# WELCOME TO
# NASA APPLIED REMOTE SENSING TRAINING (ARSET)
# WEBINAR SERIES

## INTRODUCTION TO REMOTE SENSING FOR CONSERVATION MANAGEMENT

**COURSE DATES: EVERY TUESDAY, MAY 5 – JUNE 2**
**TIME: 12:00 – 1:00 PM EDT (GMT-04:00)**
**OR**
**10:00 – 11:00 PM EDT**

# Course Structure

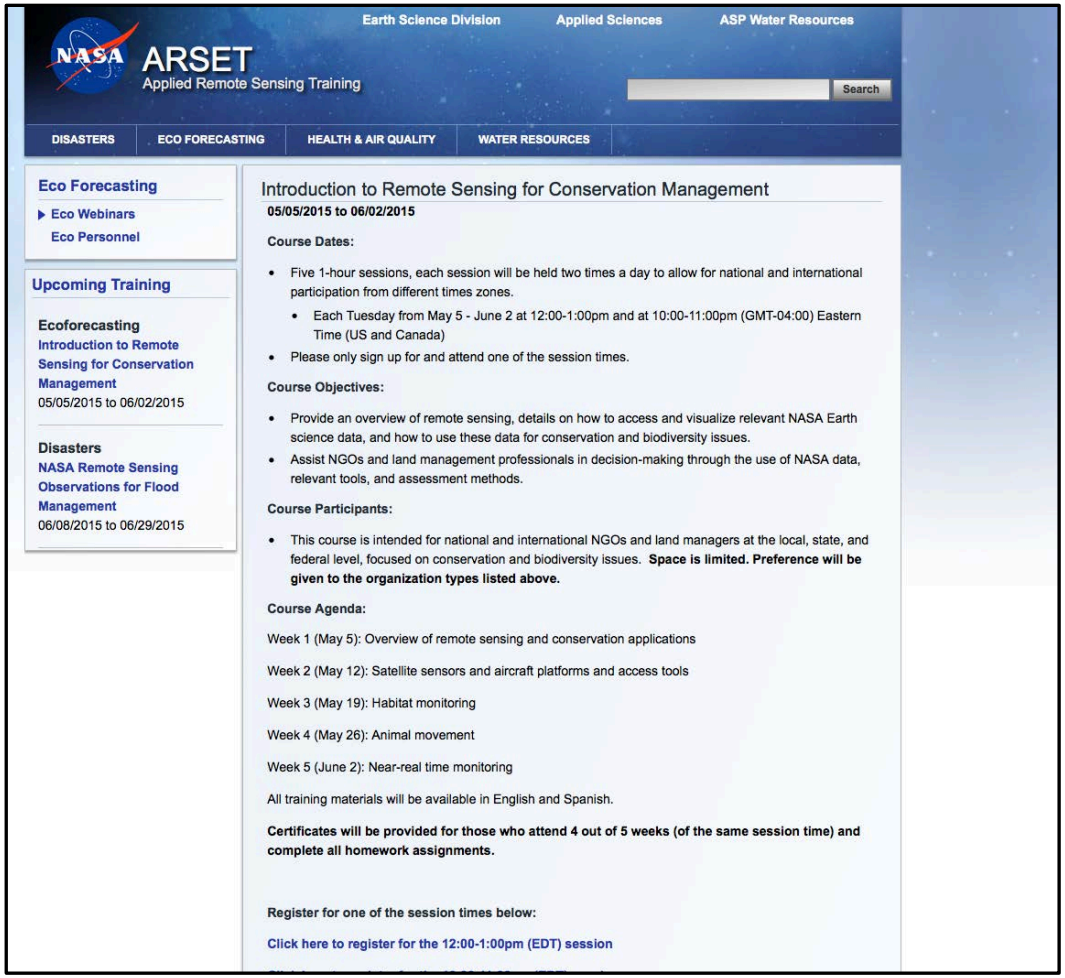
- One lecture per week – every Tuesday May 5 to June 2
  - 12:00 – 1:00 PM EDT (GMT-04:00) (Session 1)
  - 10:00 – 11:00 PM EDT (Session 2)

- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management

- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET Conservation Management webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com

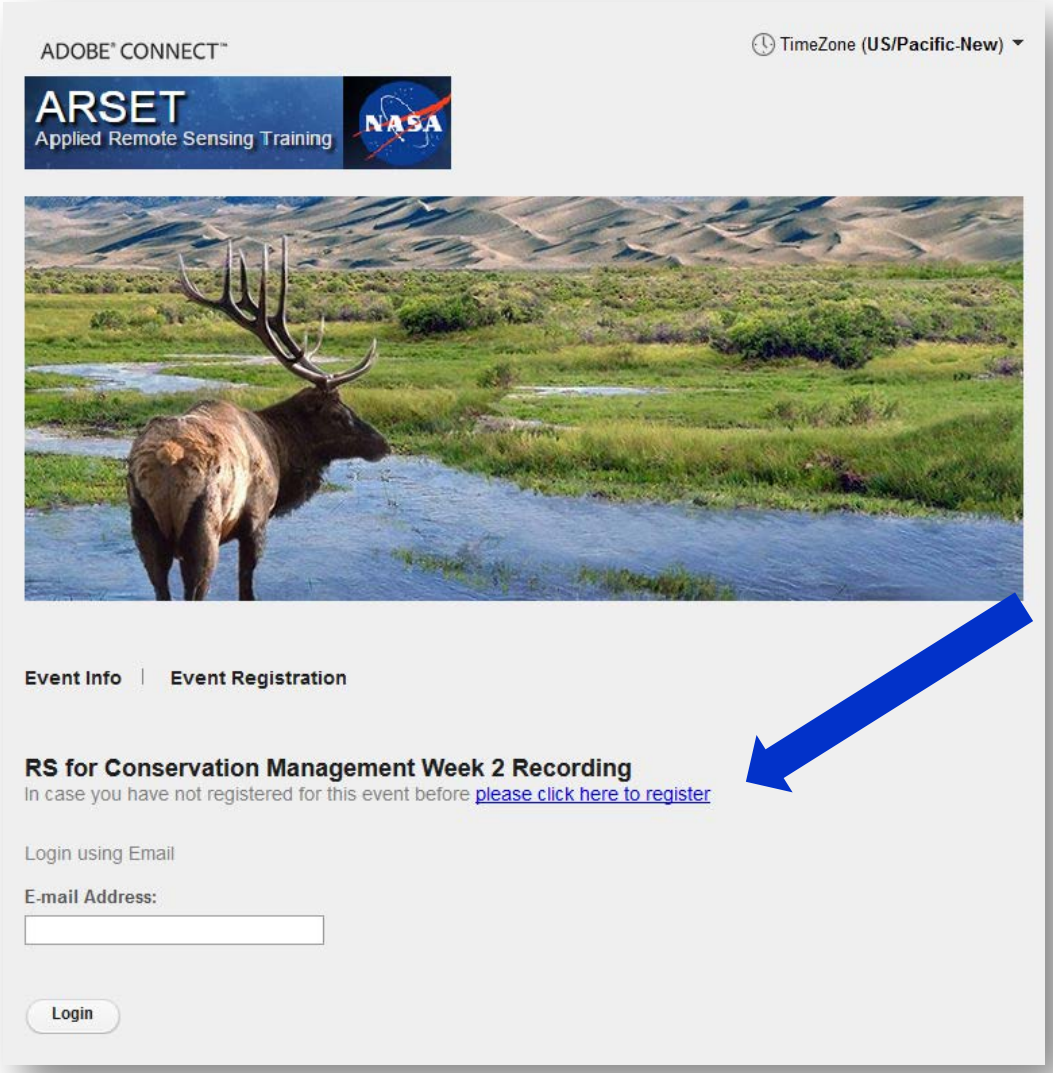
- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

# ARSET Conservation Management




https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management

# Accessing the Recordings




You must register to access the recordings!
This is different from your webinar registration.

