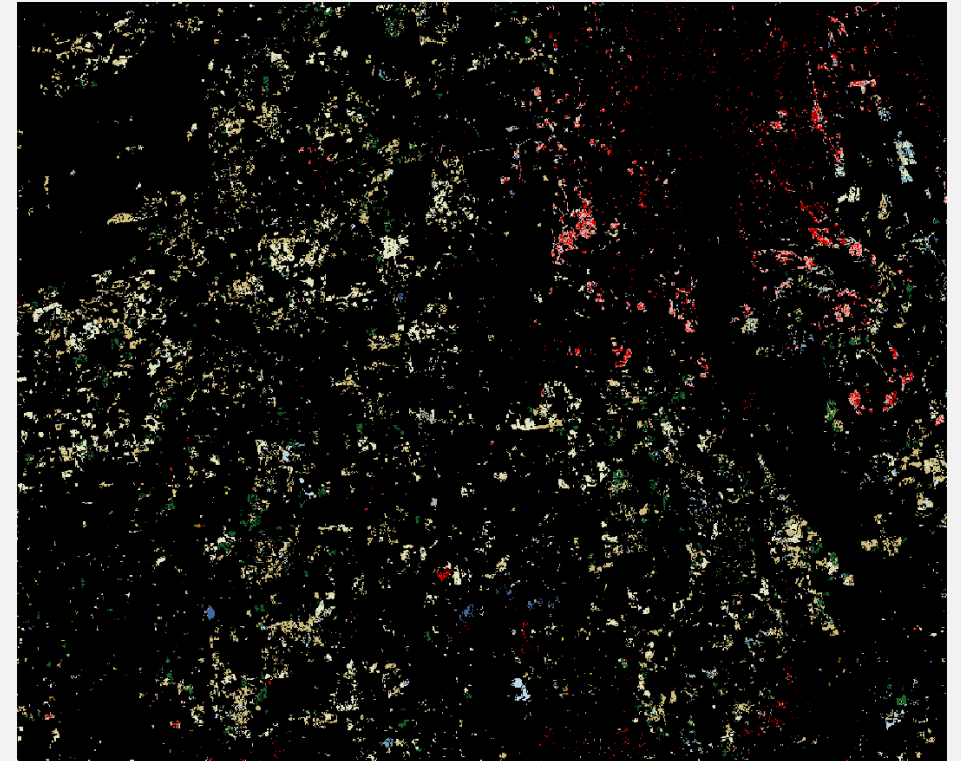


FAO Global Land Cover

National Land Cover Database (NLCD)

United States

- Landsat-based, 30 m resolution
- 16 land cover classes
- 2001, 2006, 2011
- Other products include:
 - Land Cover Change (1992/2001)
 - Percent Tree Canopy (2001)
 - Percent Developed Imperviousness for (1992, 2001, and 2006)
- <https://www.mrlc.gov/index.php>



Land cover changes in northeastern Florida, reds indicate conversion to development, browns/yellows indicate shrubland and grassland, and blues indicate open water (NLCD 2011).

LANDFIRE

United States

- A vegetation, fire and fuel characteristic mapping program
- Products include: Vegetation, fire regime, fuels, disturbance and topographic
- Spatial resolution: 30 meters
- The base product suite was developed in 2001 with updates in 2008, 2010, 2012 and 2014.
- LANDFIRE 2015 is a complete remapping effort and is currently underway
- <https://www.landfire.gov>

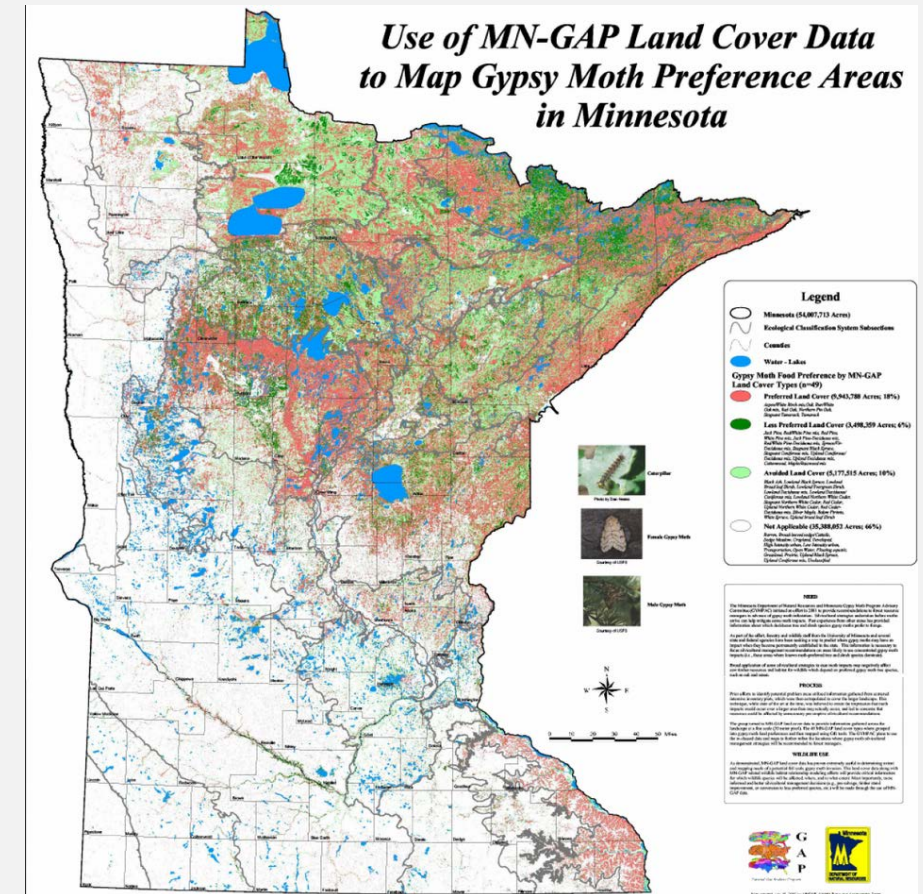


Zahn, S.G., 2015, LANDFIRE: U.S. Geological Survey Fact Sheet 2015-3047, 2 p.

GAP/LANDFIRE

United States

- Combines land cover data generated by the GAP program with LANDFIRE data
- Spatial resolution: 30 m
- Dates of imagery used: 1999 – 2001
- More information:
 - <https://gapanalysis.usgs.gov/gaplandcover/>
- Imagery can be downloaded directly or visualized through a web-based viewer



Gergely, K.J., and McKerrrow, A., 2016, Terrestrial ecosystems—National inventory of vegetation and land use (ver. 1.1, August 2016): U.S. Geological Survey Fact Sheet 2013–3085, 1 p., <https://pubs.usgs.gov/fs/2013/3085/>.


National Gap Analysis Program (GAP) | Land Cover Data Viewer

[GAP HOME](#) [LAND COVER HOME](#)

Contact Us   

Build a Map

Select a Land Cover Area

State 

County 

- or -













LCC 

Select NVC Level or Land Use Class

- Class
- Formation
- Macrogroup 
- Ecological System

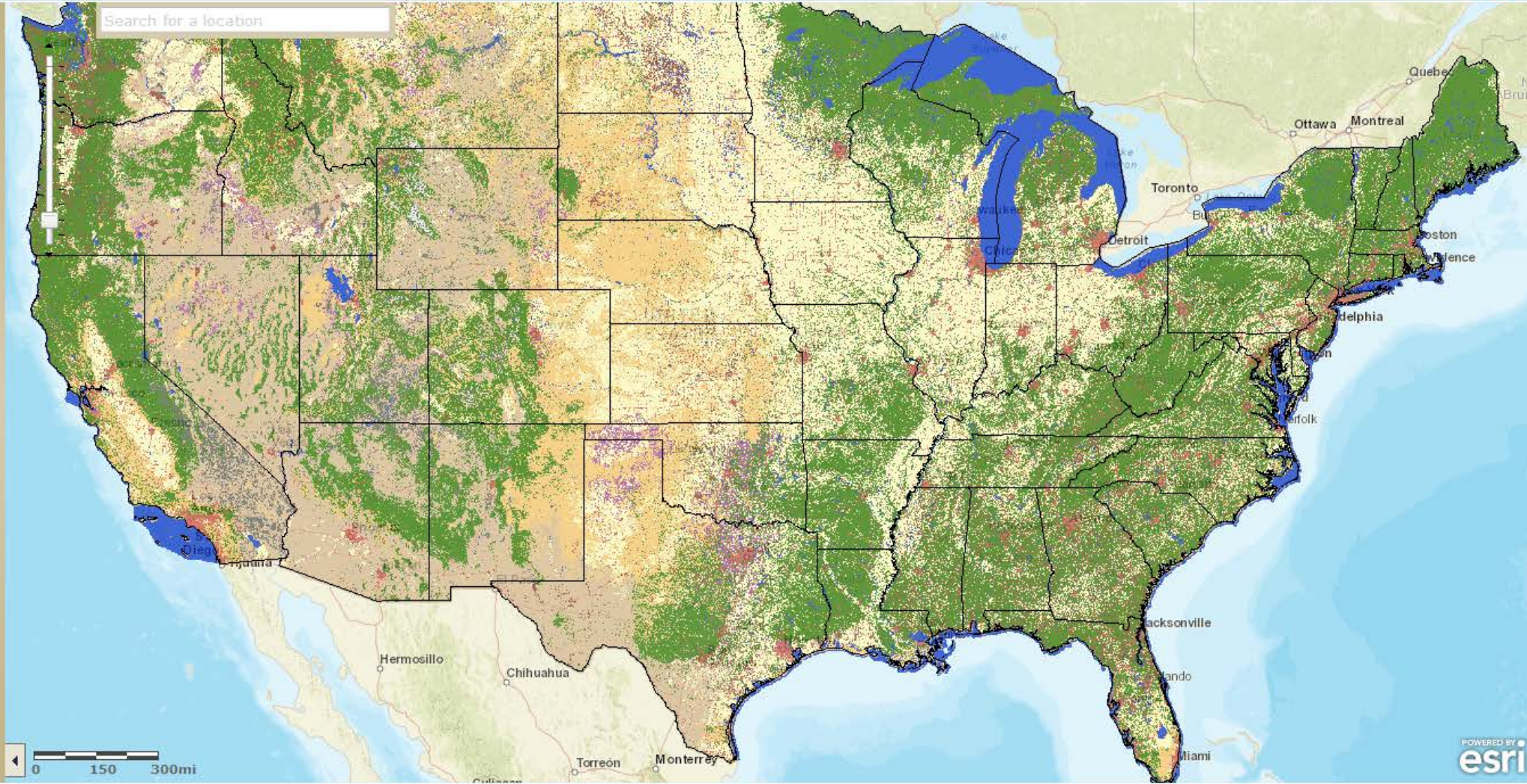
Please select a state or LCC to view Macrogroups and Ecological Systems.

Legend

-  Forest & Woodland
-  Shrubland & Grassland
-  Semi-Desert
-  Polar & High Montane Vegetation
-  Aquatic Vegetation
-  Nonvascular & Sparse Vascular Rock Vegetation
-  Agricultural Vegetation
-  Developed & Other Human Use
-  Introduced & Semi Natural Vegetation
-  Recently Disturbed or Modified
-  Open Water
-  Mixed physiognomy wetlands

Select a Base Map

- Streets
- Basic Reference
- Satellite
- USGS Topographic 



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[Reset](#) [Printable Map](#) [Report](#) [Download Data](#) [Metadata](#)



National Gap Analysis Program (GAP) | Land Cover Data Viewer

[GAP HOME](#)

[LAND COVER HOME](#)

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Build a Map

Select a Land Cover Area

State

County

- or -

LCC

Select NVC Level or Land Use Class

- Class
- Formation
- Macrogroup
- Ecological System

Please select a state or LCC to view Macrogroups and Ecological Systems.

