Hyperspectral Data for Land and Coastal Systems

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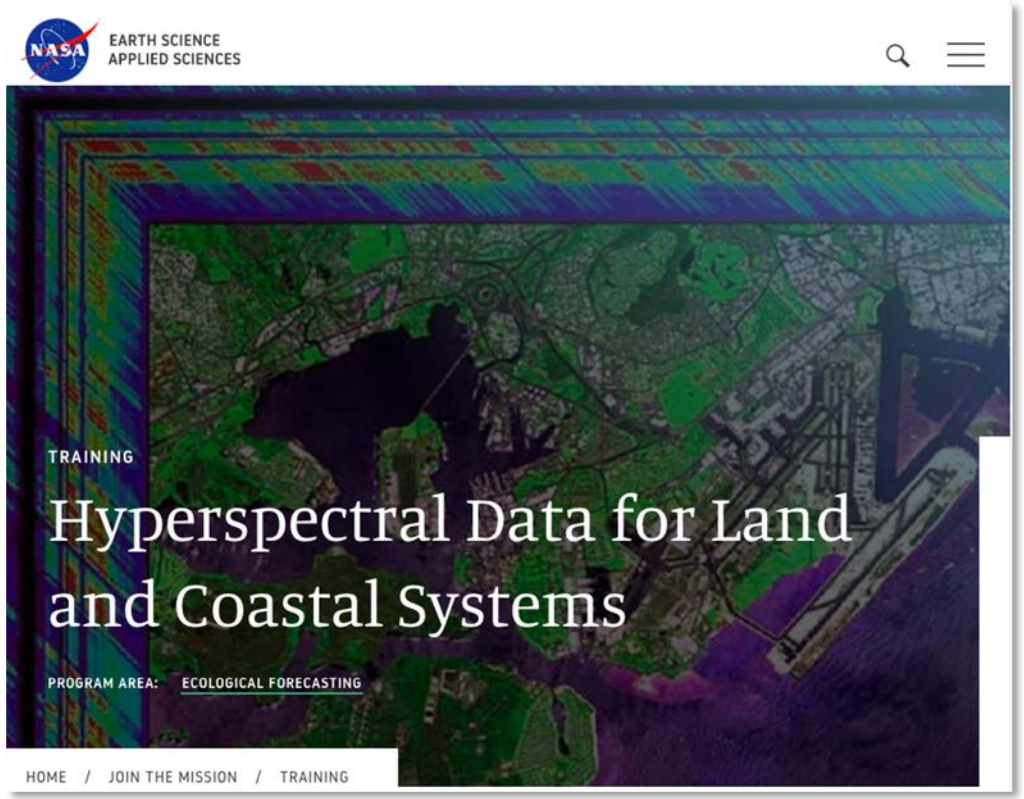
January 26, 2021

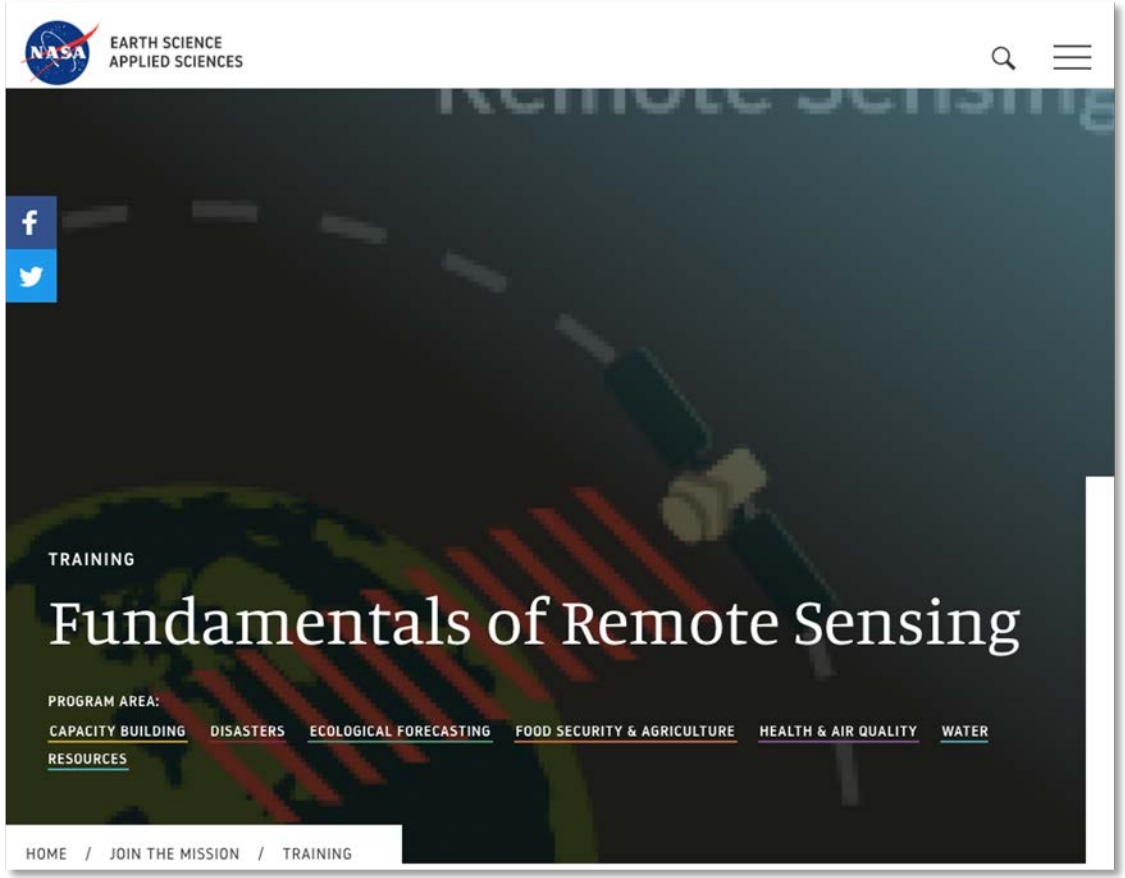
Course Structure and Materials

- Three, 1.5-hour sessions on January 19, January 26, and February 2
- The same content will be presented at two different times each day:
  - Session A: 11:00-12:30 EST (UTC-5)
  - Session B: 16:00-17:30 EST (UTC-5)
  - **Please only sign up for and attend one session per day.**
- Webinar recordings, PowerPoint presentations, and the homework assignment can be found after each session at:
  - https://appliedsciences.nasa.gov/join-mission/training/english/hyperspectral-data-land-and-coastal-systems
- Q&A following each lecture and/or by email at:
  - juan.l.torresperez@nasa.gov
  - amberjean.mccullum@nasa.gov or
  - bengtsson@baeri.org



Prerequisites

- Prerequisites:
  - Please complete Fundamentals of Remote Sensing or have equivalent experience.
- Course Materials:
  - https://appliedsciences.nasa.gov/join-mission/training/english/fundamentals-remote-sensing



Homework and Certificates

- **Homework:**
  - One homework assignment
  - Answers must be submitted via Google Forms
  - **HW Deadline: Tuesday February 16**

- **Certificate of Completion:**
  - Attend all live webinars
  - Complete the homework assignment by the deadline (access from ARSET website)
  - You will receive certificates approximately three months after the completion of the course from: marines.martins@ssaihq.com

Course Outline

Session 1: Overview of Hyperspectral Data

Session 2: Hyperspectral Data for Land Management

Session 3: Hyperspectral Data for Coastal and Ocean Systems

Learning Objectives

- By the end of this session, you will be able to…
  - Illustrate how hyperspectral data can be used for monitoring land-based ecosystems
  - Recall many case-study examples of hyperspectral-based research and management projects such as invasive species, forest monitoring, agricultural monitoring, and more
  - Apply techniques to access, download, and display hyperspectral data