# Your Course Instructors

- Cindy Schmidt (ARSET): cynthia.l.schmidt@nasa.gov
- Amber Kuss (ARSET): amberjean.m.kuss@nasa.gov
- Guest Speakers:
  - Walter Jetz – Yale University (week 3)
  - Jeff Cavner –University of Kansas (week 4)
  - Karyn Tabor – Conservation International (week 5)

General inquiries about ARSET: Ana Prados (ARSET)
aprados@umbc.edu

# Course Outline

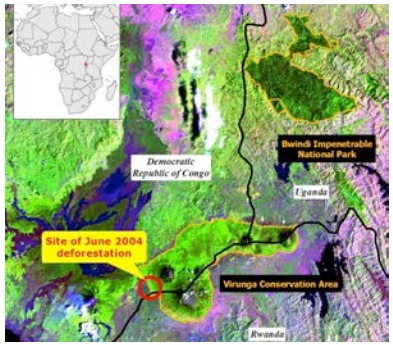
## Week 1

Overview of satellite remote sensing

## Week 2

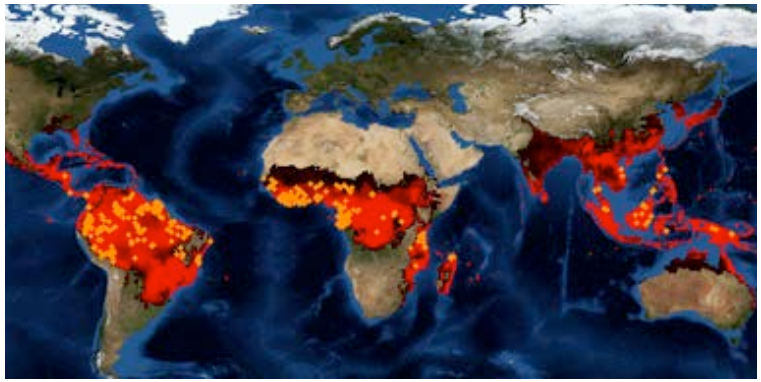

Platforms and sensors for conservation

## Week 3



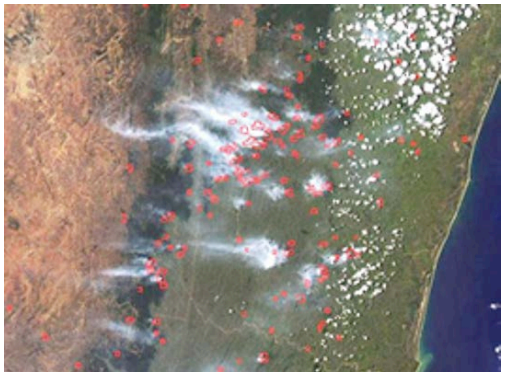

Habitat monitoring

## Week 4



Animal movement

## Week 5



Near-real time data

# Week 4 Agenda

- Review of Week 3
- Overview of monitoring animal movement
- Remote sensing and animal movement
  - NDVI and Phenology
  - NDVI products
  - Examples
- Additional Resources
- Live demo
  - LifeMapper: Guest speaker Dr. Jeff Cavner, University of Kansas

# Review of Week 3

# Overview of Habitat Monitoring

- Used to assess the threat and conservation status of species and protected areas
- IUCN Red List key criteria:
  - Habitat extent
  - Fragmentation
  - Rate of Change