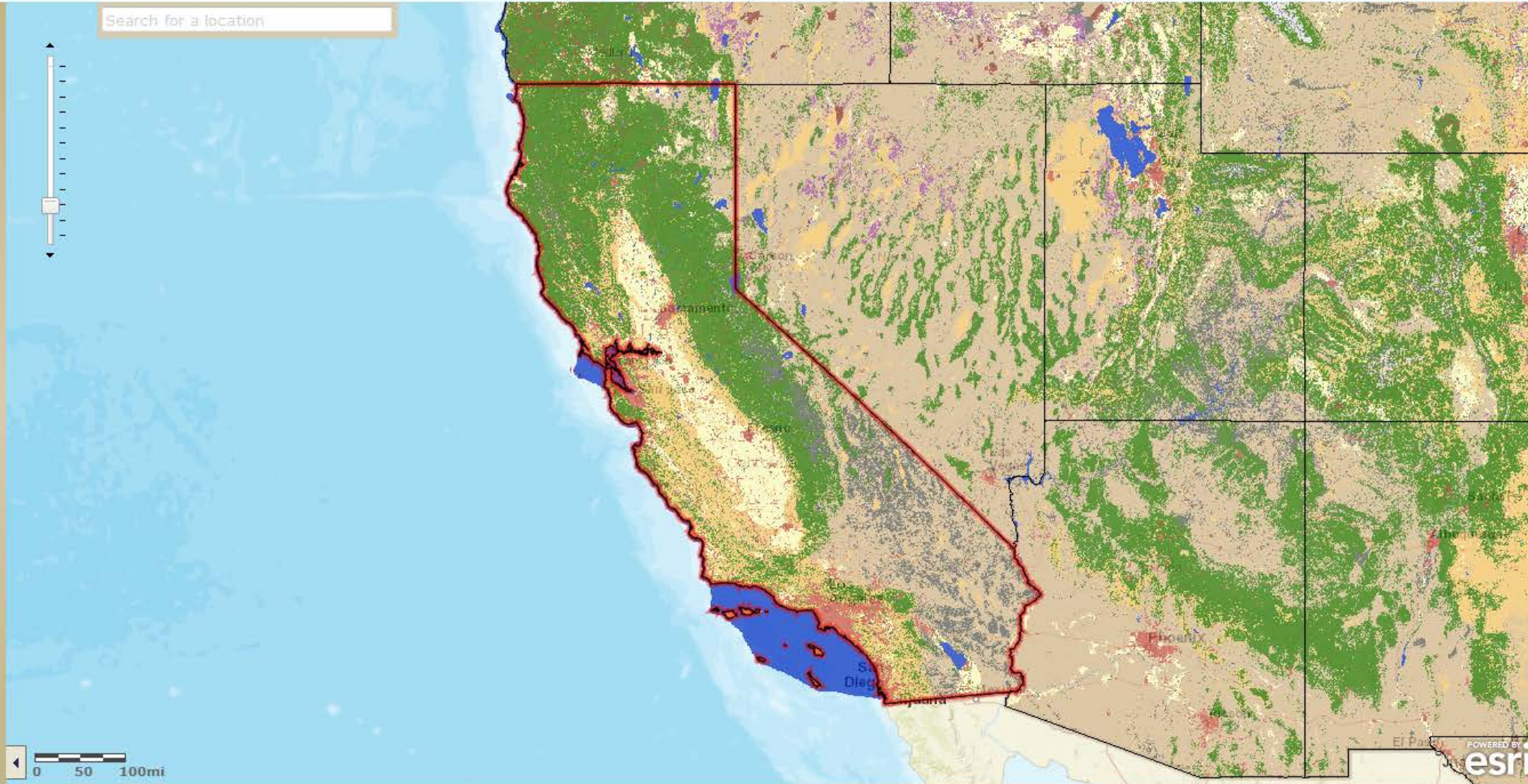
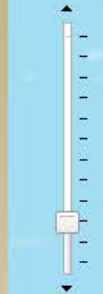
Legend

- Forest & Woodland
- Shrubland & Grassland
- Semi-Desert
- Polar & High Montane Vegetation
- Nonvascular & Sparse Vascular Rock Vegetation
- Agricultural Vegetation
- Developed & Other Human Use
- Introduced & Semi Natural Vegetation
- Recently Disturbed or Modified
- Open Water

Select a Base Map

- Streets
- Basic Reference
- Satellite
- USGS Topographic

Search for a location

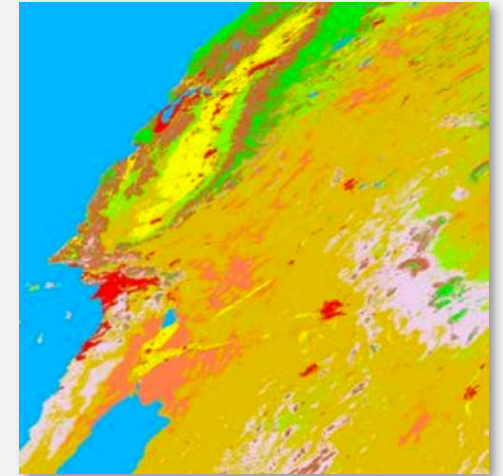


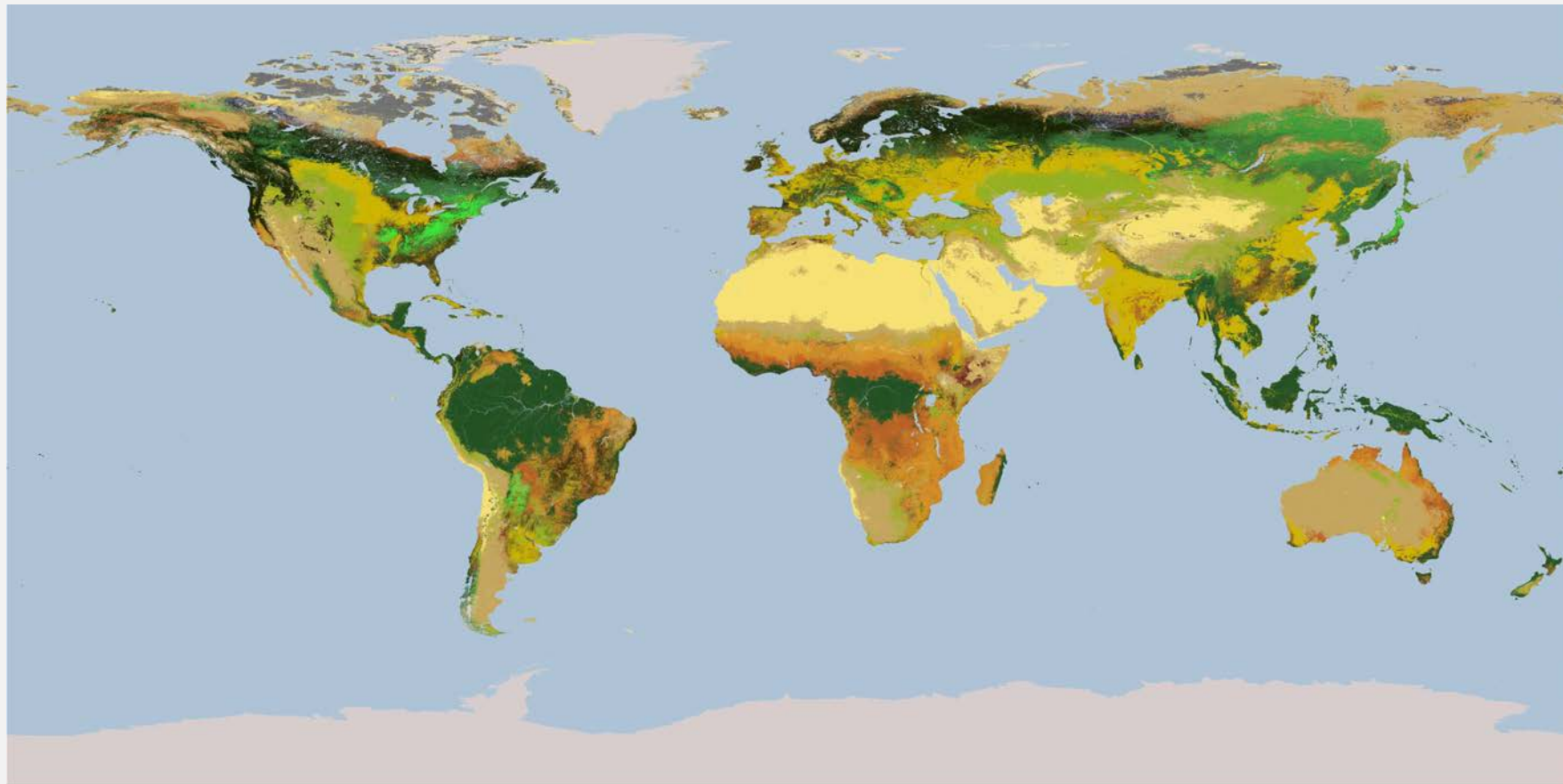
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MODIS Land Cover (MCD12Q1)

- 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 m
- 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>





EARTHDATA Search

Browse Collections

Features

- Map Imagery
- Near Real Time
- Subsetting Services

Keywords

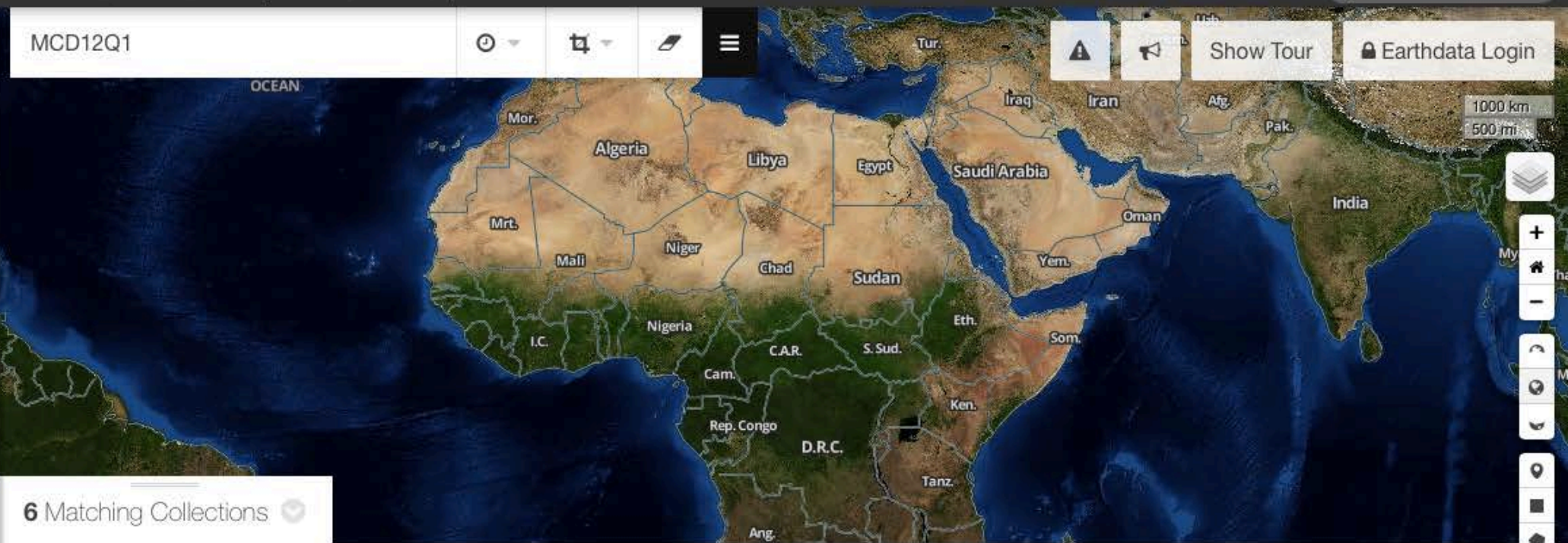
Platforms

Instruments

Organizations

Projects

Processing levels



MCD12Q1

Show Tour Earthdata Login

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

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...