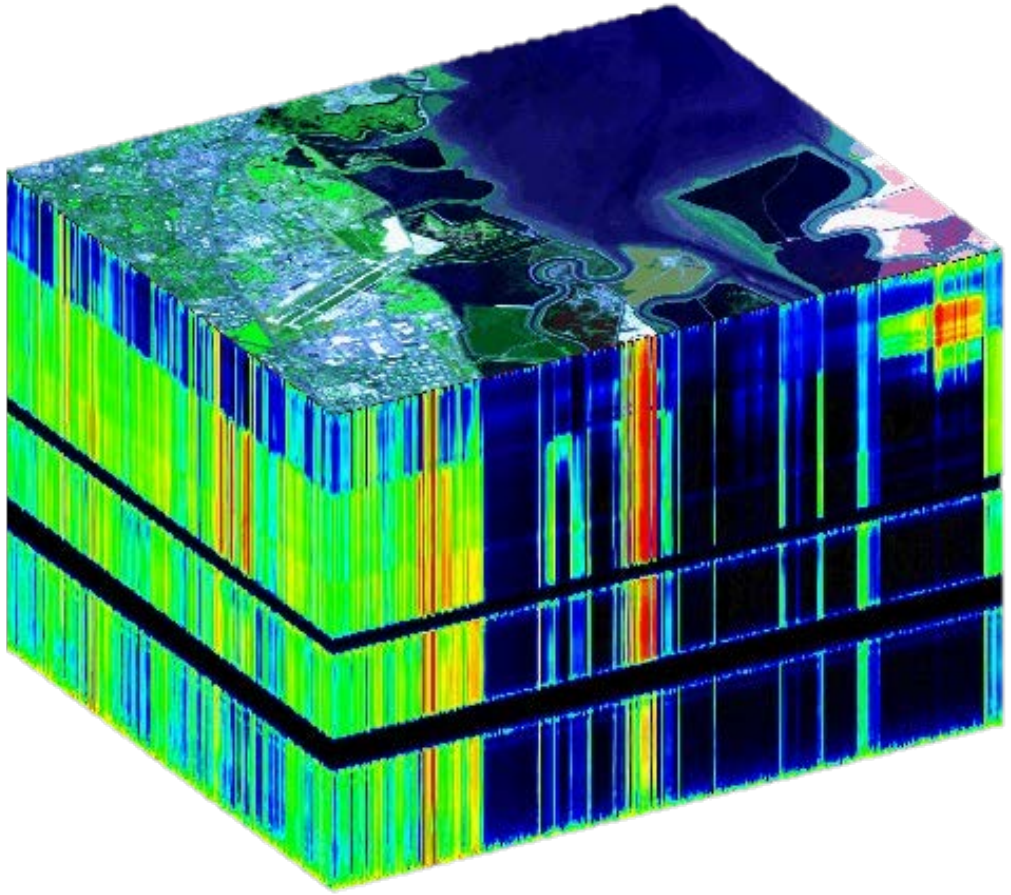
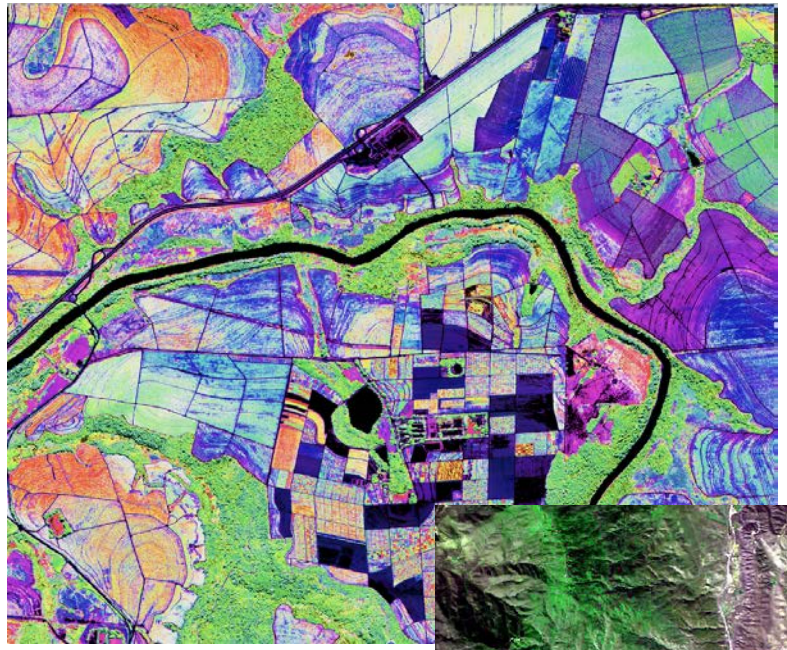


Image Credit: NASA JPL

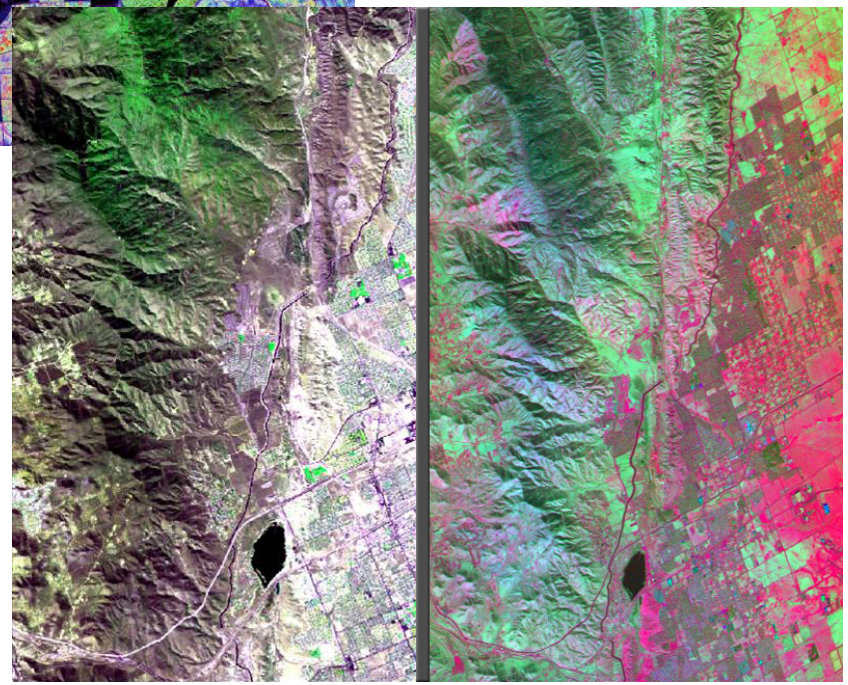
Hyperspectral Applications for Land Management

Applications of Hyperspectral Imagery

- Agriculture
- Forest health and restoration
- Invasive species
- Drought/vegetation monitoring
- Geologic/microbial mapping
- Hazard Detection: Volcanic activity and landslides