Image credit: E. De Merode

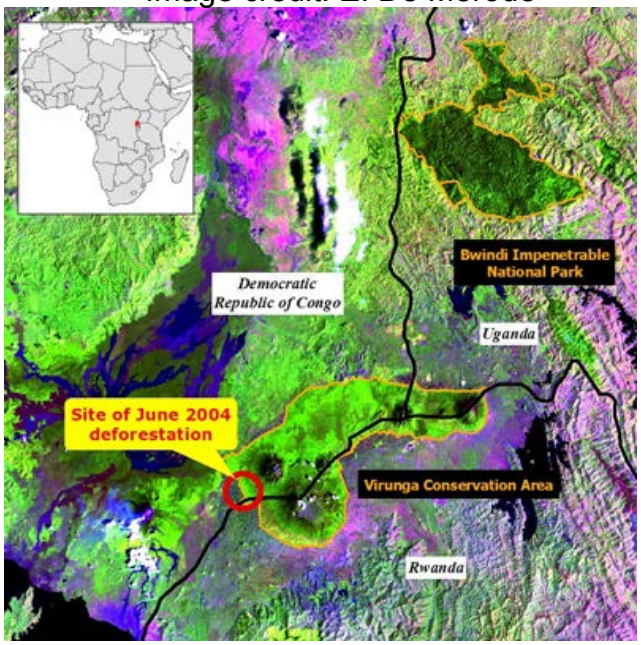


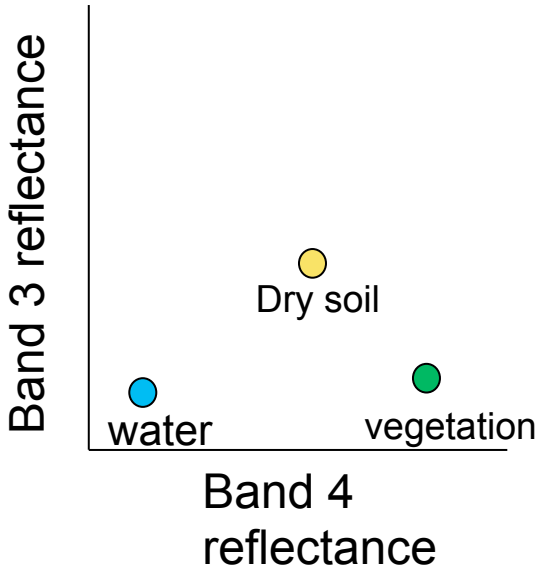

Image credit: Nadine Laporte/Tiffany Lin

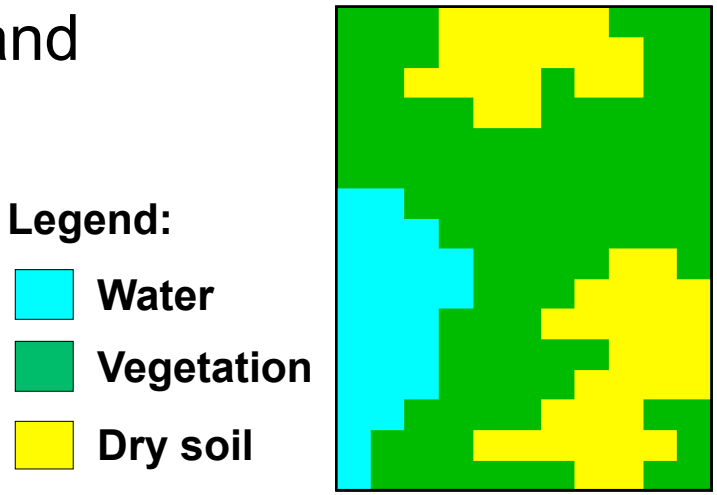
*Land changes in the Virunga Conservation Area which provides habitat to approximately 380 mountain gorillas*

*Rapid deforestation occurred in June 2004 in the "Mikeno" section of the park*

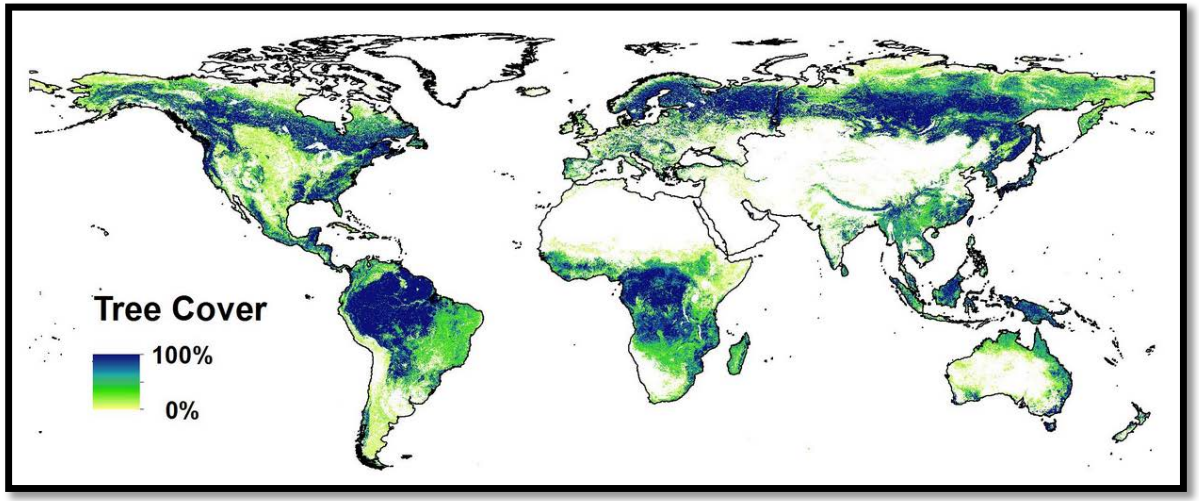
# Land Cover Mapping Basics

- Using Image Processing software, image classification involves using n number of bands, not just 2.
- You specify the number of land cover classes that are in your study area.
- There are many methods, but two common ones are Supervised and Unsupervised classification



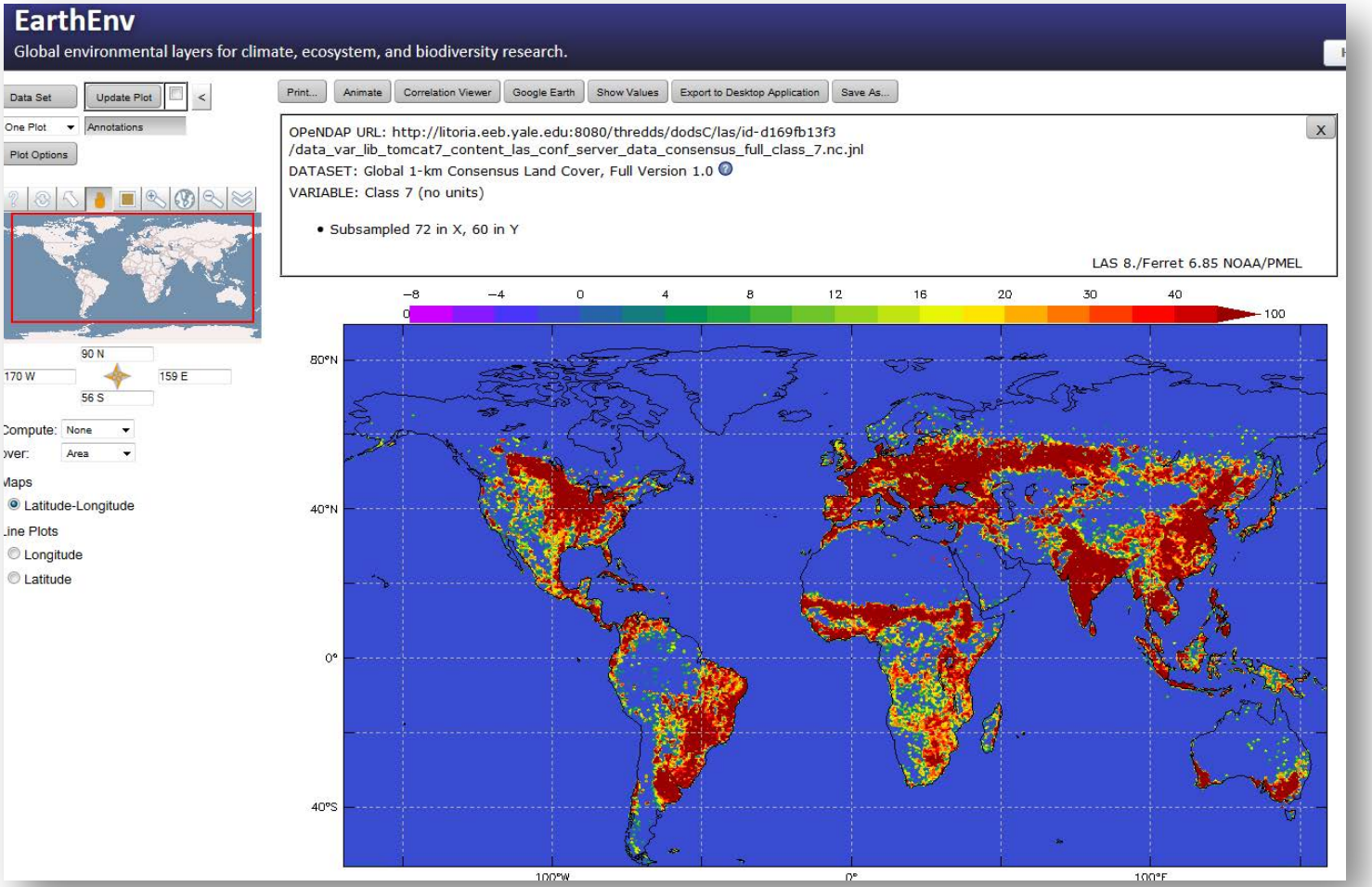
# Global 1-km Consensus Land Cover




- Integrates multiple global remote sensing-derived land-cover products
- Includes 12 land cover classes at 1-km resolution
- Each land cover class is available as an individual layer for download in GeoTIFF format

www.earthenv.org/landcover.html

# Global 1-km Consensus Land Cover




www.earthenv.org/landcover.html

# Overview of Monitoring Animal Movement

# Animal Movement

- Spatial and temporal animal movement patterns are a central focus of animal ecology.
- Four fundamental questions:
  - Why move?
  - How to move?
  - When and where to move?
  - What are the ecological and evolutionary consequences of movement?