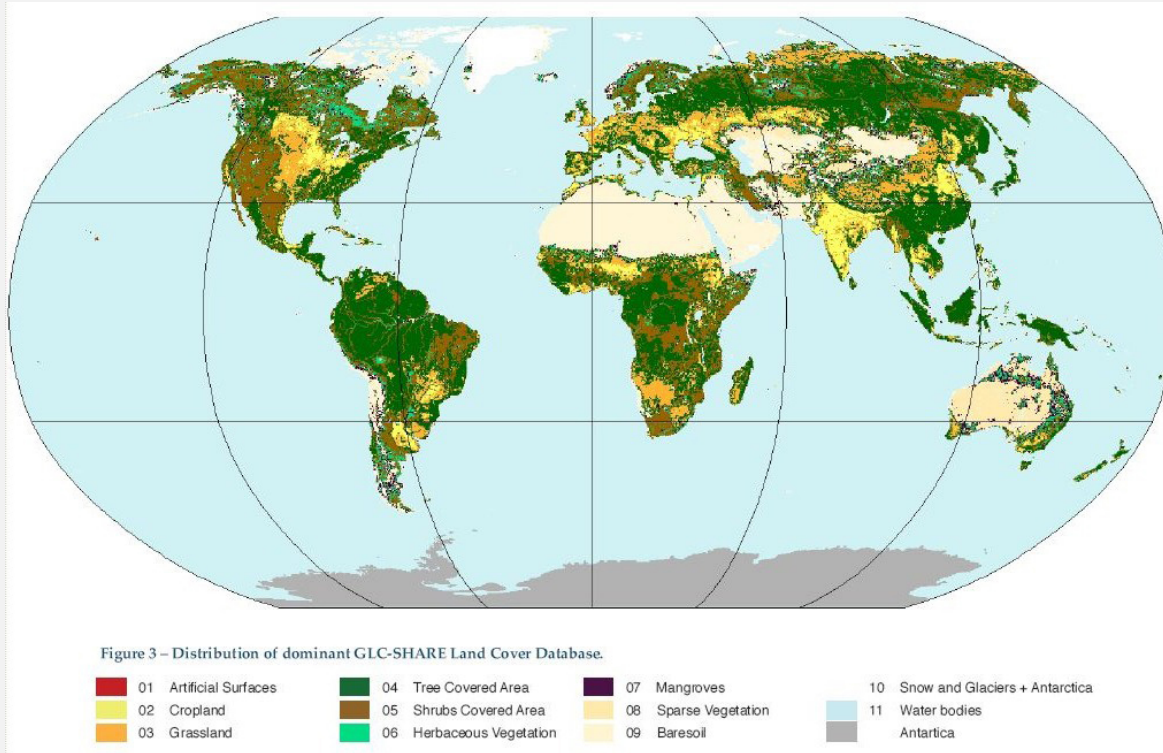
SUBSETTING MCD12Q1 v051 - LP DAAC

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

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.glcnet.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 m
- Remote Sensing Sources:
 - NOAA AVHRR
 - SPOT
 - ENVISAT
 - PROBA-V
- 22 land cover classes based on the UN Land Cover Classification System
- Visualize and download:
 - CCI Land Cover viewer: <http://maps.elie.ucl.ac.be/CCI/viewer/>





Land cover legend

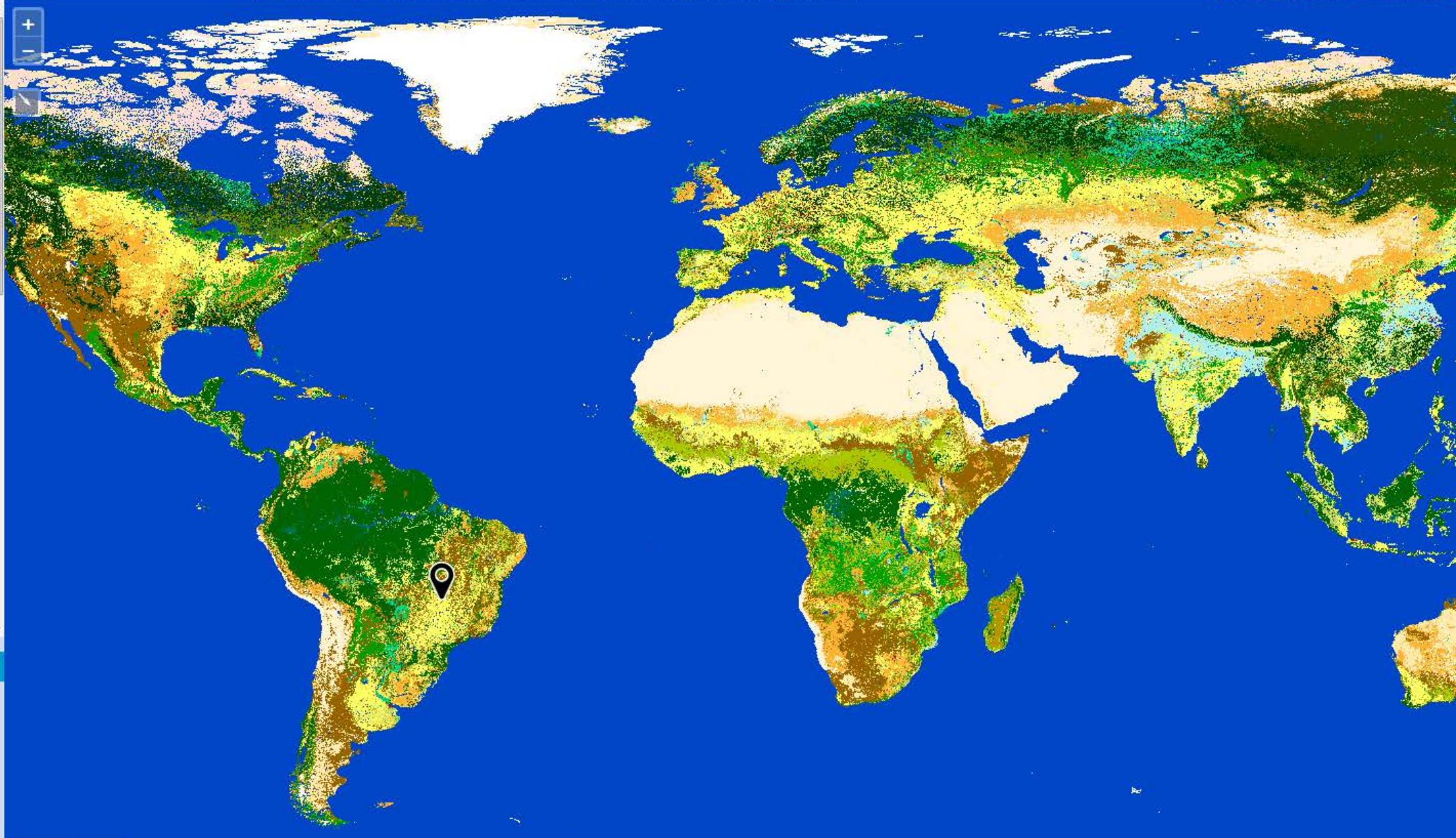
view global (level 1)

- 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, deciduous, open (>15%)

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](#)



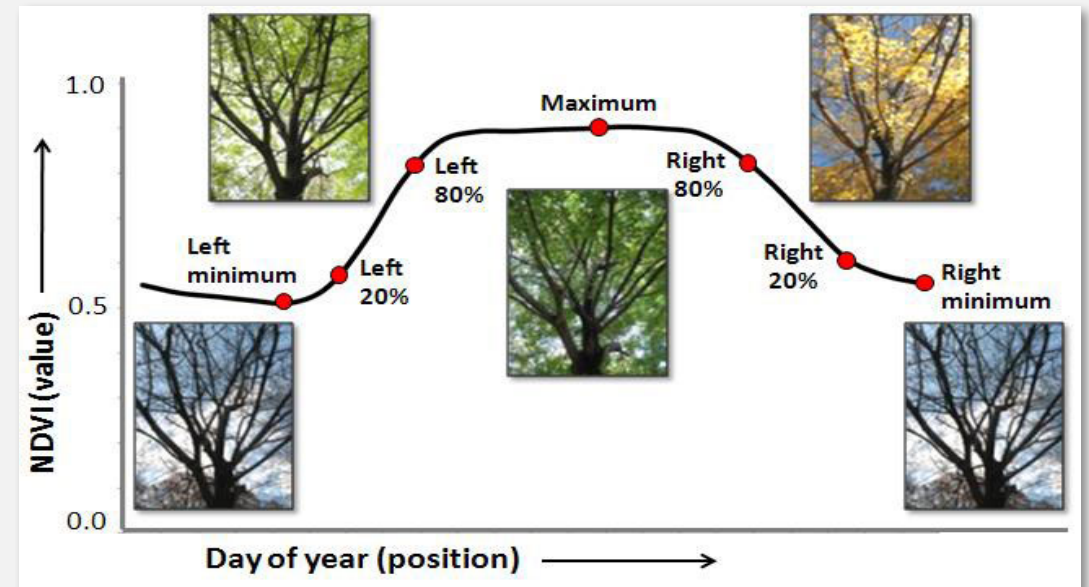


Gombe
National Park

Phenology

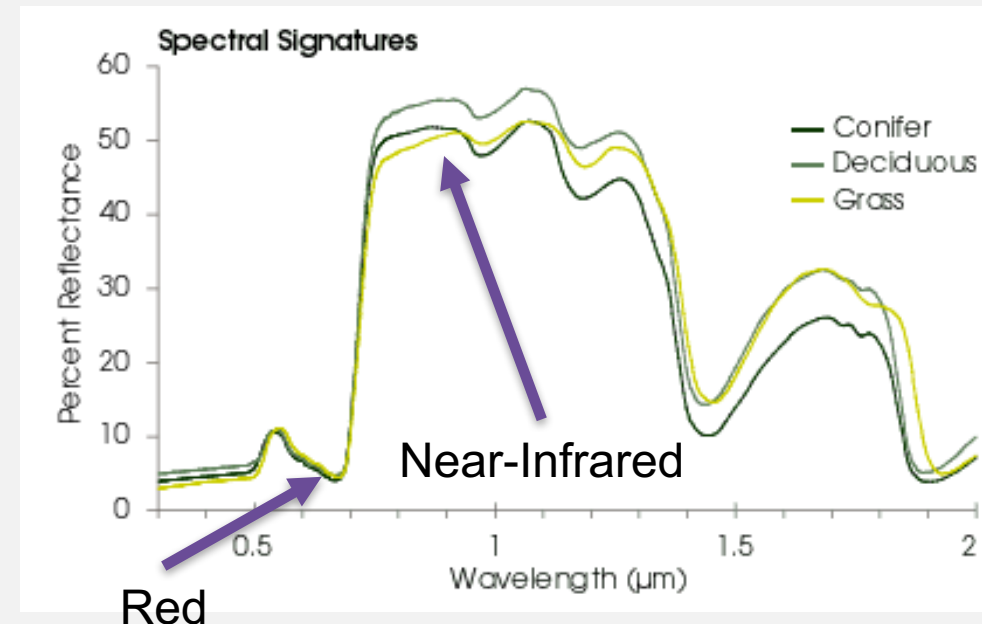
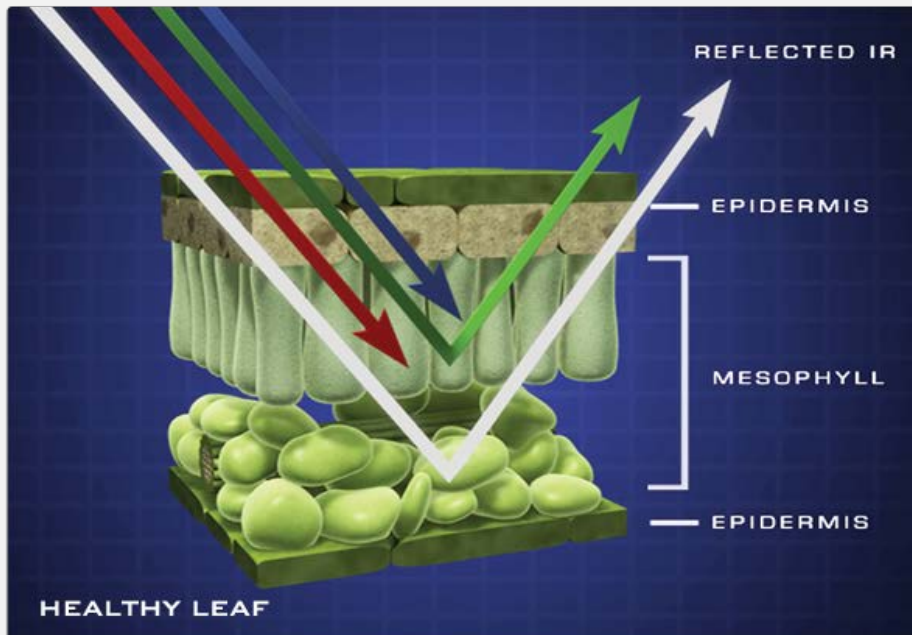
What is Phenology?

- Phenology is the study of the timing of biological events in plants and animals such as flowering, leafing, and hibernation
- Plant phenology is the annual dynamic of vegetation greenness (green-up and green-down)
- Vegetation indices from satellite imagery (such as NDVI or EVI) can be used to monitor plant phenology



What is NDVI?

- Normalized Difference Vegetation Index
 - Based on the relationship between red and near-infrared wavelengths
 - Chlorophyll strongly absorbs visible (red)
 - Plant structure strongly reflects near-infrared



What is NDVI?