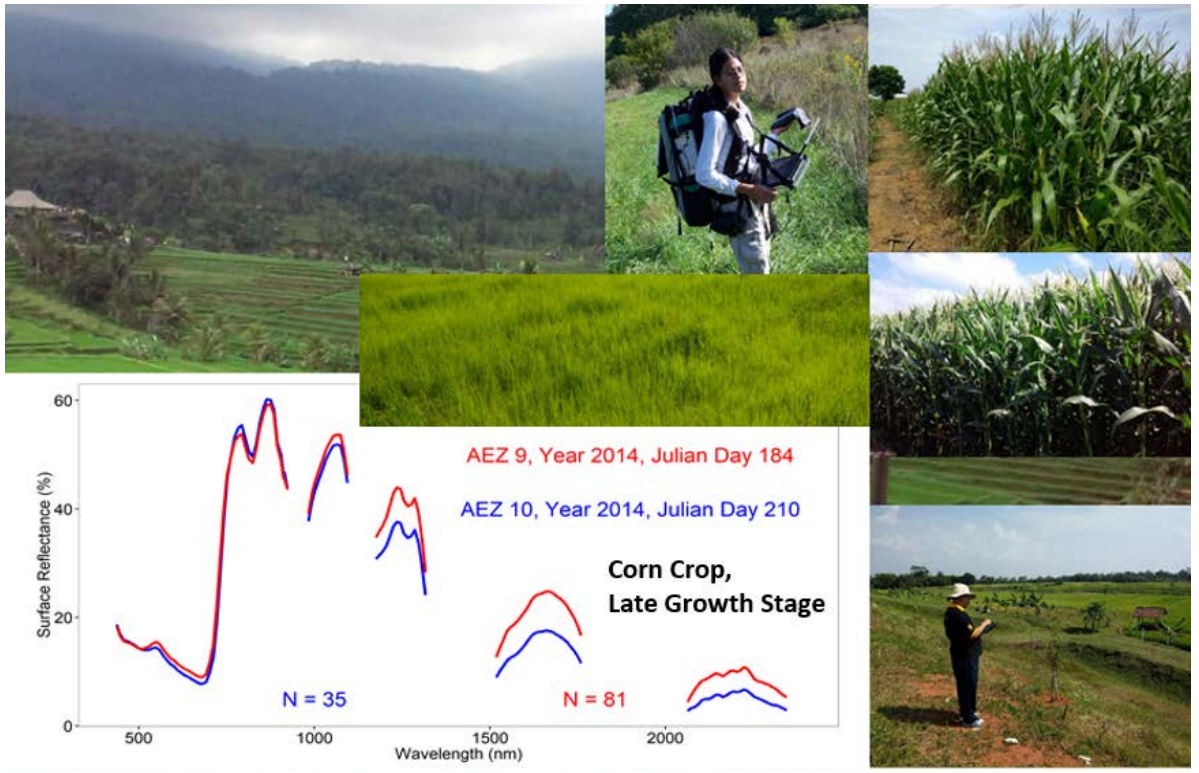
Sugarcane Varieties, Image Credit: Igor 2020



San Andres Fault, Image CreditL NASA

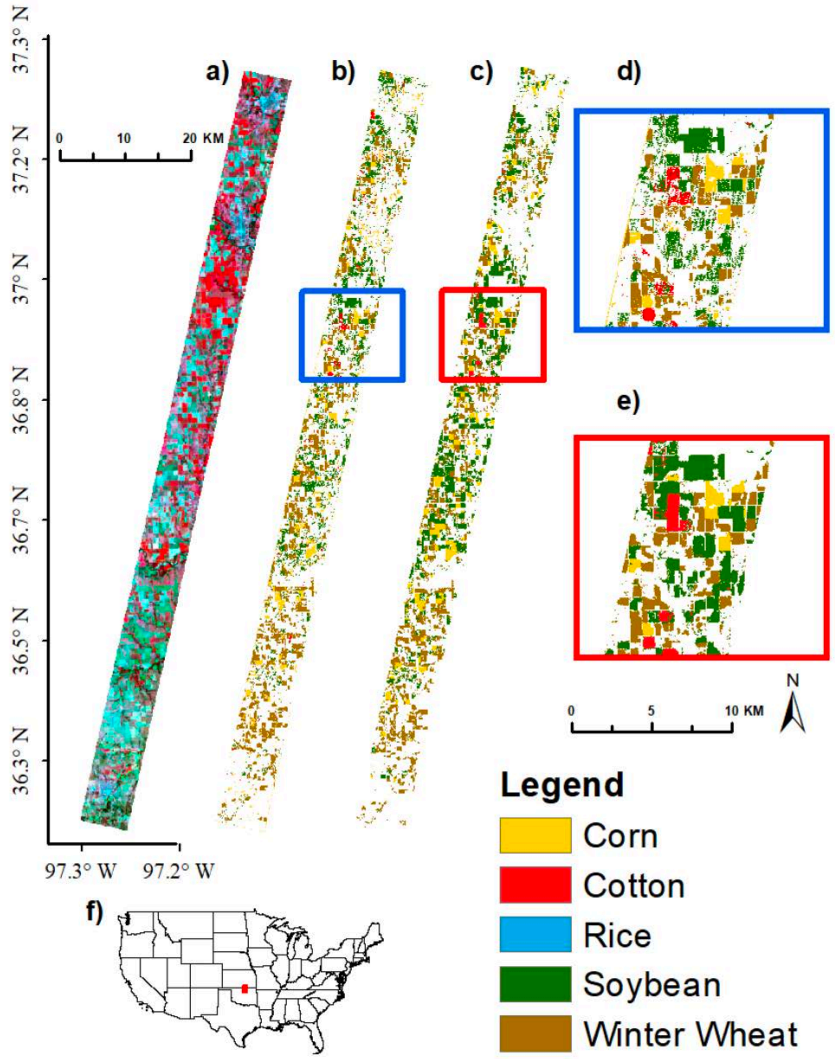
Agriculture

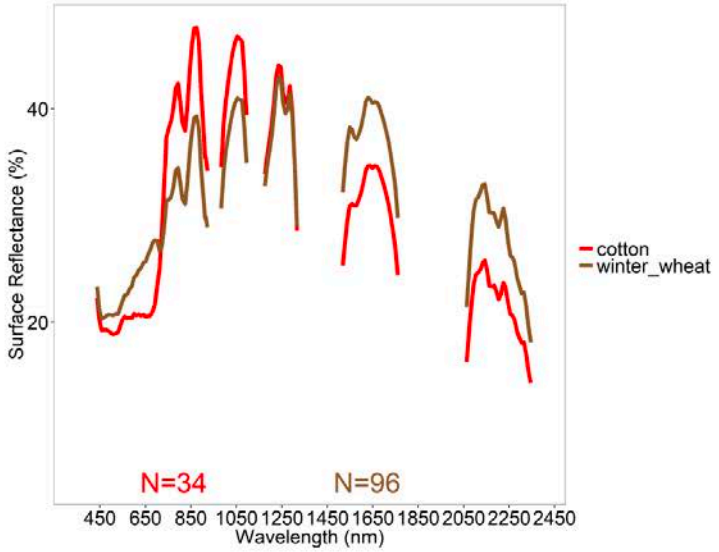
- Previous study of five leading world agricultural crops (corn, soybean, winter wheat, rice, and cotton) that occupy 75% and 54% of principal crop areas in the United States
- 99 Hyperion images
- Established optimal hyperspectral narrowbands
- Used GEE and machine learning algorithms to map crop type

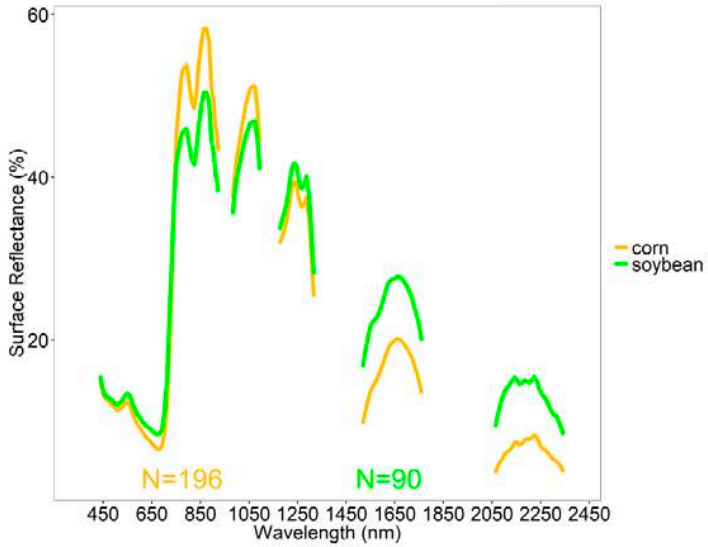


Crop type classifications with Hyperion data and field sampling for accuracy assessment. Image Credit: Aneece et al., 2018

Agriculture







Hyperion images from Oklahoma identifying different crop types for individual fields (left). Spectral signatures of cotton, winter wheat, corn, and soybeans (right). Image Credit: Aneece et al., 2018

Forest Monitoring: Santa Monica Mountains Restoration

- Native oak and riparian woodlands support hundreds of species and provide billions of dollars of ecosystem services to the Los Angeles region.
- Current threats from wildfires, floods, drought, and invasive beetles have caused extensive mortality in the past seven years.
- The recent Woolsey Fire (November 8-21, 2018) has damaged this sensitive area.