Credit: Elizabeth Gordon

*Serengeti wildebeest migration*

Credit: tanzaniaonfoot.com

# Animal Movement: Technologies

- Non-electronic tags (e.g. metal bands)
  - Requires capture and re-capture
- Radio or satellite tracking
  - Does not require re-capture
  - Sometimes have to follow animal, but sometimes not
  - Giving a complete, continuous picture of migration patterns

Credit: The Migratory Connectivity Project

# Remote Sensing and Animal Movement: NDVI and Phenology

# Remote Sensing and Animal Movement

- Animals interact with their environment at multiple spatiotemporal scales
- Remote sensing data can capture characteristics about the environment at different scales
- Animal locational data combined with remote sensing data can help determine why and where animals move

Credit: gallery.hd.org

This Burchells zebra is grazing on green grass in Addo Elephant Park, Eastern Cape, South Africa

# Example: Wildebeest

- Between December and April the wildebeest are on the short grass plains in the southern Serengeti
- In April and May the rains stop and the plains in the south and east of the Serengeti dry out. The herd then moves north and west where there is more grass and water.
- In June to July is transitional between rainy and dry season. The herds push further north towards the Maasai Mara.
- Between July and August many thousands of wildebeest move to the Maasai Mara.
- We can use remote sensing (precipitation and vegetation green up) to determine when and where the wildebeest will migrate.

# Remote Sensing and Animal Movement

- Paper: “Opportunities for the application of advanced remotely-sensed data in ecological studies of terrestrial animal movement” Neumann et al., 2015, *Movement Ecology*
  - Studies of small-scale movement included data about land cover, infrastructure, and terrain
  - Studies of coarser-scale movement (e.g. migration) often used data on vegetation phenology, sometimes combined with climate, weather, and terrain data

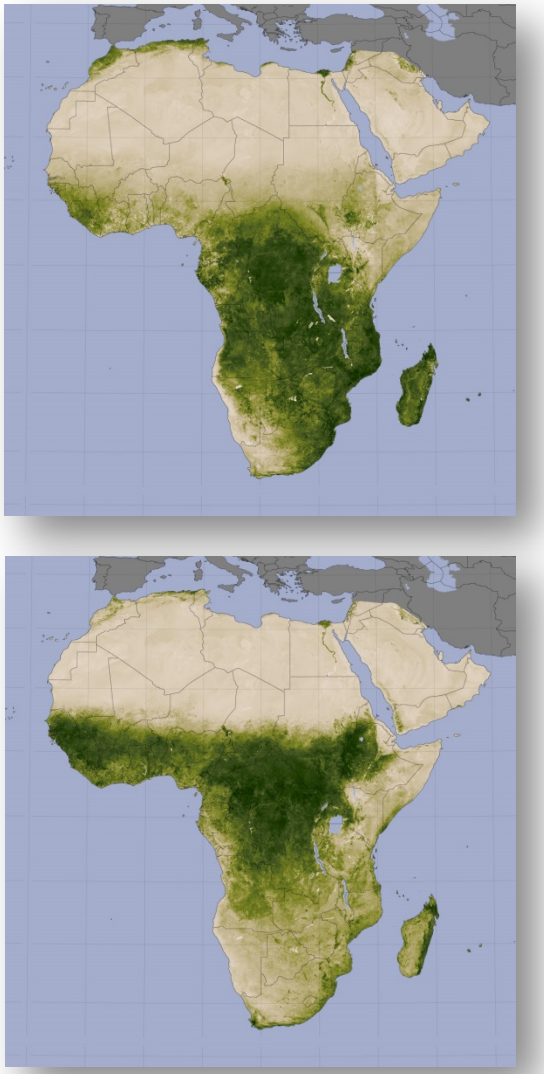
# Remote Sensing and Animal Movement

- Plants and animals have life cycles events that occur regularly every year that are dependent on temperature, precipitation and available sunlight.

- Vegetation information from satellite imagery is useful to study animal movement because plant phenology and vegetation productivity can often be linked to location of individuals.

# Remote Sensing and Animal Movement

- RS information on vegetation productivity can be obtained through vegetation indices: Normalized Difference Vegetation Index (NDVI) or Enhanced Vegetation Index (EVI)
  - At coarser scales, shifts in relative NDVI distribution can explain movement to and from seasonal ranges
  - At finer scales, NDVI might explain the habitat choices of individuals at a particular point in time

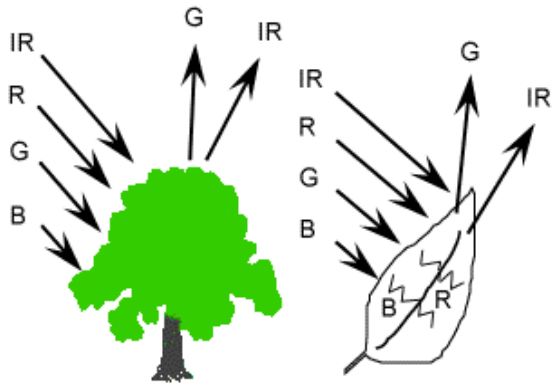


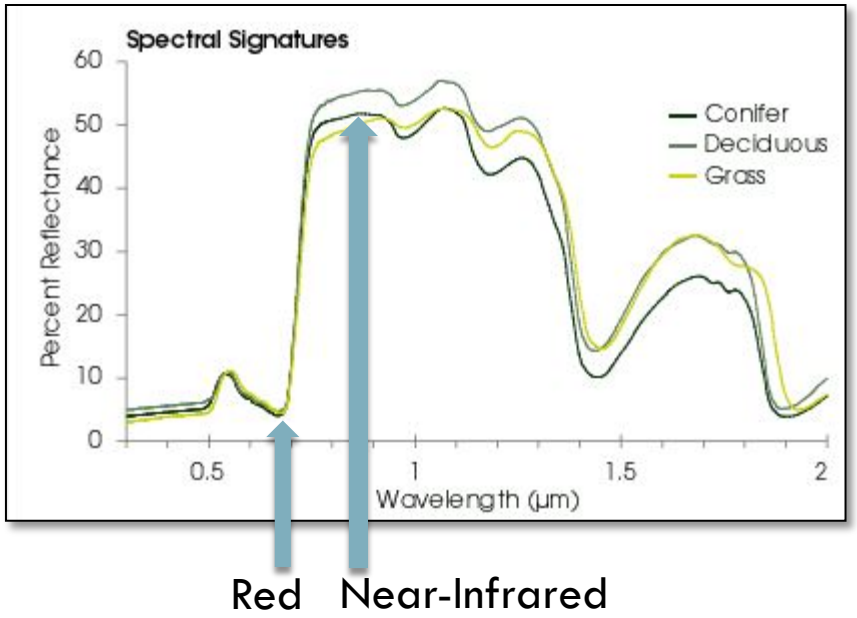
*Vegetation changes in Africa from March 2004 (top) to September 2004 (bottom)*