- NDVI Formula:

$$\frac{\text{Near-Infrared} - \text{Red}}$$
$$\frac{\text{Near-Infrared} + \text{Red}}$$

- Values range from -1.0 to 1.0
 - Negative values to 0 mean no great leaves
 - Values close to 1 indicate the highest possible density of green leaves

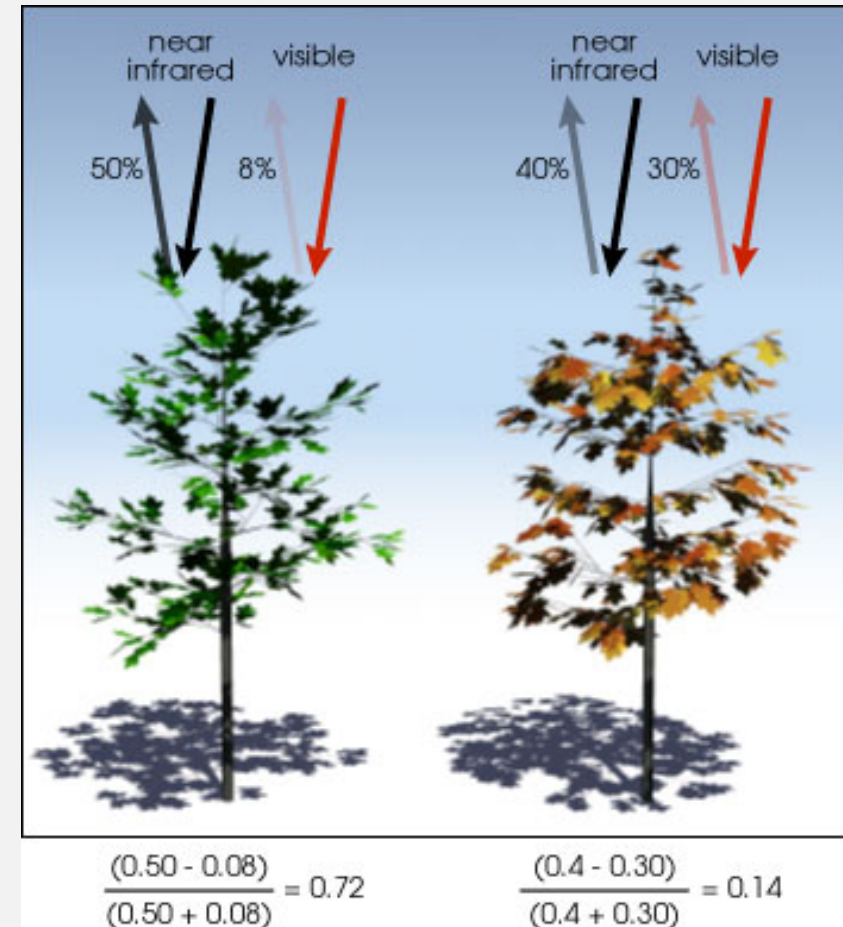
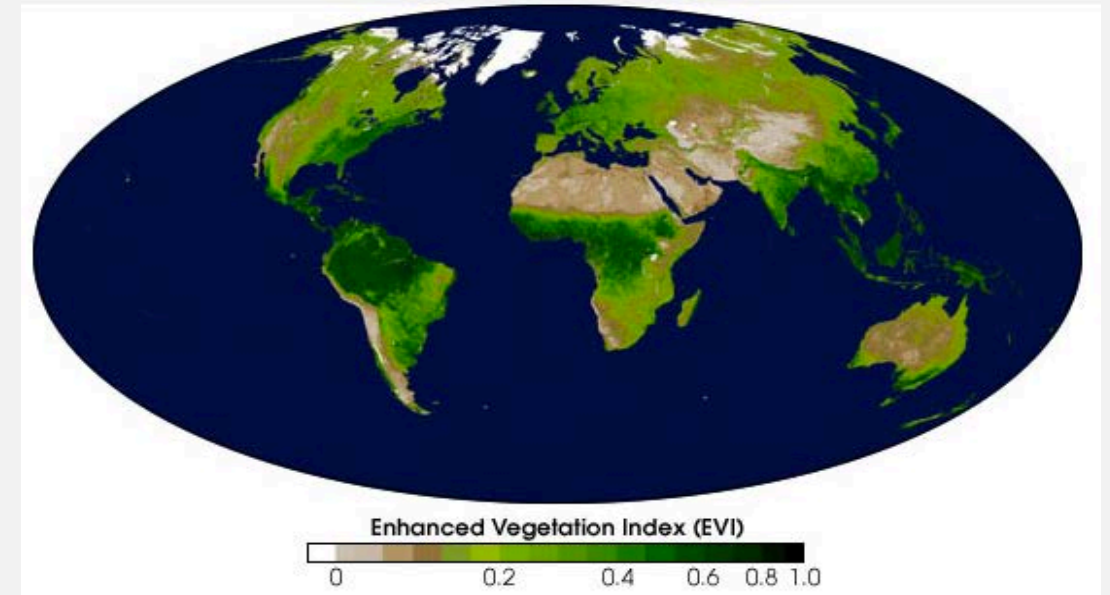


Image Credit: Robert Simmon/NASA Earth Observatory

What is EVI?

- Enhanced Vegetation Index (MOD13Q1) – only from MODIS
 - Maintains sensitivity over dense vegetation conditions
 - Uses the blue band to remove residual atmosphere contamination caused by smoke and sub-pixel thin clouds
- Formula:
$$\frac{2.5 * NIR - Red}{NIR + C1 * Red - C2 * Blue + L}$$
- Where C1, C2 and L are coefficients to correct for atmospheric condition
- For the standard MODIS EVI product:
 - C1 = 6, C2 = 7.5, L=1



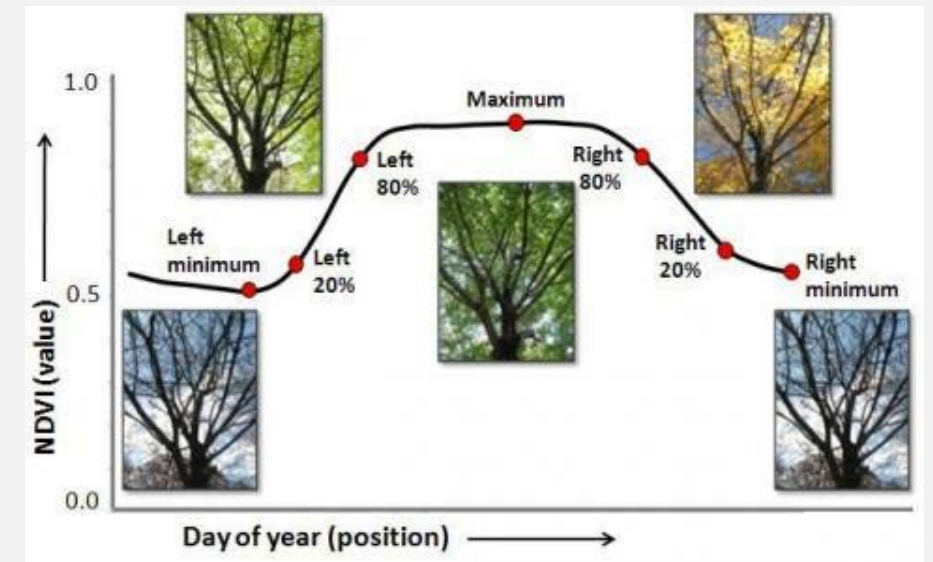
Phenology from Satellites

- Remote sensing is used to track the seasonal changes in vegetation
- Monthly NDVI or EVI images from MODIS or Landsat can be used to monitor phenology



Left: North American NDVI images in winter and summer. Credit: <http://spacegrant.montana.edu>

Right: USDA ForWarn



Phenology Products

- MODIS Land Cover Dynamics (MCD12Q2) and VIIRS Global Land Surface Phenology (VNP12Q2)
 - Spatial resolution: 500 m
 - Produced annually
 - Primarily uses EVI
 - MCD12Q2 Version 5 available through Earthdata Search:
<https://search.earthdata.nasa.gov/search>
 - MCD12Q2 Version 6 and VNP12Q2 coming soon



Gombe
National Park

Burn Severity

Burn Severity

- Degree to which a site has been altered or disrupted by fire
- Loosely, a product of fire intensity and residents time
- The effect of a fire on ecosystem properties, often defined by the degree of mortality of vegetation



Landsat image of the Soberanes Fire in California from September 15, 2016.

How do we connect pixels in a satellite image to burn severity?



Right: Post-wildfire landscape. Image Credit: Bcasterline

Landsat for Post-Fire Mapping

Exploiting Spectral Response Curves

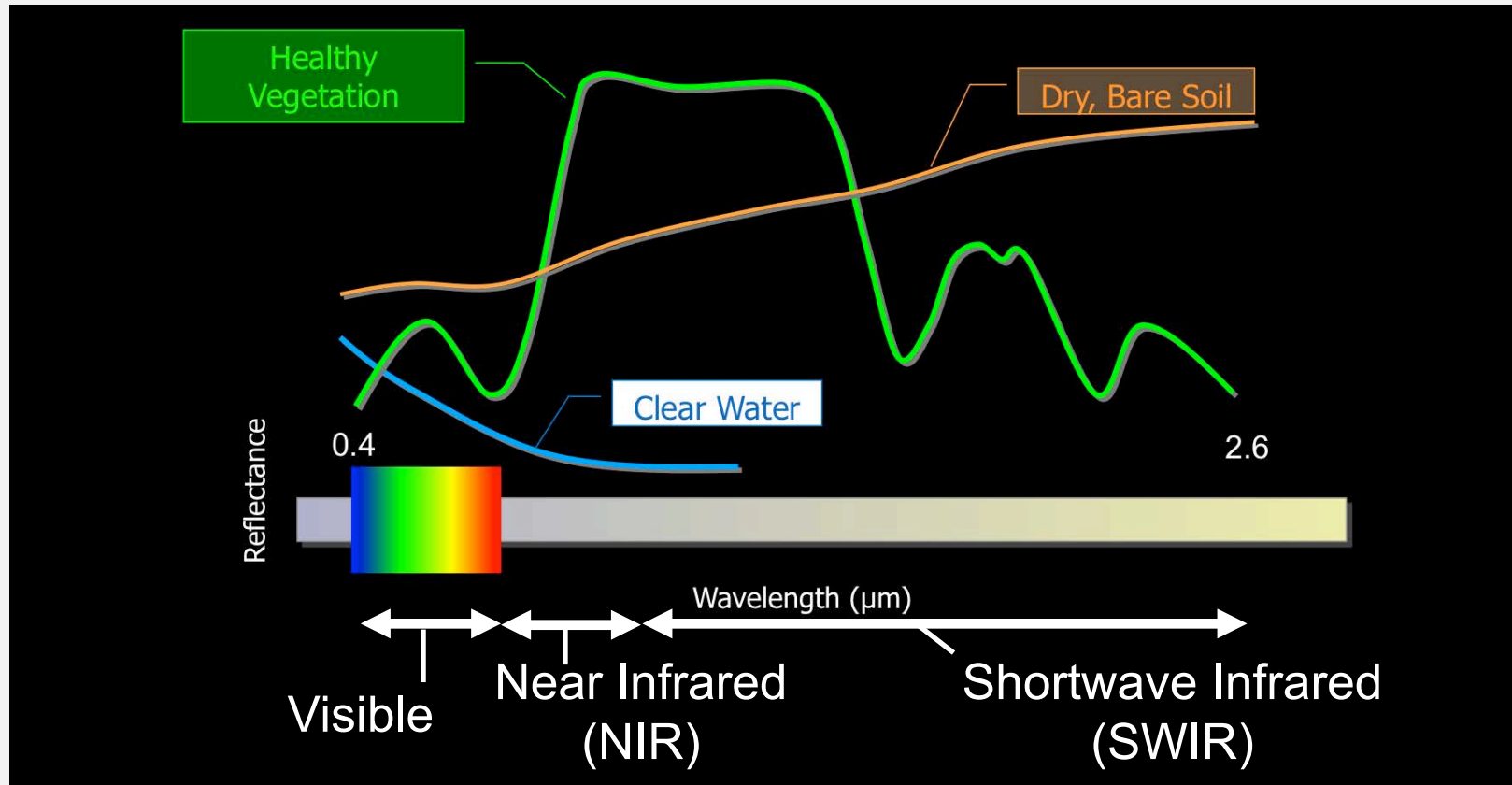
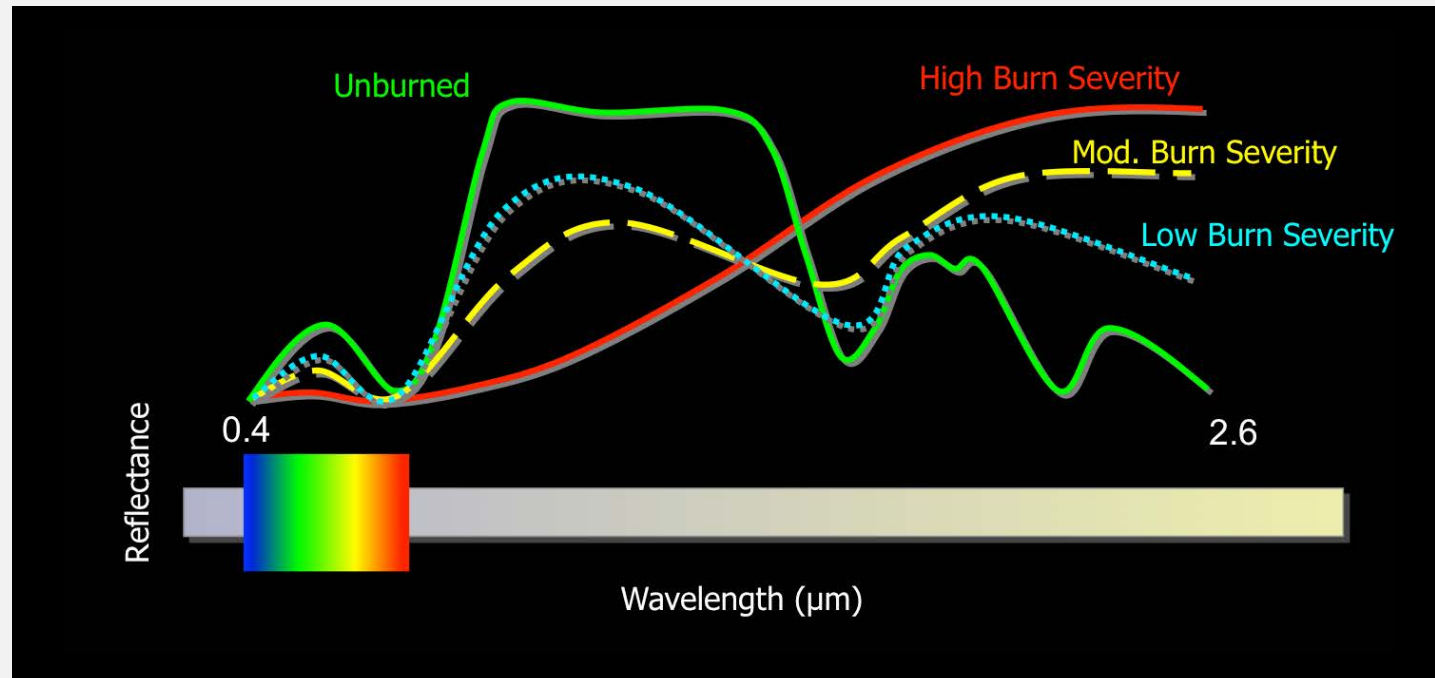