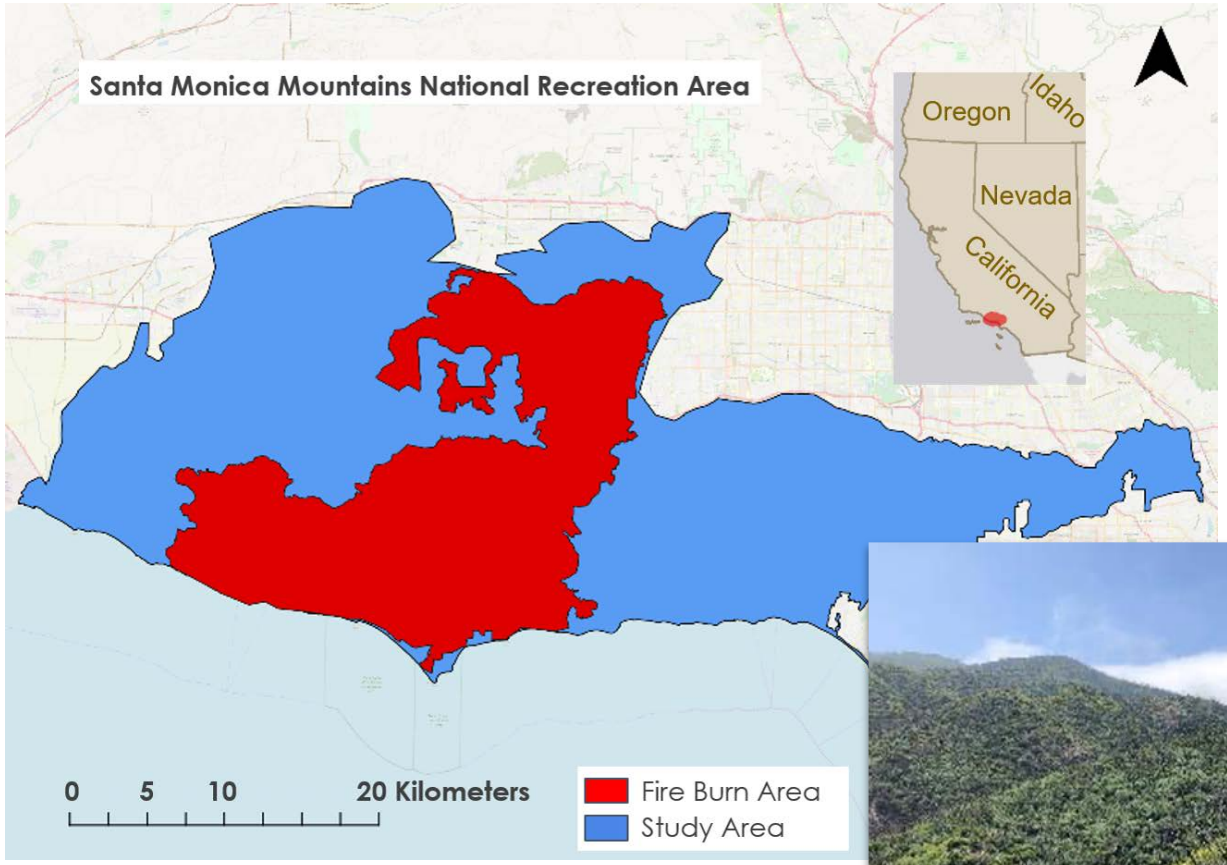


Image Credit: NASA DEVELOP JPL

Image Credit: Laura Jessup

Forest Monitoring: Santa Monica Mountains Restoration

- AVIRIS spectral profiles are used to differentiate vegetation for wildfire restoration in the Santa Monica Mountains.
- AVIRIS imagery collected in the months prior to the Woolsey Fire provides land managers with vegetation information necessary to recreate pre-fire conditions.