Source: www.earthobservatory.nasa.gov

# 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:

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

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

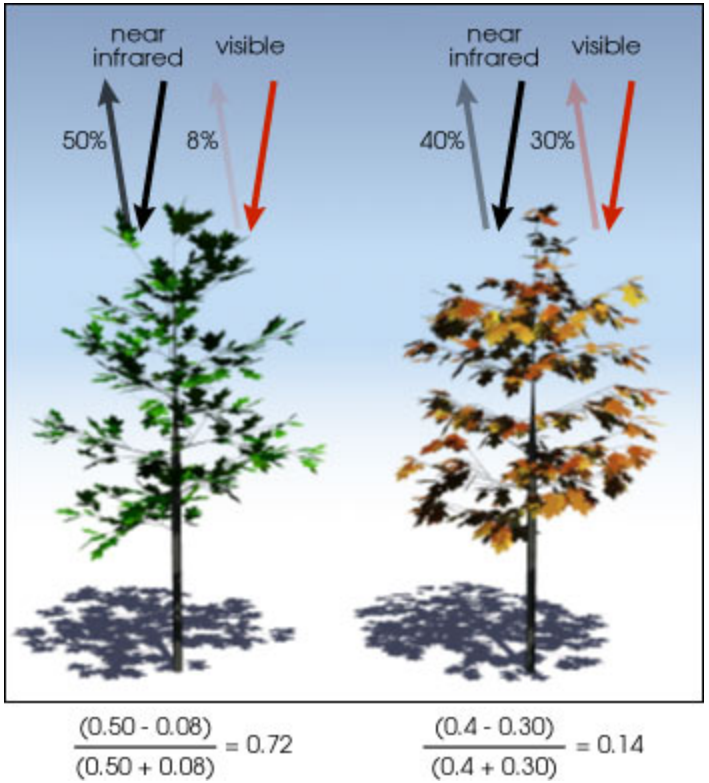


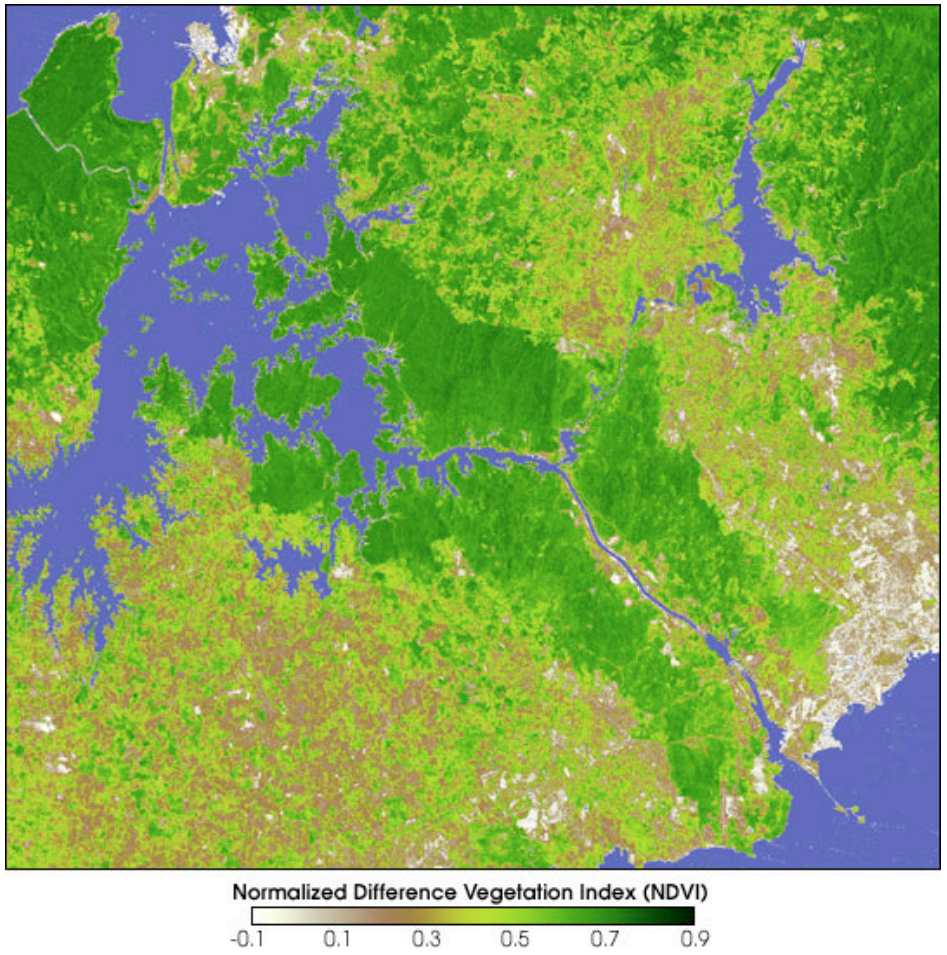

Image Credit: Robert Simmon

# NDVI Example

This is  Landsat NDVI image of the Panama Canal watershed

The darker green the area, the higher the NDVI value, the more green vegetation is present

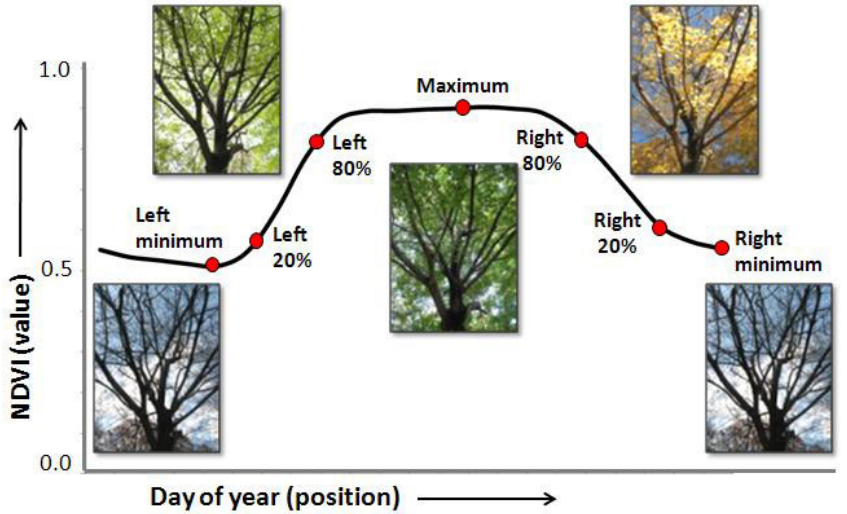
This image was acquired in March 2000 during Panama's annual dry season.