Figure modified from USDA Forest Service, RSAC

Landsat for Post-Fire Mapping

Exploiting Spectral Response Curves



The goal of remote sensing is to take advantage of differences in spectral response curves to distinguish one thing from another

Figure modified from USDA Forest Service, RSAC

Landsat for Post-Fire Mapping

Exploiting Spectral Response Curves

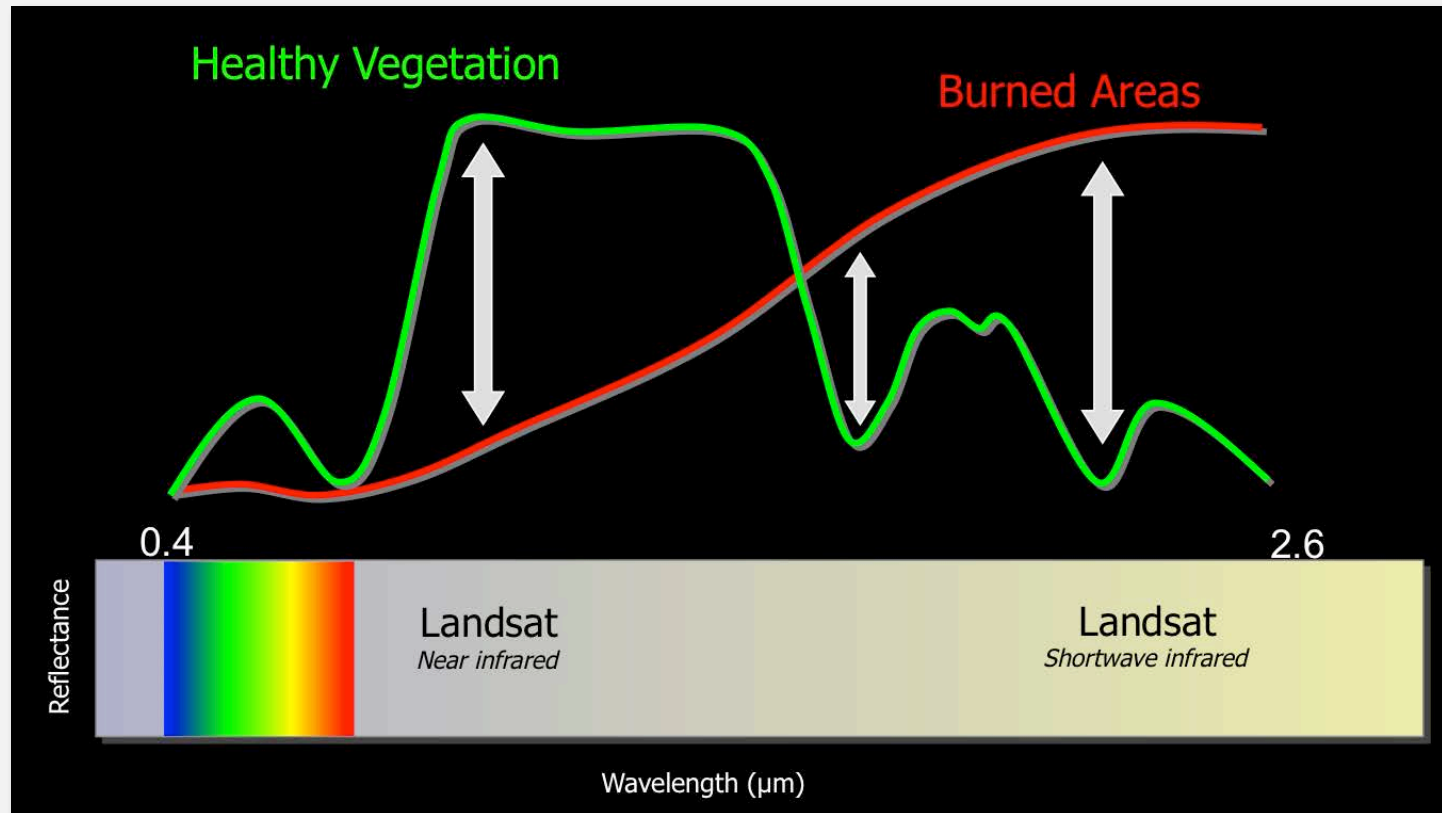
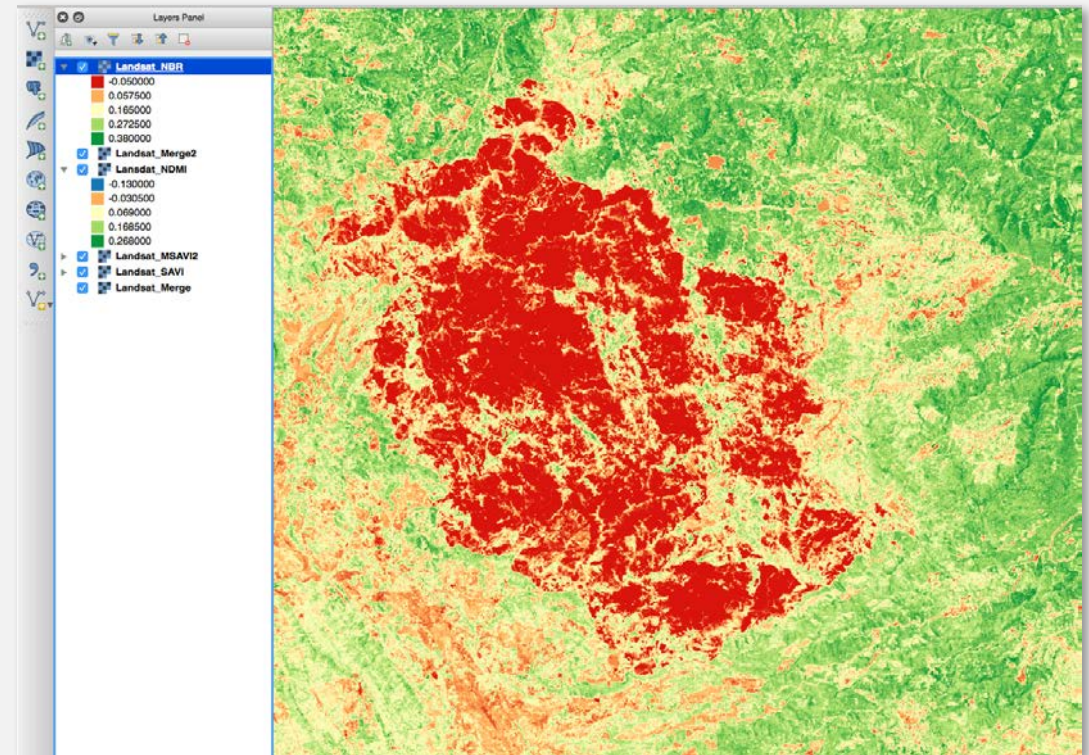


Figure modified from USDA Forest Service, RSAC

Normalized Burn Ratio

- Used to identify burned areas
- Compare pre- and post-burn to identify burn extent and severity
- Use Band 7 for SWIR in Landsat 8 images
- Can be used to create a Burned Area Reflectance Classification (BARC)
 - Input to a Burn Severity Map

$$\text{NBR} = \frac{(\text{NIR} - \text{SWIR})}{\text{NIR} + \text{SWIR}}$$



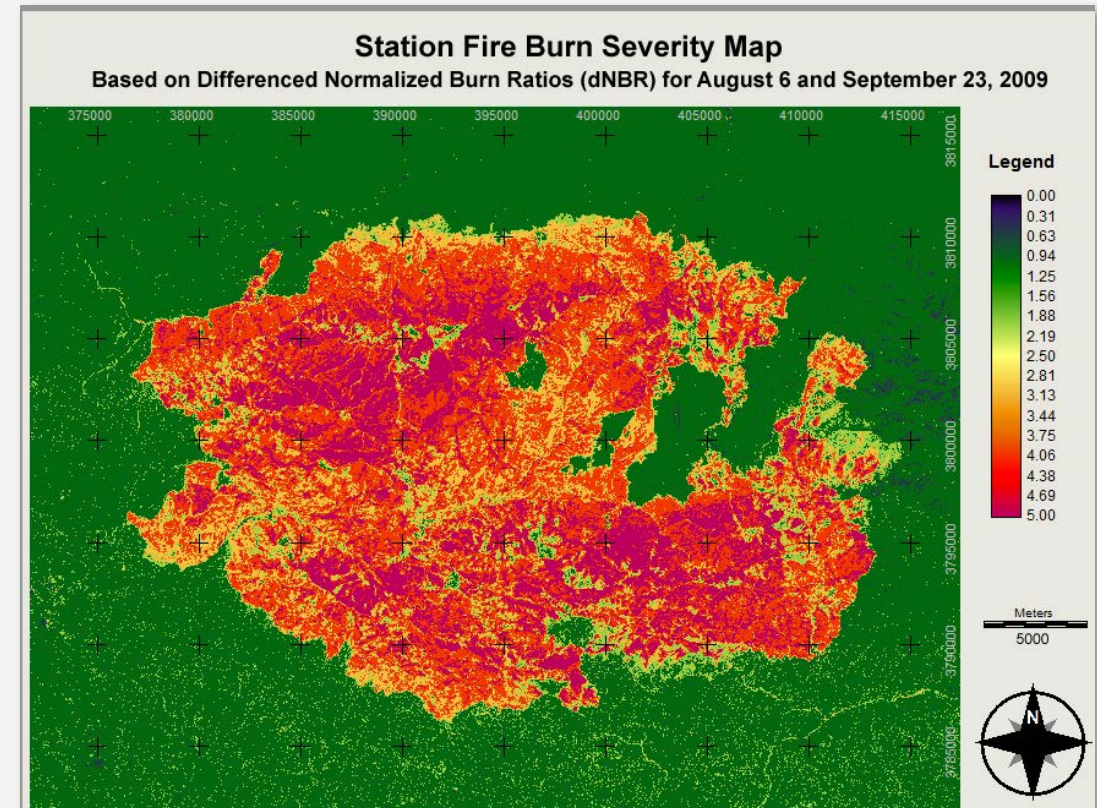
Example of NBR using Landsat in QGIS software. This is the NBR of the Rim Fire in California from August 2013

Landsat for Post-Fire Mapping

- Need at least 2 images:
 - One pre-burn
 - One post-burn
- Create NBR for each image
- Subtract post-fire image from pre-fire image
- Evaluate differenced map

Example of dNBR from the Station fire in Angeles National Forest from August-September 2009. Image Credit: Irene Nester

$$dNBR = NBR_{prefire} - NBR_{postfire}$$



Monitoring Trends in Burn Severity

<http://www.mtbs.gov/>

- Project designed to consistently map burn severity and fire perimeters across the U.S.
 - Partnership: USGS & USDA Forest Service
- Remote sensing and ground-based assessments
- Outputs
 - NBR from Landsat (pre- and post-fire)
 - Differenced NBR (dNBR)
 - Classification of burn severity
 - Based on pre and post imagery, plot data, & analyst's experience with fire behavior
 - Fire Perimeter
 - Geospatial Metadata

Monitoring Trends in Burn Severity (MTBS)

Home
What's NEW?
Background and Partners
Documents and References
Methods
Product Descriptions
Mapping Status
Applying MTBS Data
Project Reports
Data Access
Tech Transfer
Glossary
Related Websites
FAQs

USGS
US
RSAC
MTBS
Forest Service: Accessibility Privacy Policy Important Notices FOIA

MTBS Data Search and Distribution Tools

Query Builder

Selection Criteria:
Temporal Spatial Name Admin Ownership Size Type Assessment Type Data Version

Fire Occurrence Date Release Date

Fire Occurrence Date

For fire occurrences in a specific time period, choose "Select Date Range" and specify the beginning and ending dates by clicking on the calendar icon below and selecting a month, day and year.
For all available fire datasets, choose "All Years".