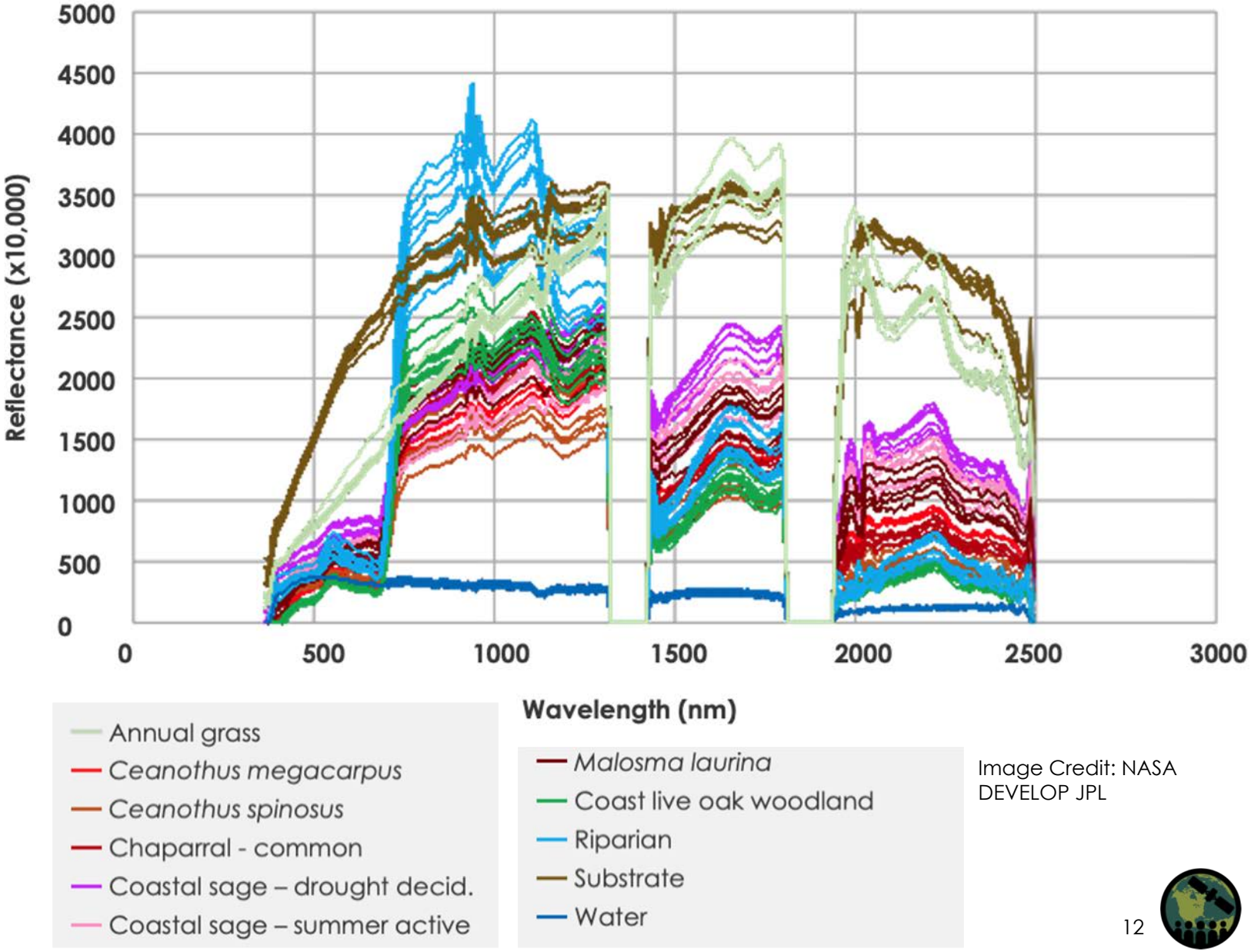
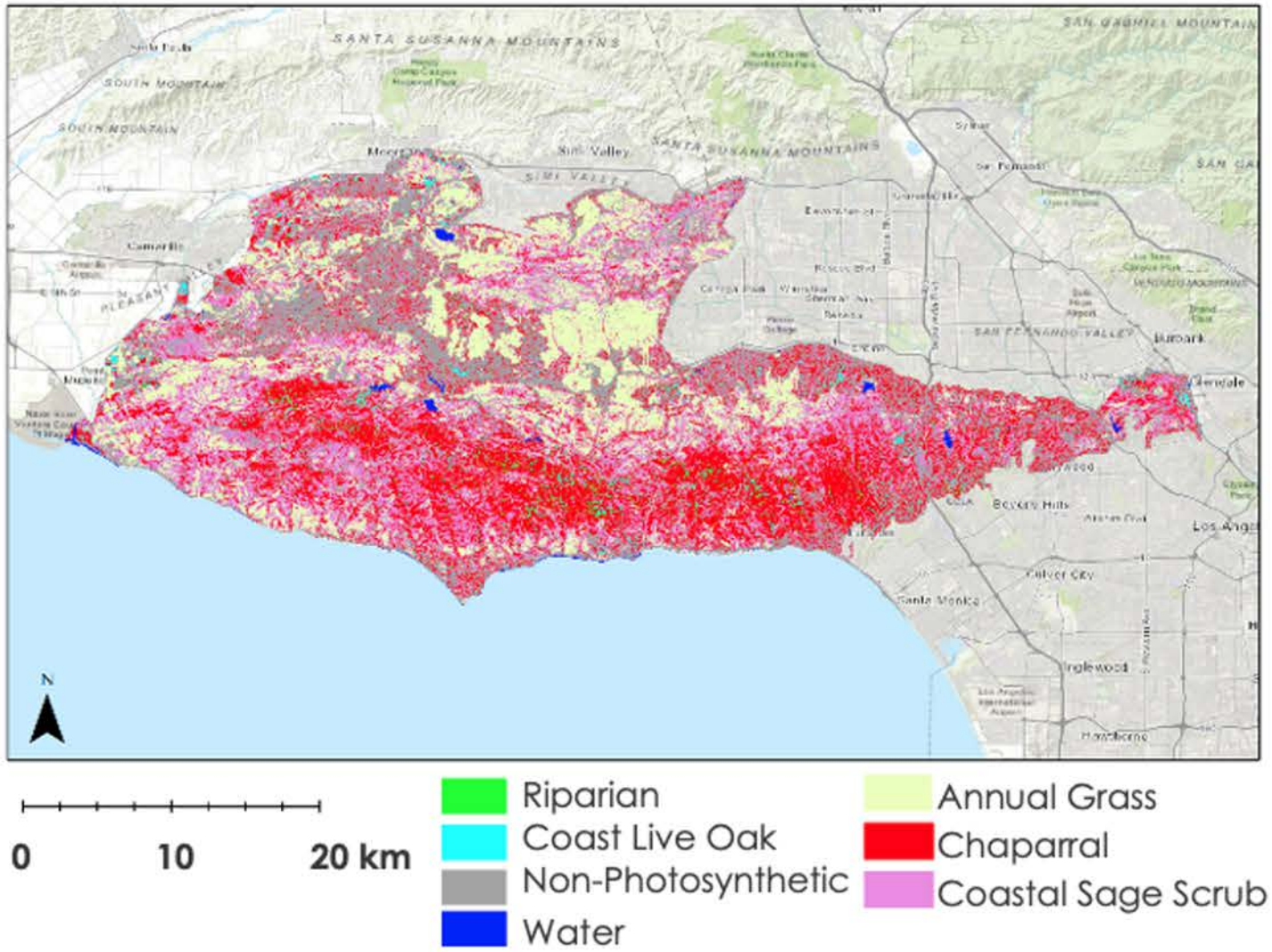


Image Credit: NASA DEVELOP JPL

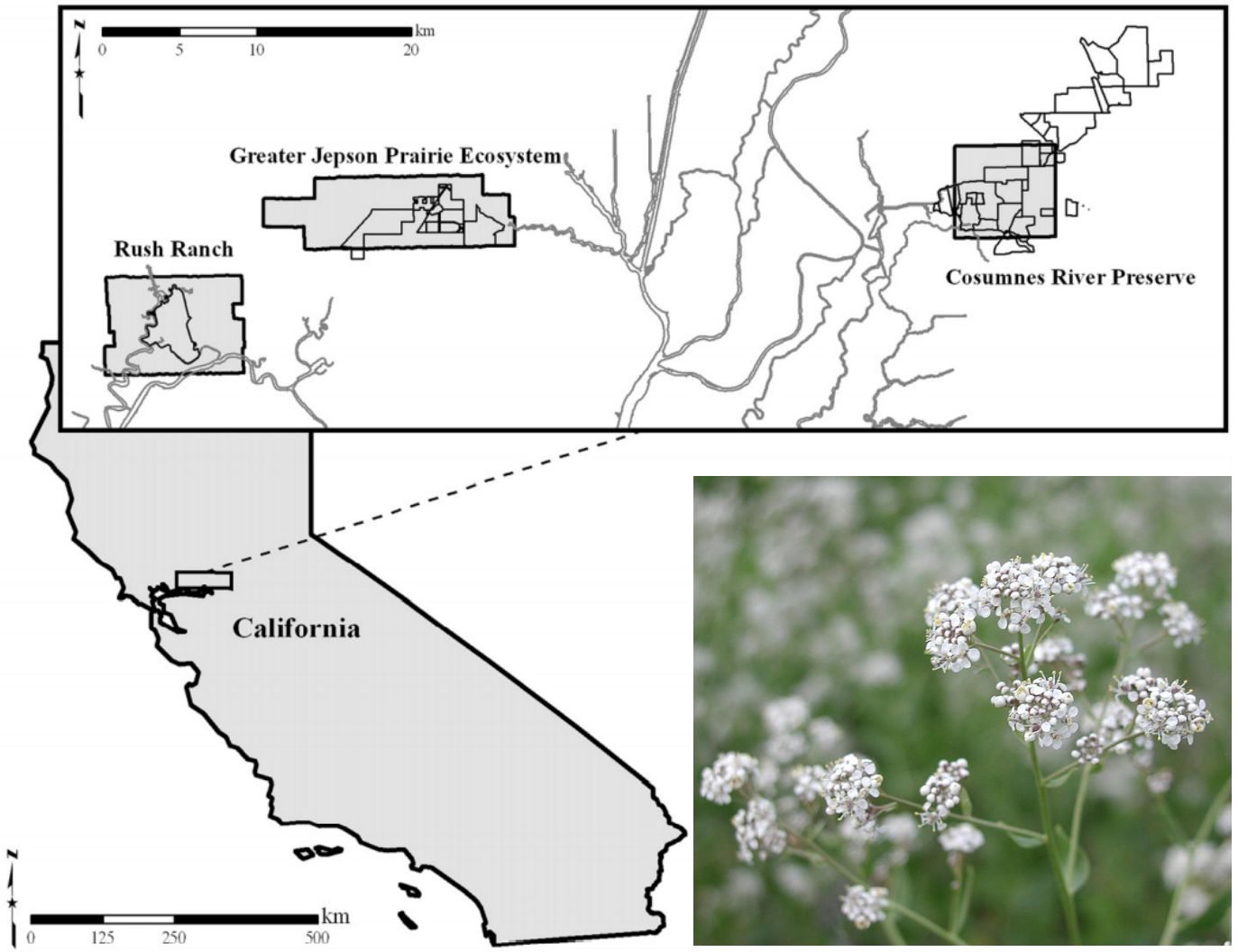
Forest Monitoring: Santa Monica Mountains Restoration