Source: http://earthobservatory.nasa.gov

# NDVI: Phenology

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





Credit: spacegrant.montana.edu

North America NDVI images in winter and summer

# Remote Sensing and Animal Movement: NDVI and Phenology Products

# MODIS Products

| MODIS Name | Product Name | Spatial Resolution (m) | Temporal |
|---|---|---|---|
| MOD 09 | Surface Reflectance | 500 | 8-day |
| MOD 11 | Land Surface Temperature | 1000 | Daily, 8-day |
| MOD 12 | Land Cover/Change | 500 | 8-day, Yearly |
| MOD 13 | Vegetation Indices | 250 – 1km | 16 day |
| MOD 14 | Thermal Anomalies/Fire | 1000 | Daily, 8-day |
| MOD 15 | Leaf Area Index/Fraction of Absorbed Photosynthetically Active Radiation (FPAR) | 1000 | 4-day, 8-day |
| MOD 16 | Evapotranspiration | | |
| MOD 17 | Primary Production | 1000 | 8-day, yearly |
| MOD 43 | Bidirectional reflectance distribution function (BRDF)/Albedo | 500-1000 | 16-day |
| MOD 44 | Vegetation Continuous Fields | 250 | yearly |
| MOD 45 | Burned Area | 500 | monthly |

# MODIS NDVI and EVI

| Composite | Spatial Resolution | Terra | Aqua |
|---|---|---|---|
| 16-day | 250 m | MOD13Q1 | MYD13Q1 |
| 16-day | 500 m | MOD13A1 | MYD13A1 |
| 16-day | 1km | MOD13A2 | MYD13A2 |
| 16-day | .05 deg (~5.5 km) | MOD13C1 | MYD13C1 |
| Monthly | 1km | MOD13A3 | MYD13A3 |
| Monthly | .05 deg (~5.5 km) | MOD13C2 | MYD13C2 |

http://reverb.echo.nasa.gov
https://mrtweb.cr.usgs.gov

# 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

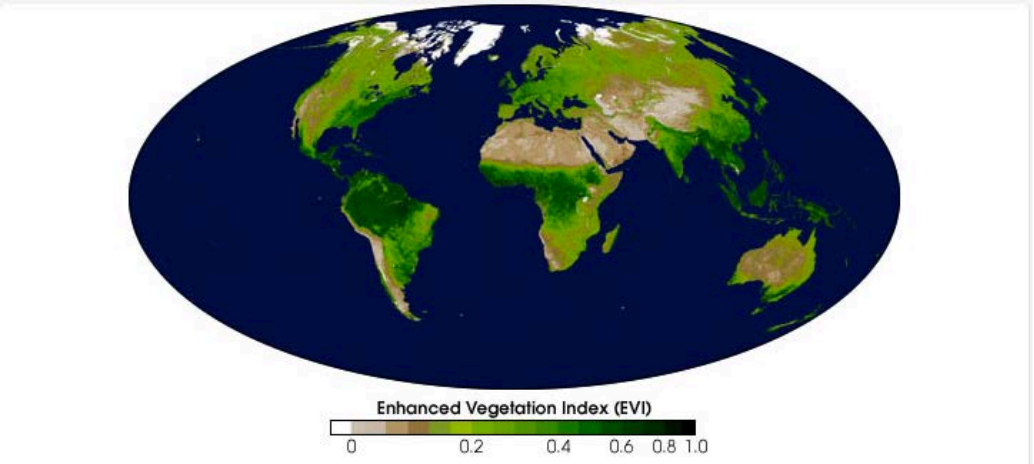


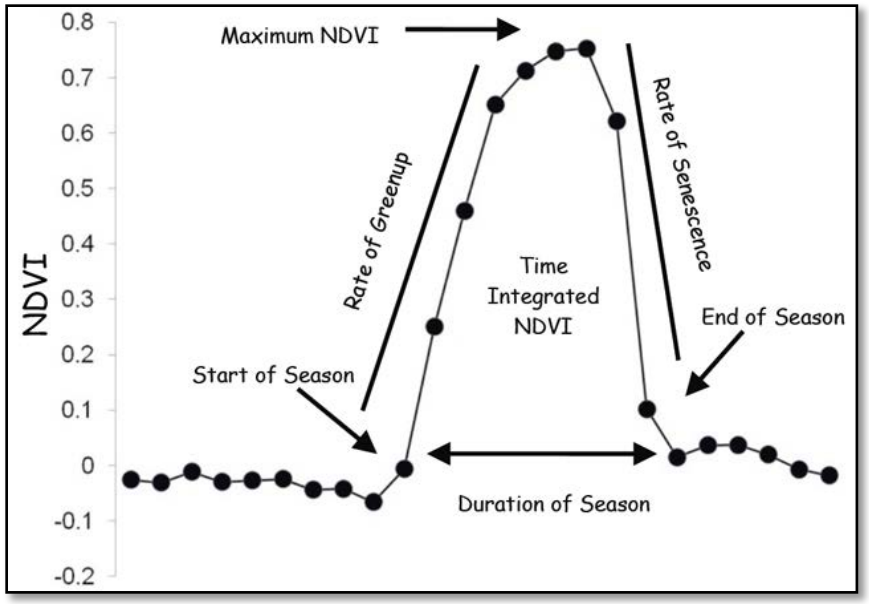

Image credit: NASA Earth Observatory

# MODIS Products

| MODIS Name | Product Name | Spatial Resolution (m) | Temporal |
|---|---|---|---|
| MOD 09 | Surface Reflectance | 500 | 8-day |
| MOD 11 | Land Surface Temperature | 1000 | Daily, 8-day |
| MOD 12 | Land Cover/Change | 500 | 8-day, Yearly |
| MOD 13 | Vegetation Indices | 250 – 1km | 16 day |
| MOD 14 | Thermal Anomalies/Fire | 1000 | Daily, 8-day |
| MOD 15 | Leaf Area Index/Fraction of Absorbed Photosynthetically Active Radiation (FPAR) | 1000 | 4-day, 8-day |
| MOD 16 | Evapotranspiration | | |
| MOD 17 | Primary Production | 1000 | 8-day, yearly |
| MOD 43 | Bidirectional reflectance distribution function (BRDF)/Albedo | 500-1000 | 16-day |
| MOD 44 | Vegetation Continuous Fields | 250 | yearly |
| MOD 45 | Burned Area | 500 | monthly |

# MODIS Land Cover Dynamics (MCD12Q2)

- MODIS Phenology (2001-2012)
  - Start of season time/NDVI
  - End of season time/NDVI
  - Time of Maximum NDVI
  - Length of growing season
  - Maximum increase in canopy
  - Photosynthetic activity across entire growing season