Select Date Range From: [] To: []
 All Years

Currently Specified Selection Criteria: (only currently enabled criteria below will be applied to the query)

Fire occurrence dates have not been selected.
 Area of Interest has not been selected.
 Fire Names have not been selected.
 Administrative Ownership category has not been defined.
 Fire size has not been defined.
 Fire Types: WF, RX, WPU, UNK
 Assessment Type: Both Initial and Extended Assessments
 Dataset Version Status: Both Original and Revised Datasets

[Back To Introduction] [Submit Query]

Query Results

MTBS Data Search

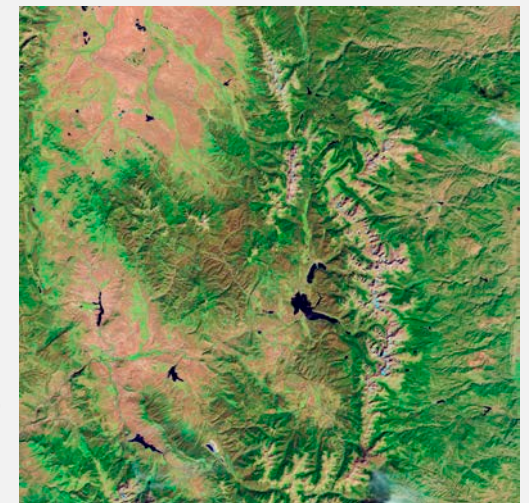
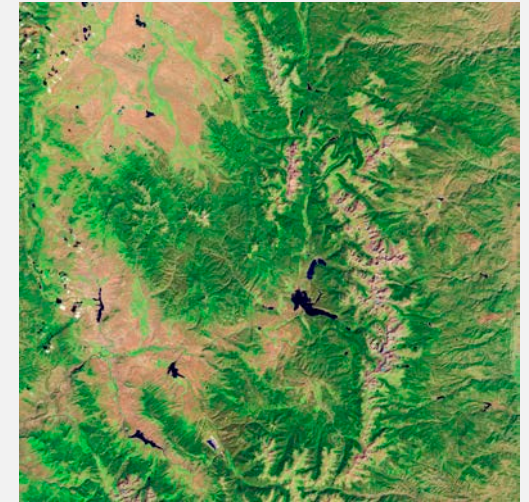


Gombe
National Park

Tree Mortality

Tree mortality/Vegetation disturbance

- Some tree mortality can be easily detected by satellites
 - Must be large enough area
- Sources/Methods
 - Use existing disturbance maps (i.e. Global Forest Watch)
 - Aerial surveys
 - Use change detection methodology

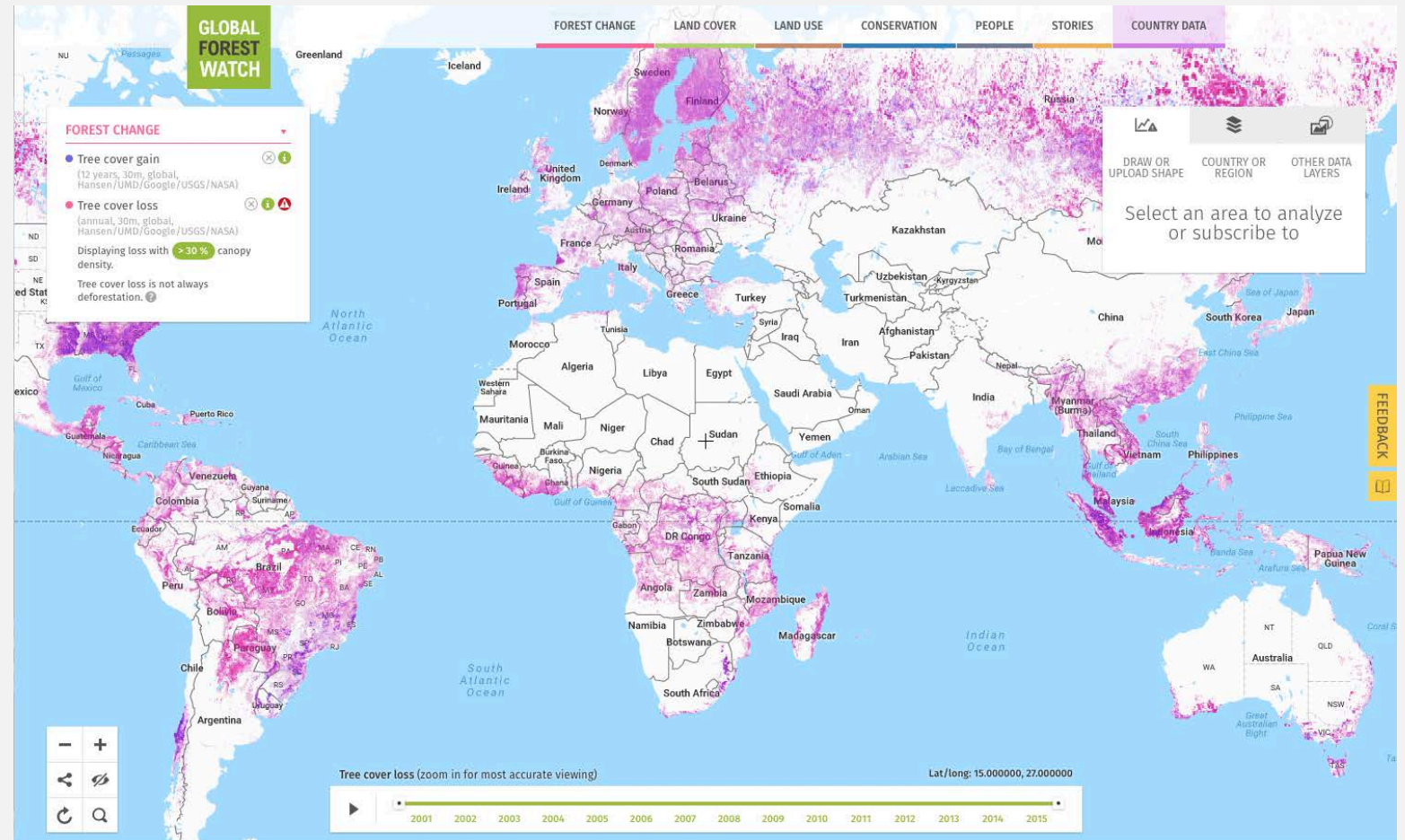


Landsat imagery of bark beetle epidemic in Lodgepole pine forests in Colorado. Top image was acquired in September 2005 and bottom image in September 2011

Global Forest Watch

<http://www.globalforestwatch.org>

- Identifies areas of tree cover loss 2001-2015
- 30 m spatial resolution
- Includes location and amount of disturbance but not cause



DEMOCRATIC REPUBLIC OF THE CONGO DATA

Visit Forest Atlas >

GLOBAL DATA

FOREST CHANGE

- Tree cover gain
- Tree cover loss

Displaying loss with > 30 % canopy density.

Tree cover loss is not always deforestation.

DRAW OR UPLOAD SHAPE COUNTRY OR REGION OTHER DATA LAYERS

DEMOCRATIC REPUBLIC OF THE CO... (x) v

SELECT JURISDICTION (OPTIONAL) v

TOTAL SELECTED AREA
234,363,285 ha

LOSS 2001-2015 with >30% canopy density
9,141,608 ha

GAIN 2001-2012
1,392,581 ha

This algorithm approximates the results by sampling the selected area. Results are more accurate at closer zoom levels.

NOTE: tree cover loss and gain statistics cannot be compared against each other. [Learn more.](#)

SUBSCRIBE

DOWNLOAD DATA SHARE DISCARD ANALYSIS

Map navigation controls: zoom in (+), zoom out (-), home, full screen, refresh, search.

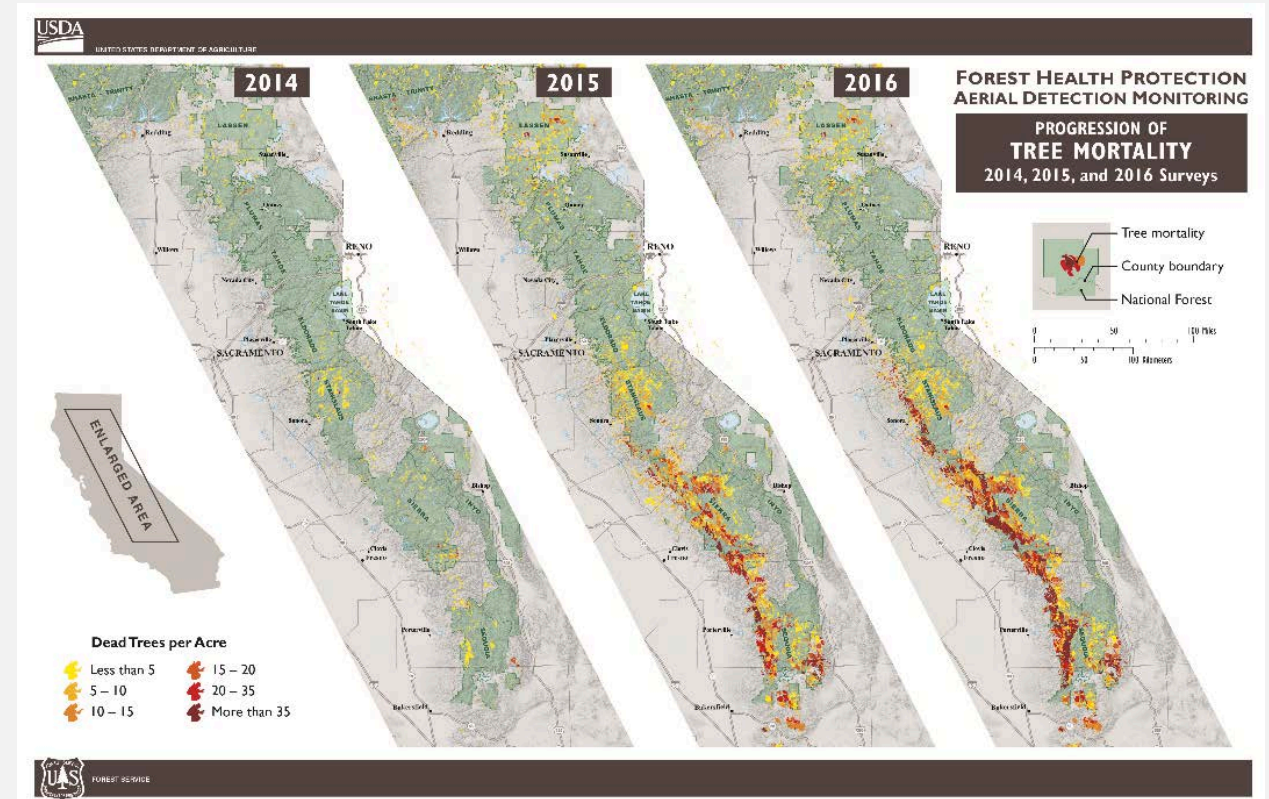
Tree cover loss (zoom in for most accurate viewing)

Timeline slider from 2001 to 2015.