	Area (M^2)	Percent of Area
Chaparral	380,068,354	31.11%
Coastal Sage	322,478,677	26.40%
Annual Grass	253,353,514	20.74%
Non-Photosynthetic	223,616,221	18.31%
Riparian	27,940,627	2.29%
Coast Live Oak	8,307,206	0.68%
Water	5,691,947	0.47%

Spatially explicit estimations of pre-fire landcover (right) used to make pre-fire surface area estimations of vegetation types (left) to inform restoration planning. Image credit: NASA DEVELOP JPL

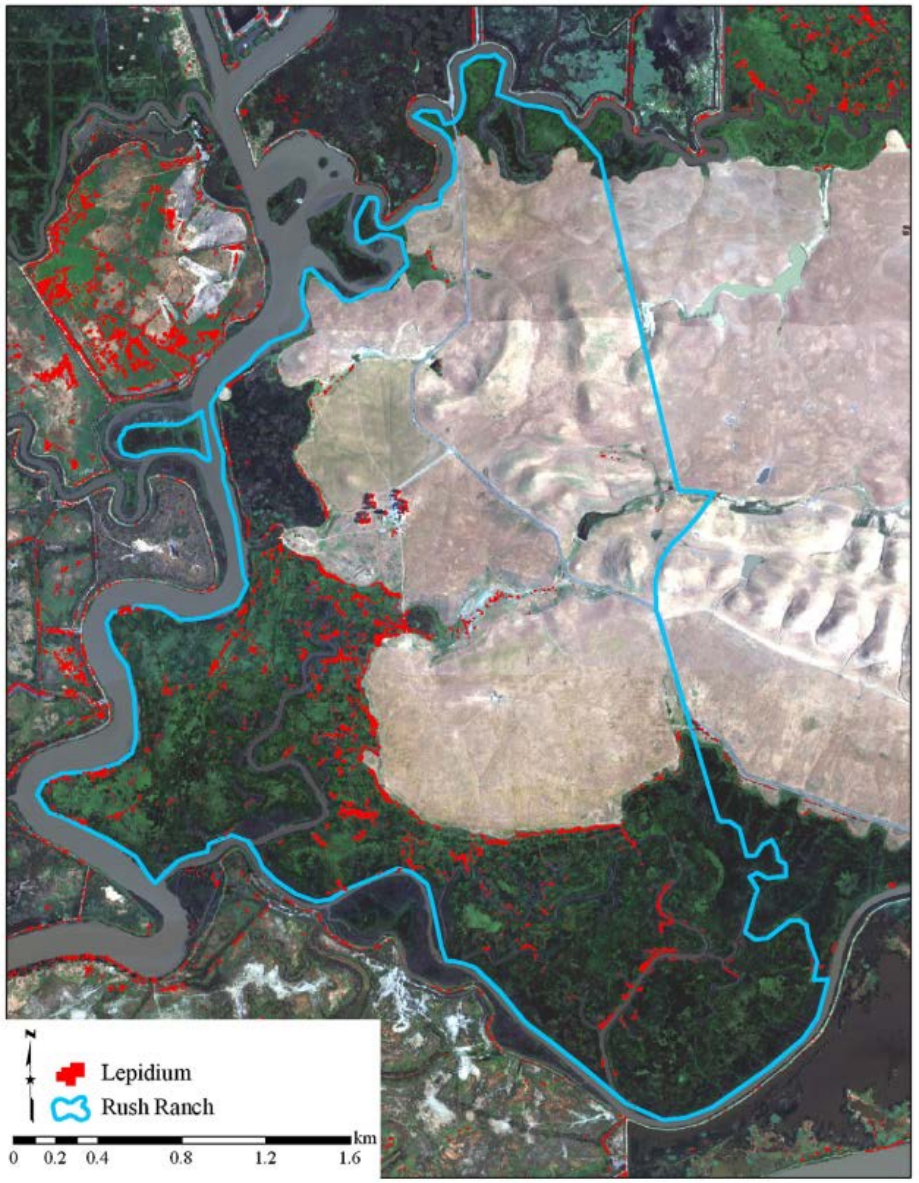
Invasive Species: Perennial Pepperweed (*Lepidium latifolium*)

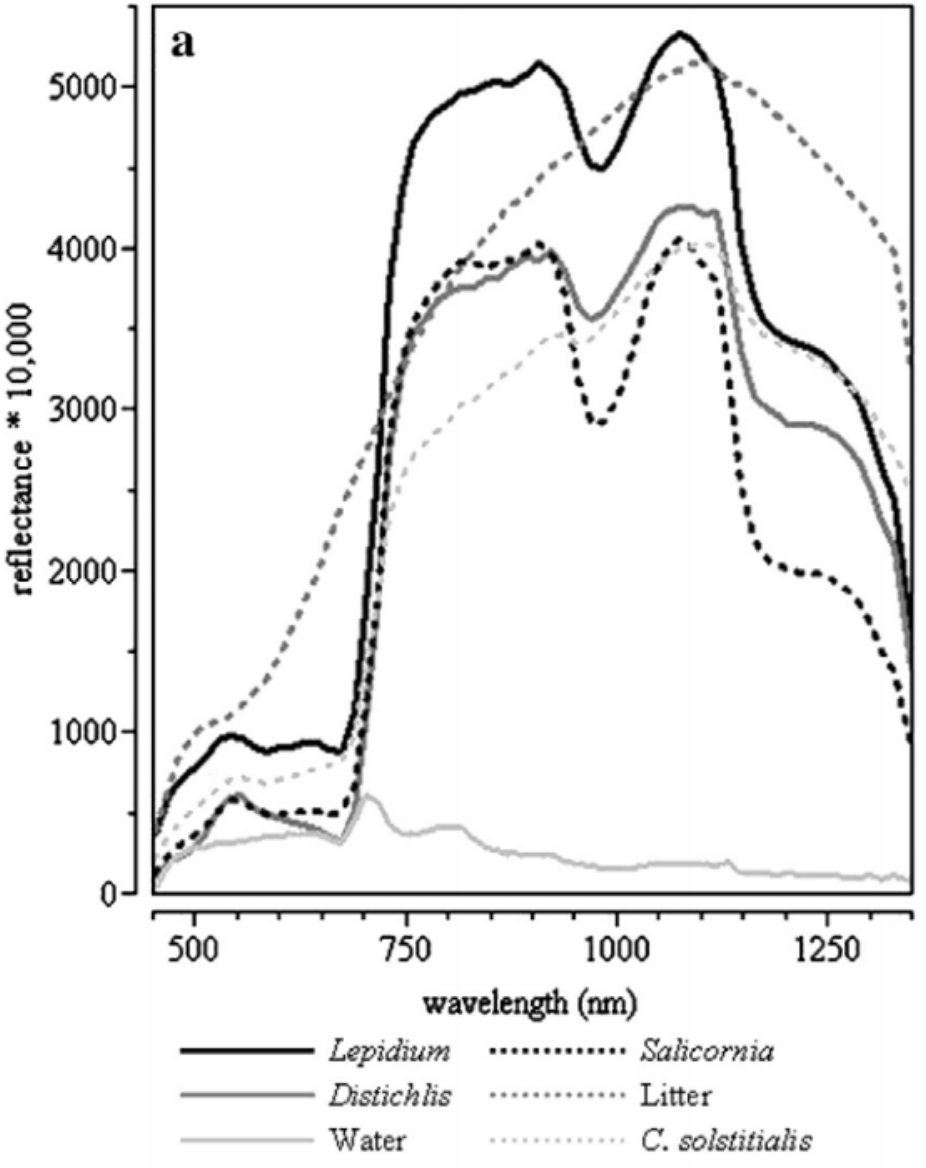


- Pepperweed is an aggressive invader that pushes out native plant species.
- Thick, white inflorescence due to flowering and fruiting phenologies distinguishes the species from surrounding vegetation.
- Airborne HyMap hyperspectral data was used to distinguish this unique spectral signature in California's San Francisco Bay/Sacramento–San Joaquin Delta Estuary.