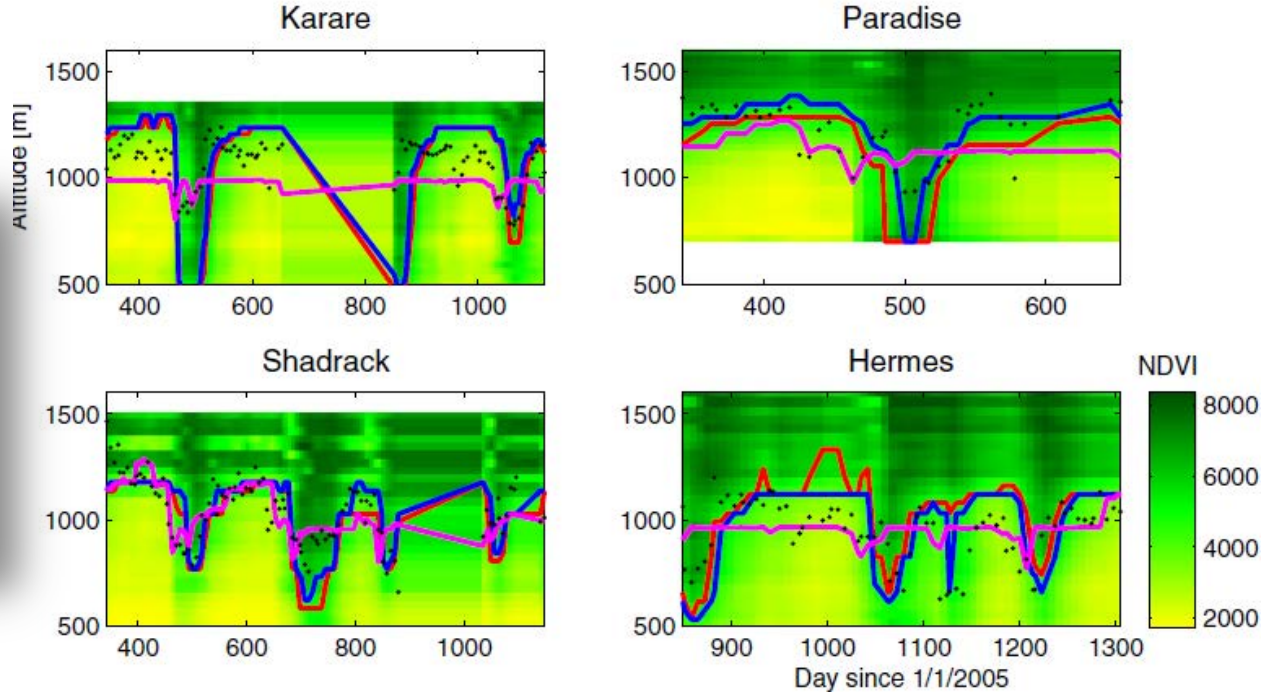



http://reverb.echo.nasa.gov

# Some Examples

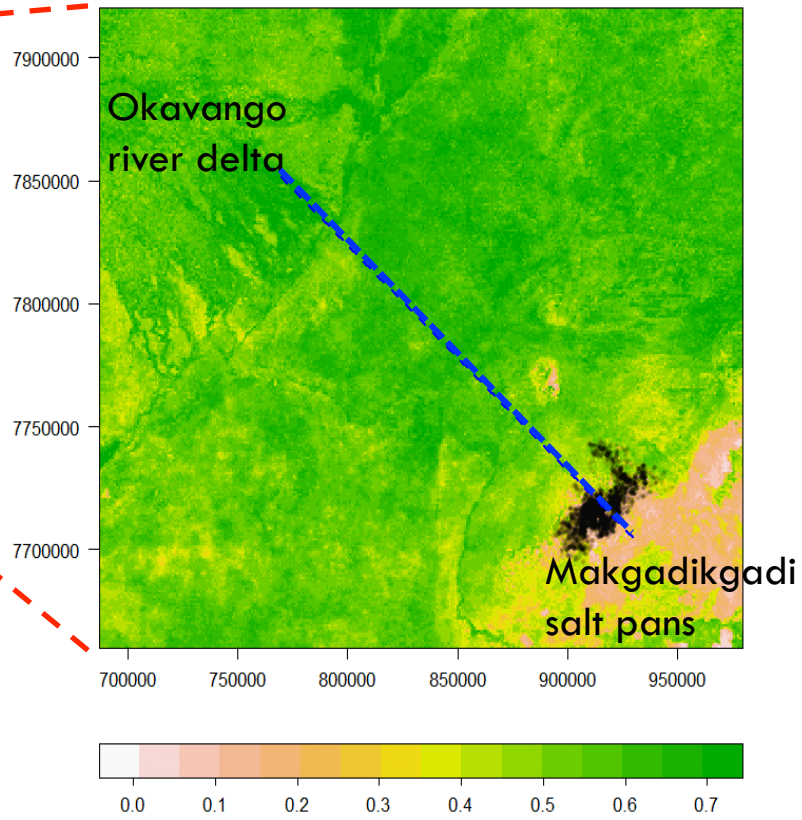
# Use Case: Phenology and Elephants

- Bohrer et al. (2014) found that the elevational migration of individual elephants closely matched the patterns of greening and senescing of vegetation in their home range.



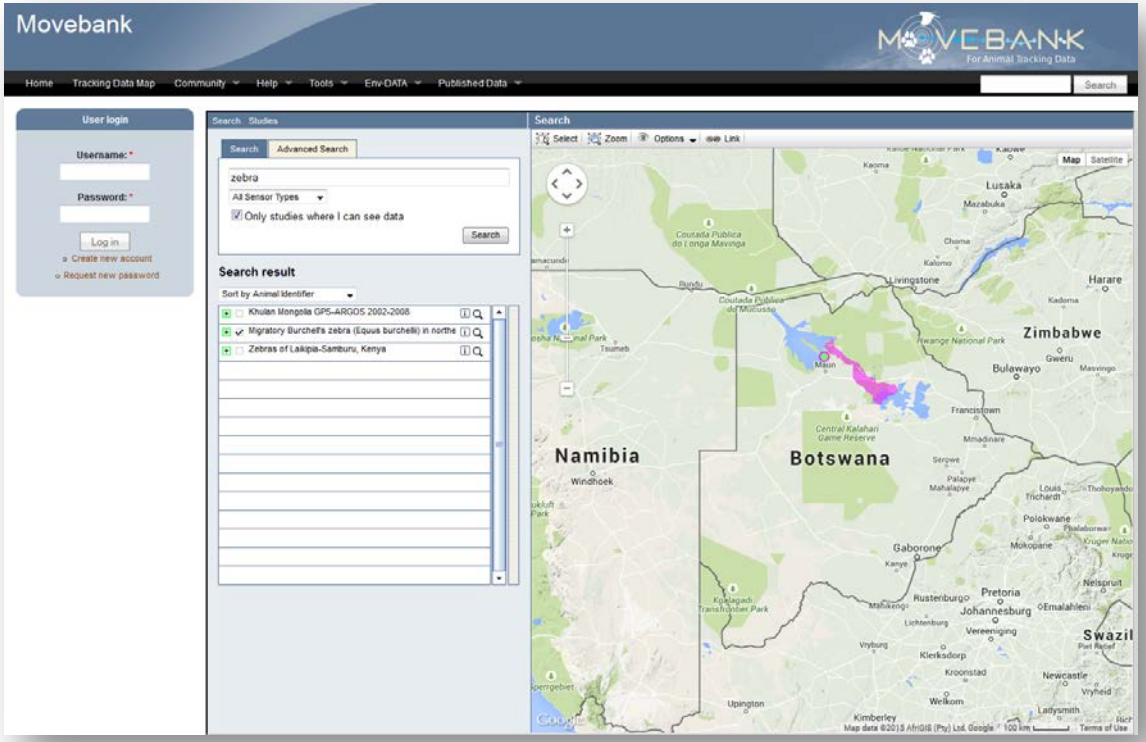
# Use Case: Zebras at the Okavango Delta: Moving to greener pastures