Aerial Surveys

United States

- The US Forest Service collects and reports data on insect, disease and other types of disturbance to forested ecosystems using aerial detection surveys
- Experts fly in planes and identify forest disturbance type and location on digital maps (sketch mapping)
- <https://www.fs.fed.us/foresthealth/fhm/dm/maps/aerial.shtml>



Progression of tree mortality in California from 2014, 2015 and 2016

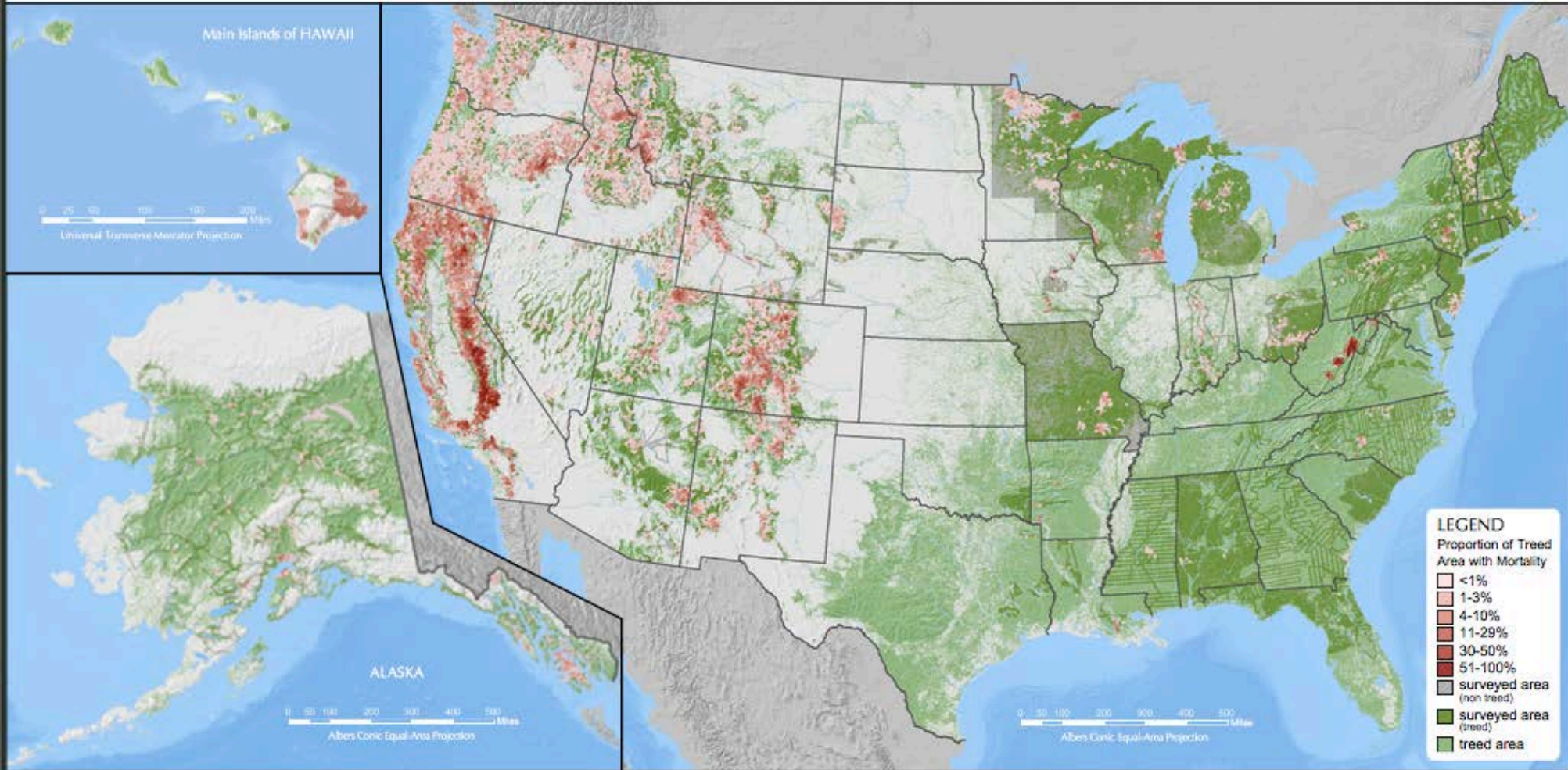


United States Department of Agriculture

FOREST HEALTH PROTECTION

2015 Insect and Disease Survey by Subwatersheds (6th Level HUCs)

Approximate Footprint Acres with Mortality: 6.1 million*



*Acres are summarized from current year's observations only and are not cumulative. The "footprint" total represents the affected area on the ground with no multiple counting of acres affected by multiple mortality agents.

May 2016



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

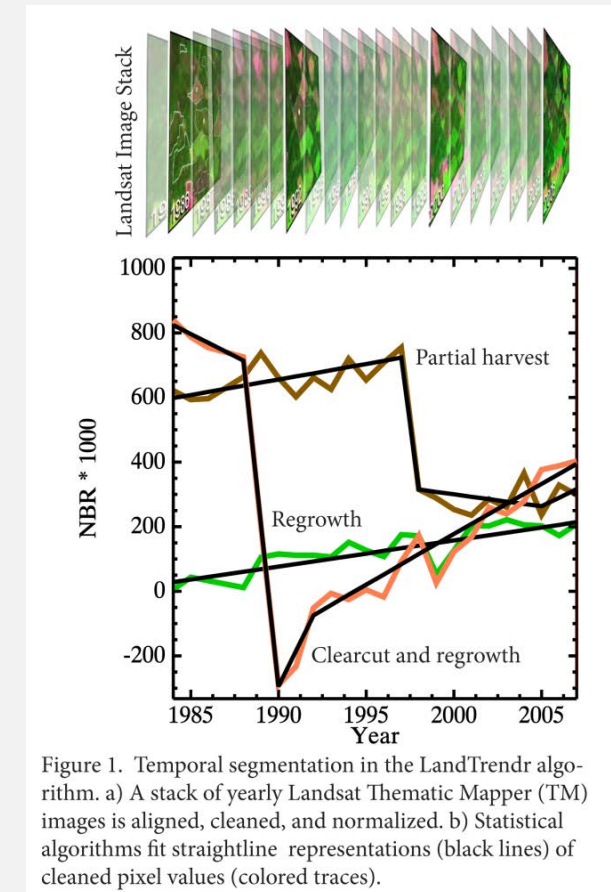


Figure 1. Temporal segmentation in the LandTrendr algorithm. a) A stack of yearly Landsat Thematic Mapper (TM) images is aligned, cleaned, and normalized. b) Statistical algorithms fit straightline representations (black lines) of cleaned pixel values (colored traces).

A satellite-style map of a mountainous region, likely Gombe National Park. A red line traces a boundary across the terrain. A semi-transparent grey box is overlaid on the map, containing text and a horizontal line.

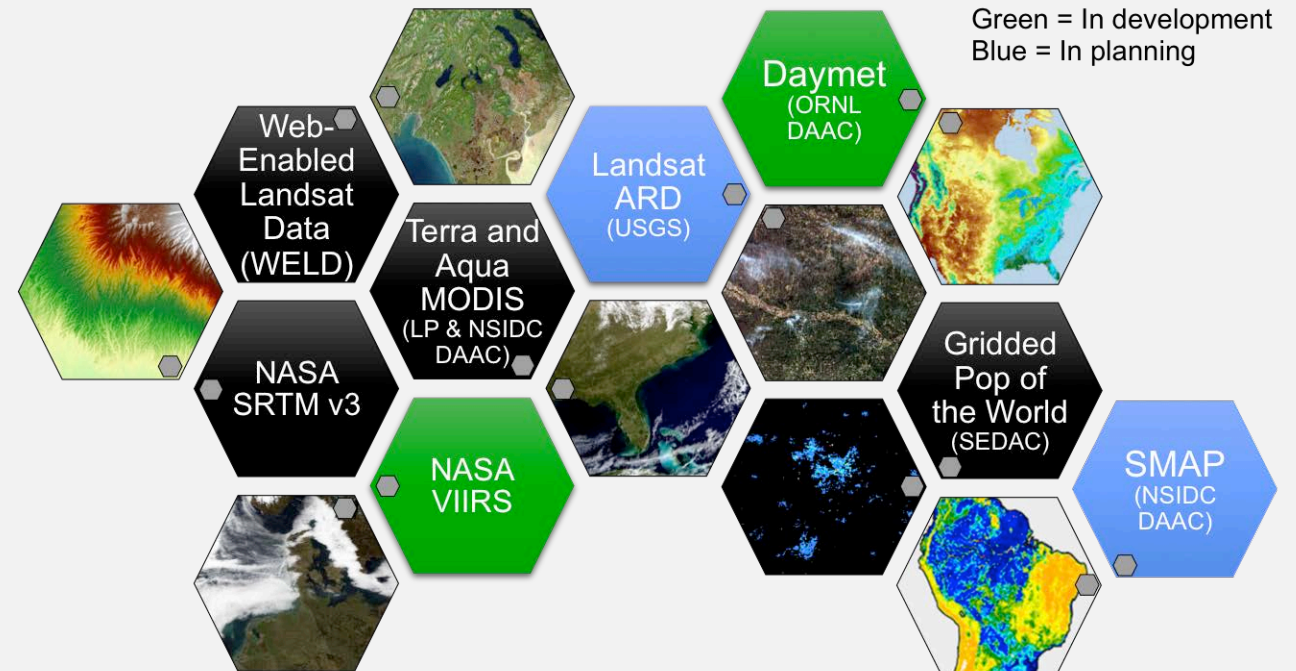
Gombe
National Park

Land Cover Data Access and Tools

Application for Extracting and Exploring Analysis Ready Samples (AppEEARS)

<https://lpdaacsvc.cr.usgs.gov/appeears>

- Quickly extract time series data from multiple datasets at multiple AOIs
- Reduce the amount of data needed to download
- Visualize output of sample results before download
- Receive just the data you want in an easy to analyze format
- Receive fully decoded MODIS and WELD quality information and SRTM source information



Data available or in development from AppEEARS (Image credit: LPDAAC)

AppEEARS: Point Samples (Operational)

User Input: Geographic Coordinates (Points)

Request Form

Extract Point Sample

Enter a name to identify your sample
NEON Appalachians

Upload coordinates from a file

Drop a CSV file containing the coordinates or click here to select the file. Coordinates can also be entered manually in the selected coordinates box.

The CSV file can contain up to 4 columns separated by commas with each coordinate on a separate line.

1. ID (optional) - uniquely identifies the coordinate
2. Category (optional) - label to group common coordinates
3. Latitude - latitude in decimal degrees (-90 to 90)
4. Longitude - longitude in decimal degrees (-180 to 180)

Start Date: 01-01-2007 End Date: 02-22-2017

Date Recurring?

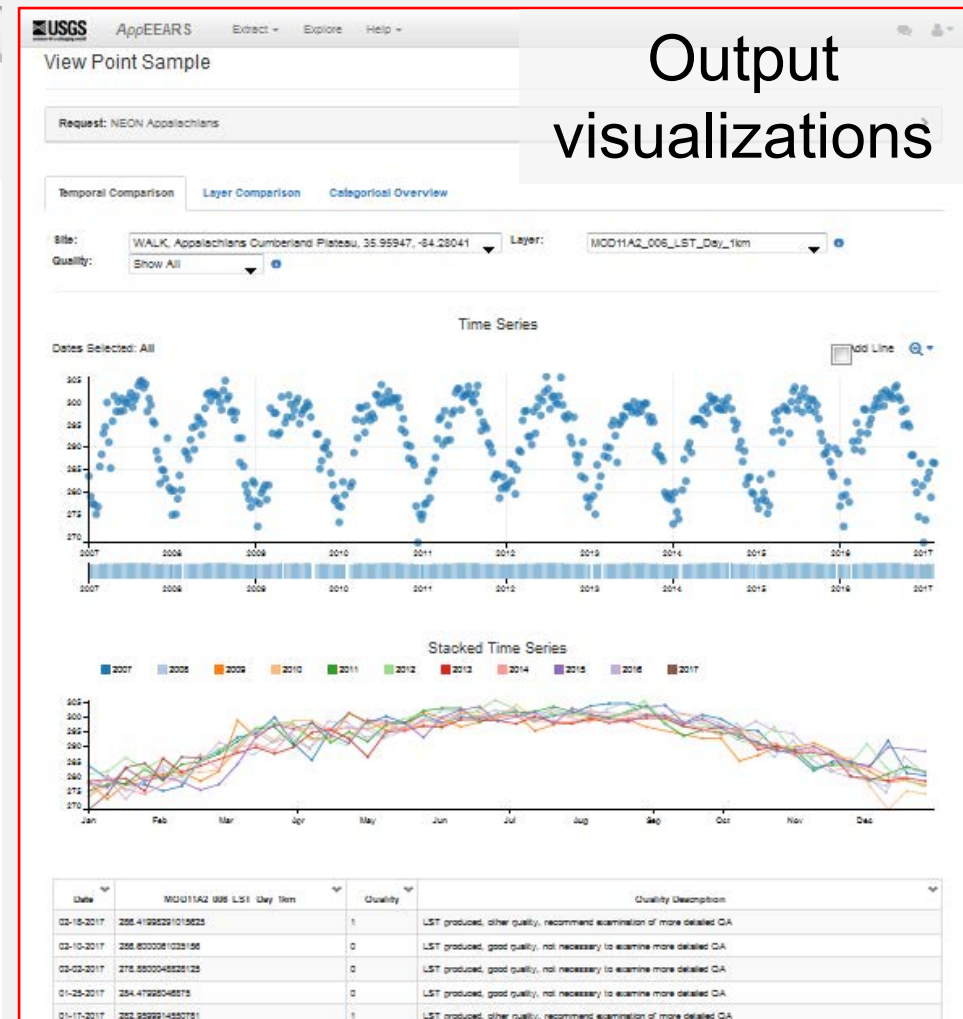
Select the layers to include in the sample

Search for a product

Selected layers

- LST_Day_1km 1000m, 8 day
- Lai_500m 500m, 8 day
- _500m_16_days_NDVI 500m, 16 day
- Fire/mask 1000m, 8 day

Submit Cancel



AppEEARS: Area Samples (Beta)

User Input: Vector Polygon File or User-Drawn Polygon/Rectangle (Areas)

Extract Area Sample

Enter a name to identify your sample

Rwanda Land and Human Dimensions

Upload a file or draw a polygon using the [icon] or [icon] tool

Drop a vector polygon file containing the area feature(s) to extract or click here to select the file.