Image credit: Andrew & Ustin, 2008; Leslie J. Mehrhoff

Invasive Species: Perennial Pepperweed (*Lepidium latifolium*)



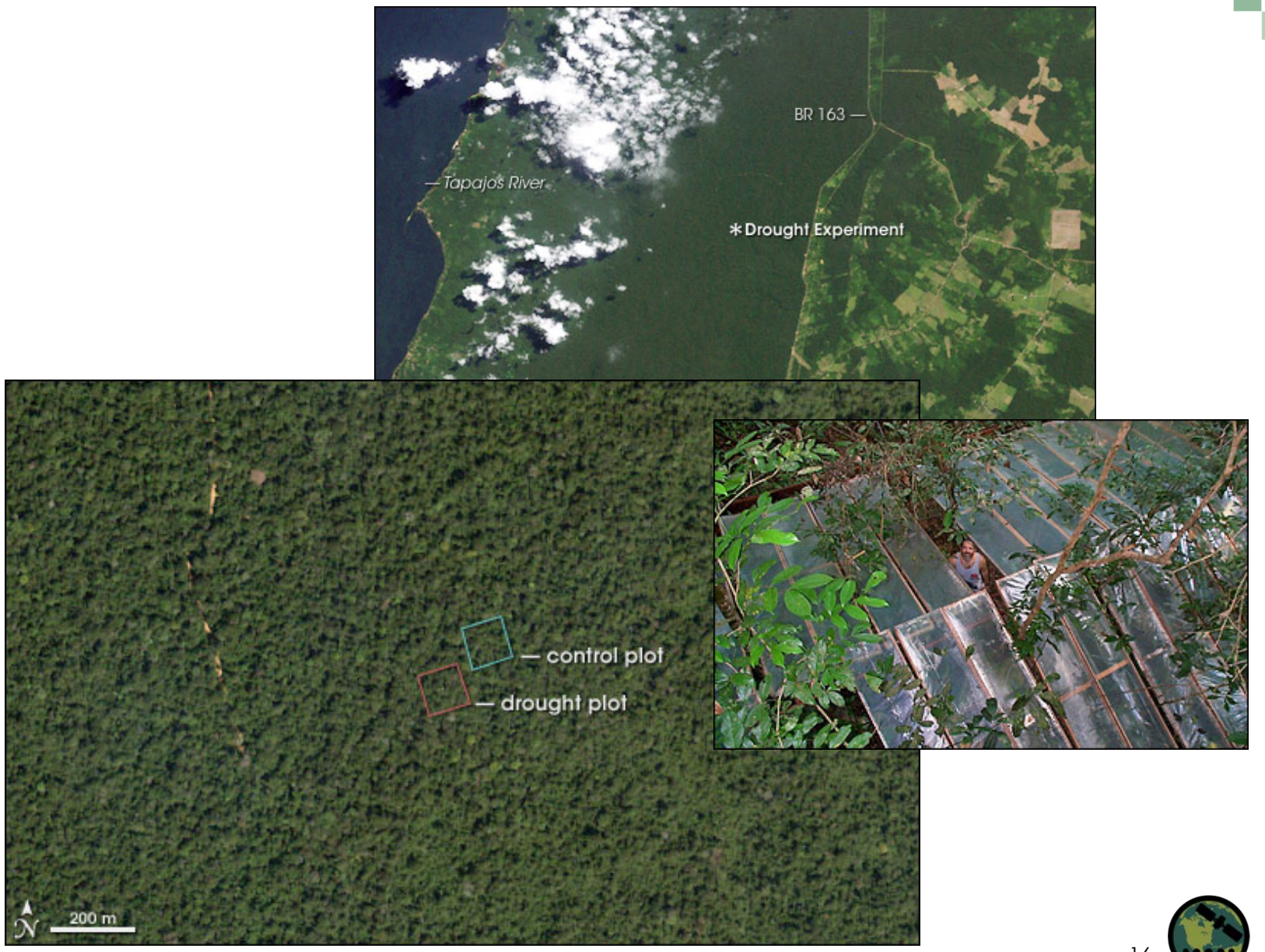


Landcover map displays locations of pepperweed infestation at Rush Ranch (left). Spectral profile of vegetation (right) shows the necessity for hyperspectral information to differentiate pepperweed.

Image Credit: Andrew & Ustin, 2008

Forest Monitoring: Amazon Drought

- Identification of precise drought-stress signals in the canopy with Hyperion
- Landsat: NDVI not sensitive enough to detect changes in pigment activity, leaf area, and carbon balance



Landsat image with experiment location (top), drought and control plots (left), and control plot where rain is being stored and used for trees. Image Credit: Robert Simmon and Asner *et al.*)

Forest Monitoring: Amazon Drought

- Hyperion provided improved estimation of drought signals.
- In Figure:
  - Reflectance measured by Hyperion in July and November 2001 from 500-1300 nm (top), zoomed in graph (bottom).
  - Dashed lines show wavelengths used for estimates of carbon uptake: green for vegetation greenness, purple for light-use efficiency, and red for the activity of anthocyanin, a chlorophyll-helper pigment.