Bartlam-Brooks et al. (2014), JGR

# Movebank

- Movebank is a free, online database of animal tracking data hosted by the Max Planck Institute of Ornithology.
  - Helps animal tracking researchers to manage, share, protect, analyze and archive their data.



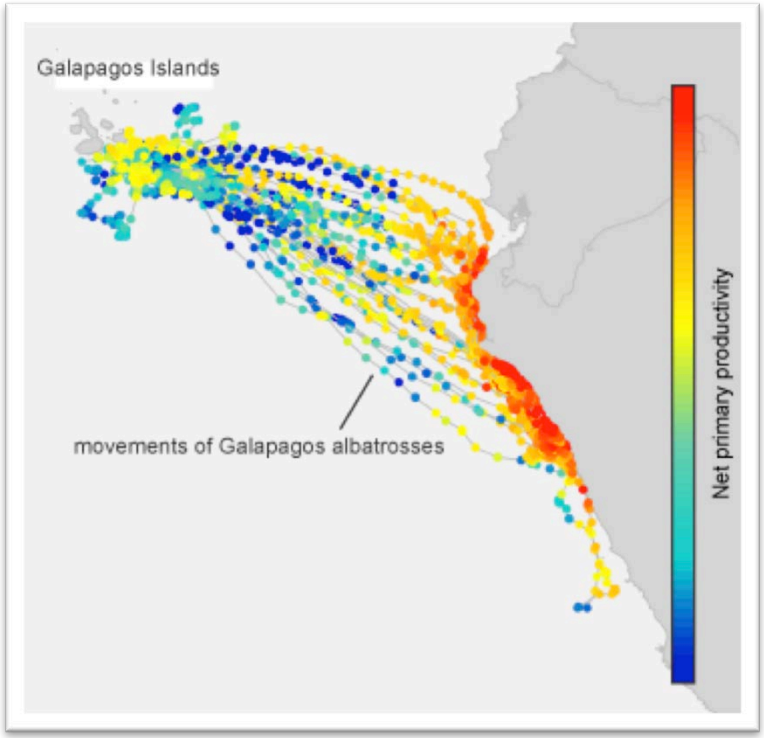

This shows the web interface for Movebank. This example shows migratory path of Burchell's zebra in northern Botswana.

http://www.movebank.org

# Movebank: The Env-DATA System

- Goals:
  - To streamline the co-registration of animal tracking data with a diverse range of environmental variables
  - To allow scientists to examine relationships between animal movement and ambient atmospheric observations and underlying landscape
  - For more information and tutorials go to:

    http://youtube.com/movebank




*This image shows 8-day ocean net primary productivity annotated to tracks of Galapagos albatrosses*

# Movebank: The Env-DATA System

- Automate the acquisition of data from open web resources of remote sensing and weather data
  - 50 large global datasets (>4000 variables)
  - NASA, NOAA, USGS, NCEP/NCAR and ECMWF weather reanalysis datasets
  - Complete list: https://www.movebank.org/mode/7471

| Datasets | Data Source | Temporal Coverage |
|---|---|---|
| Tropical Rainfall Measuring Mission (TRMM) | NASA http://trmm.gsfc.nasa.gov/ | 1998– present |
| AVHRR land NDVI | NASA http://glcf.umiacs.umd.edu/data/gimms/ | 1989–present, 1982–present |
| NCEP Global Reanalysis 2 | NOAA http://www.esrl.noaa.gov/psd/data/gridded/data.ncep.reanalysis2.html/ | 1948–present |
| North American Regional Reanalysis | NOAA http://www.emc.ncep.noaa.gov/mmb/rreanl/ | 1979–present |
| ECMWF Reanalysis | ECMWF http://www.ecmwf.int/ | 1979–present |
| MODIS Land | NASA https://lpdaac.usgs.gov/ | 2002–2012 |
| MODIS Ocean | NASA http://oceancolor.gsfc.nasa.gov/ | |
| MODIS Snow | NASA http://modis-snow-ice.gsfc.nasa.gov/ | |
| Ocean productivity | http://www.science.oregonstate.edu/ocean.productivity/ | 1997–2009 |
| ASTER GDEM | USGS http://asterweb.jpl.nasa.gov/gdem.asp | |
| SRTM | NASA http://www.cgiar-csi.org/data/srtm-90m-digital-elevation-database-v4-1/ | |
| GlobCover | ESA http://dup.esrin.esa.it/prjs/prjs68.php | 2009 |
| Socioeconomic data | http://sedac.ciesin.columbia.edu/gpw/global.jsp | 1990–2010 |
| Ocean Surface Current Reanalysis (OSCAR) | NASA http://www.oscar.noaa.gov/ | 1993–present |
| ETOPO1 | NASA http://www.ngdc.noaa.gov/mgg/global/global.html/ | 1940–2008 |

# Additional Resources

# List of Resources

- AniMove (www.AniMove.org)
  - Two-week intensive training course for studying animal movement
- EcoSens: Remote Sening and GIS in Ecology and Conservation (www.ecosens.org)
  - Applied RS and GIS training for conservation and ecology
- Book: “Remote Sensing and GIS for Ecologists” (http://book.ecosens.org)
- Book: “Analysis and mapping of animal movement in R” (Amazon.com)

# Live Demo: Life Mapper


http://lifemapper.org/

# Coming up next week!

## Near Real-Time Monitoring

# Course Structure

- One lecture per week – every Tuesday May 5 to June 2
  - 12:00 – 1:00 PM EDT (GMT-04:00) (Session 1)
  - 10:00 – 11:00 PM EDT (Session 2)

- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management

- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET Conservation Management webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com

- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

Please complete the webinar survey after Week 5!!!!

This image shows the migration routes for white storks. This is part of a large project to determine the effects of migration strategies on survival and fitness (PI: Wolfgang Fielder)

# Thank You!!

**Cindy Schmidt**

**Cynthia.L.Schmidt@nasa.gov**