Supported file formats:

- ESRI Shapefile (.shp, .shx, .dbf, .prj, and .aux files)
- GeoJSON (.json or .geojson)

Start Date: 01-01-2000

End Date: 05-23-2017

Is Date Recurring?

Select the layers to include in the sample

Search for a product

Selected layers:

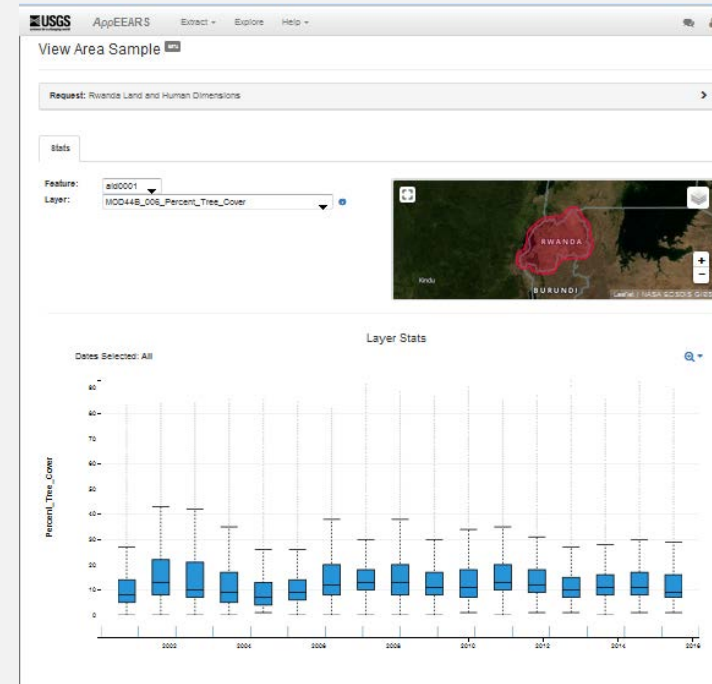
- population-count 1000m, Quinquennial
- population-density 1000m, Quinquennial
- Percent_NonTree_Vegetation 250m, Yearly
- Percent_Tree_Cover 250m, Yearly
- Land_Cover_Type_1 500m, Yearly

Output Options

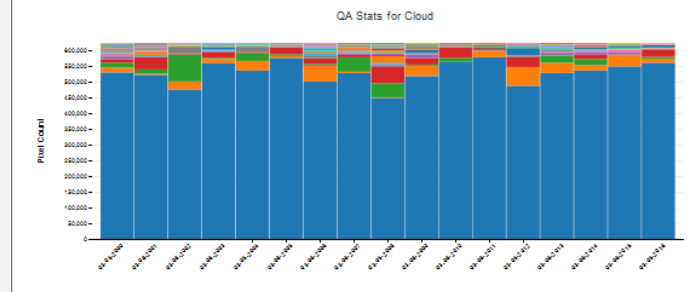
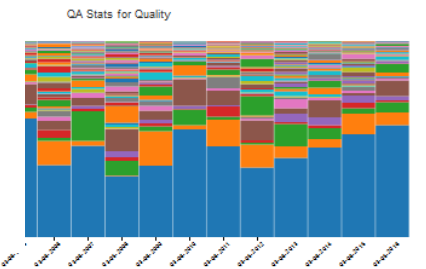
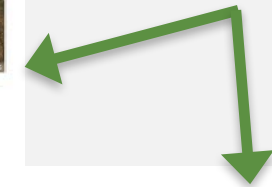
File Format: GeoTIFF

Projection: Geographic

- Geographic
- WGS84
- 4326
- PROJ_1A
- +proj=longlat +datum=WGS84 +no_defs



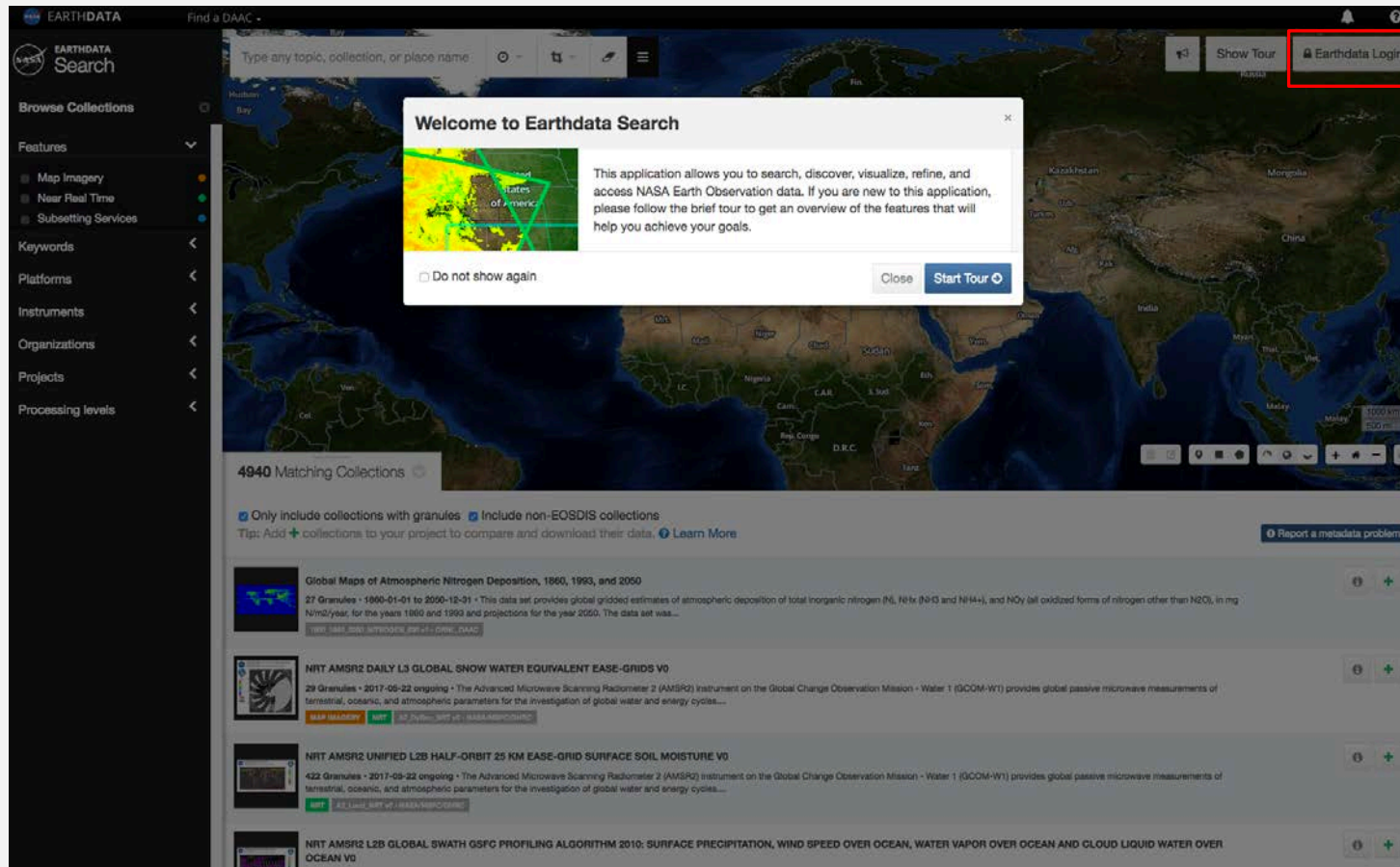
Output visualizations



Accessing MODIS Land Cover with Earthdata Search

<https://search.earthdata.nasa.gov/search>

MCD12Q1: MODIS 500 meter Yearly Global Land Cover Product



NASA Earthdata Search



Back to Collections

MODIS/Terra+Aqua Land Cover Type Yearly L3 Global 500m SIN Grid V051

Download Data

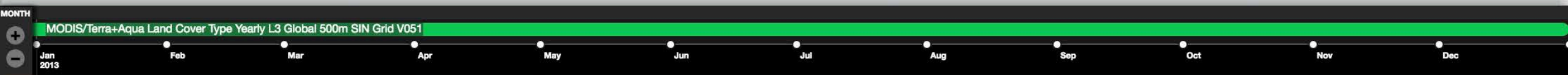
Showing 13 of 13 matching granules

Sort by: Start Date, Newest first

Granule Search: Search Single or Multiple Granule IDs...

Search Time: 0.4s Report a metadata problem

MCD12Q1.A2013001.h08v05.051.2014308185137.hdf 2013-01-01 18:00:00 2013-12-31 19:55:00	MCD12Q1.A2012001.h08v05.051.2014288195944.hdf 2012-01-01 18:00:00 2012-12-31 19:55:00	MCD12Q1.A2011001.h08v05.051.2014288190234.hdf 2011-01-01 18:00:00 2011-12-31 19:55:00	MCD12Q1.A2010001.h08v05.051.2014288182212.hdf 2010-01-01 18:00:00 2010-12-31 19:55:00	MCD12Q1.A2009001.h08v05.051.2014288175017.hdf 2009-01-01 18:00:00 2009-12-31 19:55:00	MCD12Q1.A2008001.h08v05.051.2014288150356.hdf 2008-01-01 18:00:00 2008-12-31 19:55:00	MCD12Q1.A2007001.h08v05.051.2014287210955.hdf 2007-01-01 18:00:00 2007-12-31 19:55:00
MCD12Q1.A2006001.h08v05.051.2014287194233.hdf 2006-01-01 18:00:00 2006-12-31 19:55:00	MCD12Q1.A2005001.h08v05.051.2014287190136.hdf 2005-01-01 18:00:00 2005-12-31 19:55:00	MCD12Q1.A2004001.h08v05.051.2014287173922.hdf 2004-01-01 18:00:00 2004-12-31 19:55:00	MCD12Q1.A2003001.h08v05.051.2014287182111.hdf 2003-01-01 18:00:00 2003-12-31 19:55:00	MCD12Q1.A2002001.h08v05.051.2014287165917.hdf 2002-01-01 18:00:00 2002-12-31 19:55:00	MCD12Q1.A2001001.h08v05.051.2014287161921.hdf 2001-01-01 18:00:00 2001-12-31 19:55:00	



Data Access

Review and select service options for your data prior to download

1

MODIS/Terra+Aqua Land Cover Type Yearly L3 Global 500m SIN Grid V051

Review & Select Service Options

Review

13 Granules
1.1 Gigabytes

Granule List

Expand List

Quality Information

MODIS LEVEL-2 AND HIGHER PRODUCTS AT THE Land Processes DAAC:

Product quality assessment QA and validation are integral parts of the MODIS Land product generation process. The products have different data versions and levels of maturity reflecting algorithm refinement and the input data used in production. Please view technical information regarding product maturity and QA at: http://landweb.nascom.nasa.gov/bin/QA_WWW/newPage.cgi and product validation status at: <http://landval.gsfc.nasa.gov/>

Select Data Access Method

Direct Download

Download data as-is now from your browser or access script.

Stage for Delivery

Submit a request for data to be staged for delivery. You will get an email when they are ready.

Customize Product

Select custom service options to be performed. (e.g. subsetting, etc.)

Email Address

amberjean.mccullum@

Data Access

Review and select service options for your data prior to download

1

MODIS/Terra+Aqua Land Cover Type Yearly L3 Global 500m SIN Grid V051

2

Contact Information & Submit

Amber Jean McCullum (amberjean.mccullum@nasa.gov)
Organization: NASA ARSET
Country: United States
Affiliation: Government
Study Area: Land Processes
User Type: Science Team

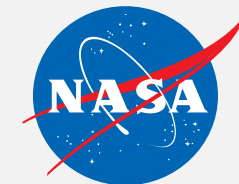
Edit Profile in Earthdata Login

Back

Submit

Contacts

- ARSET Land Management & Wildfire Contacts
 - Cynthia Schmidt: Cynthia.L.Schmidt@nasa.gov
 - Amber McCullum: AmberJean.Mccullum@nasa.gov
- General ARSET Inquiries
 - Ana Prados: aprados@umbc.edu
- ARSET Website:
 - <http://arset.gsfc.nasa.gov>



ARSET

Applied Remote Sensing Training

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

 @NASAARSET

Thank You

Next Week:

Overview of Climate Science and Data

- *Guest Speaker: Helen Sofaer, USGS Fort Collins Science Center*

Question and Answer Session

Please type your questions in the Question Box

Additionally, you can type your name, location, organization, and email address to connect with your fellow land remote sensing professionals.