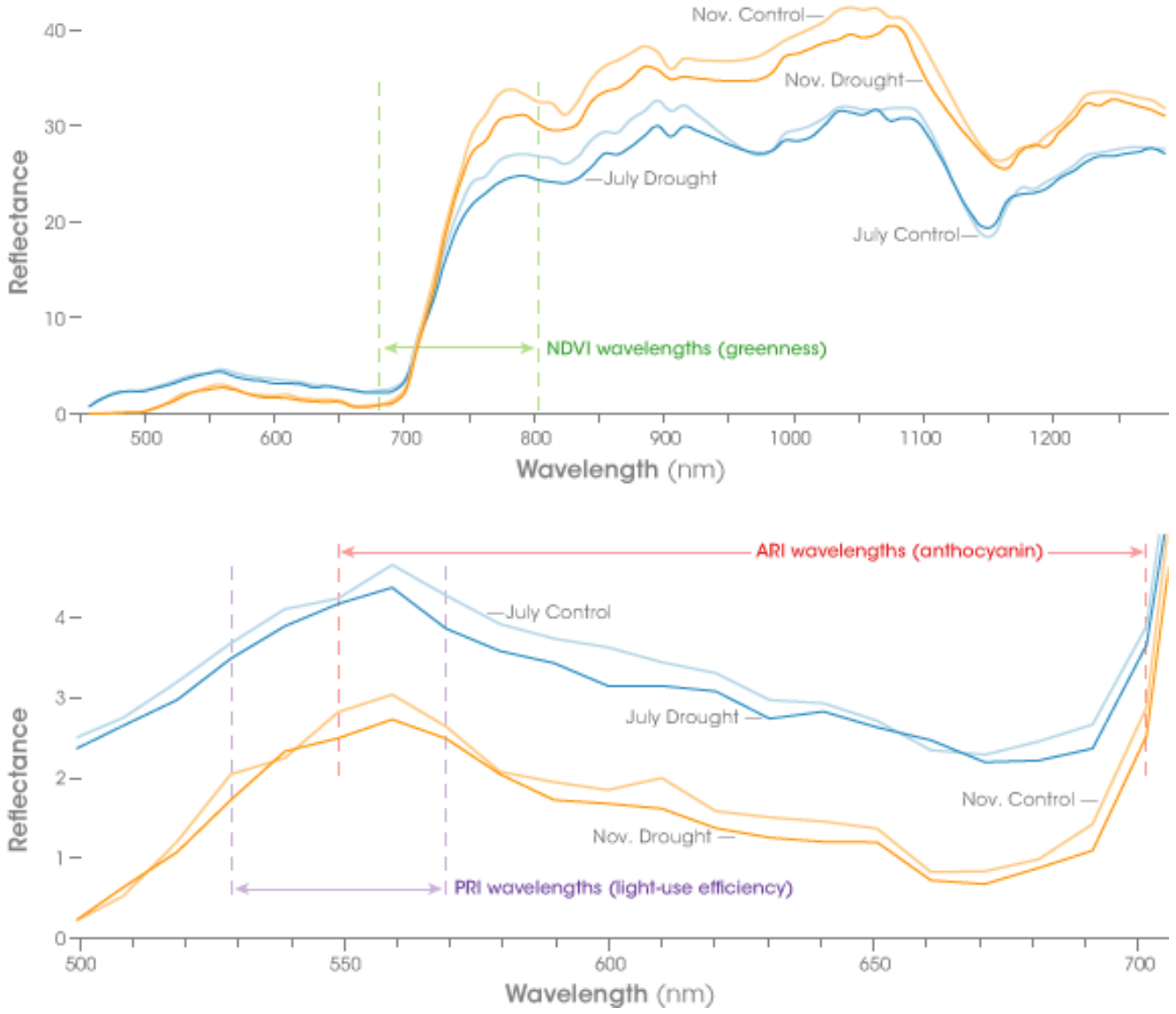
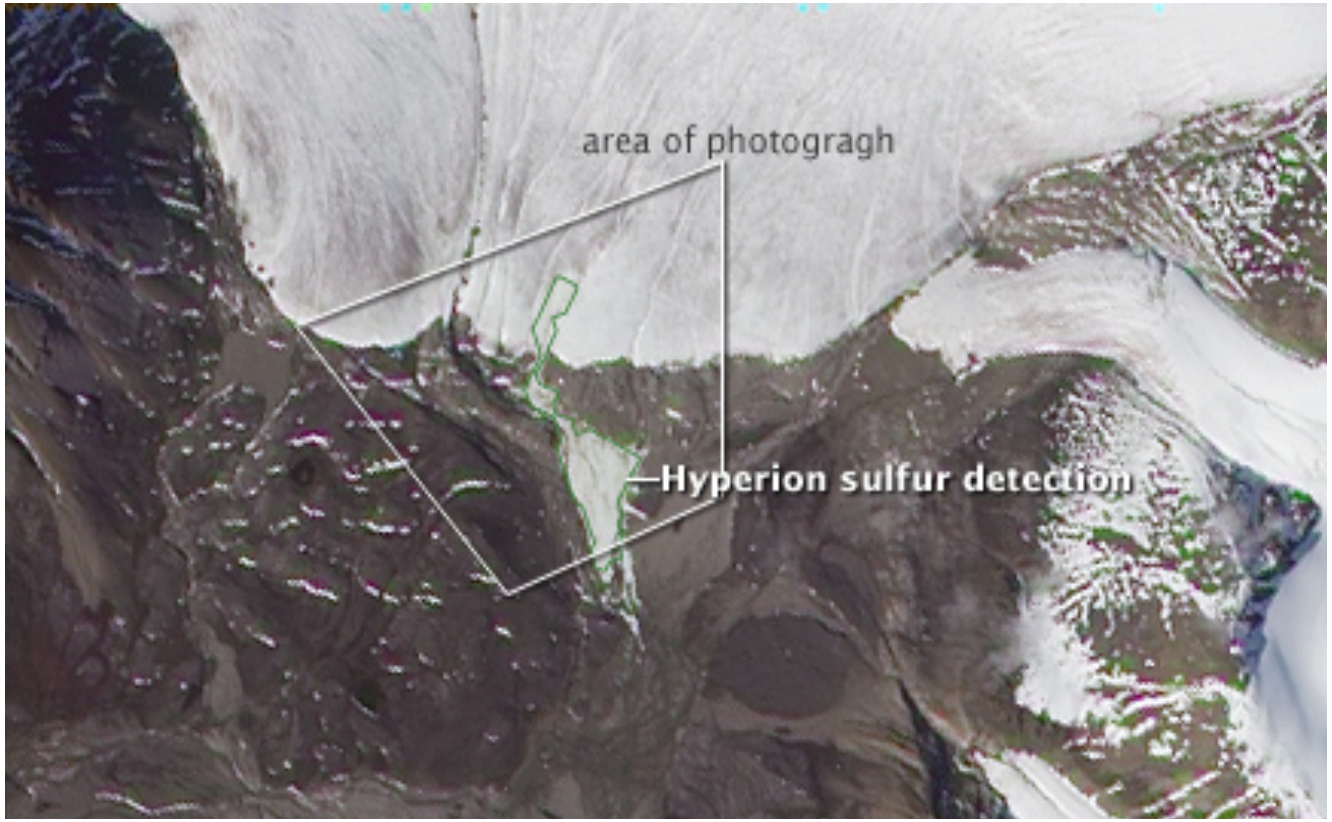


Image Credit: Robert Simmon and Asner *et al*

Sulfur Deposits in the Arctic

- Borup Fiord Pass on Ellesmere Island, Canada
- Sulfur from natural springs deposited
- Hyperion data used to map the deposits
  - Hydrogen sulfide gas and water are converted to stable deposits of sulfur or gypsum
  - This conversion usually occurs when bacteria are present
- Study site could be used to investigate life on other celestial bodies like Europa



Location of sulfur deposit (outlined in green) using data from Hyperion. Image Credit: Damhait Gleeson, NASA JPL

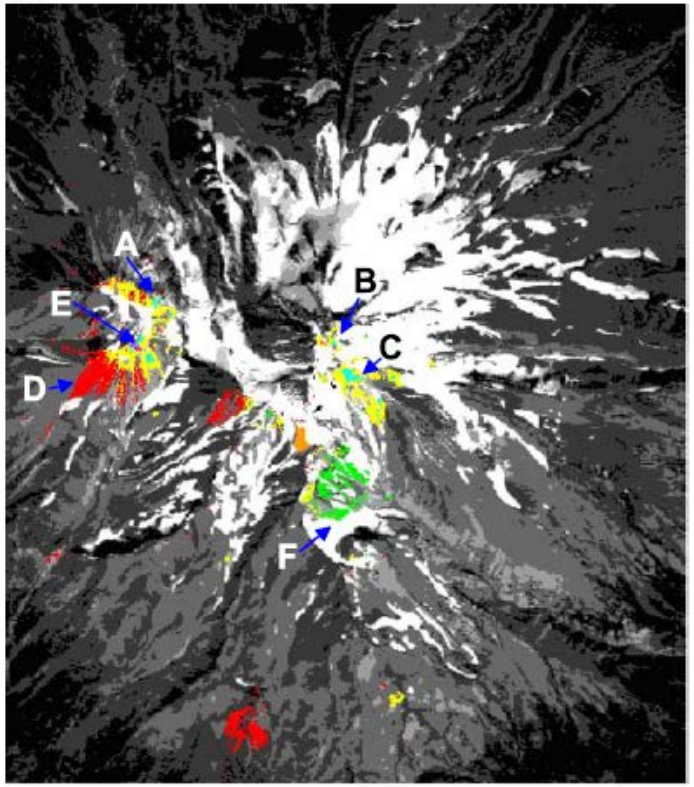
Volcanic Debris Flows: Mount Shasta, California

- Volcanic debris flows are a potentially deadly phenomena.
- Mapping rocks and structures can assist in identifying weakened zones that may be prone to collapse.
- AVIRIS and Hyperion data, along with Digital Elevation Models (DEMs) were used to map mineral deposits on Mount Shasta, CA.

Image Credit: Pixabay

Volcanic Debris Flows: Mount Shasta, California

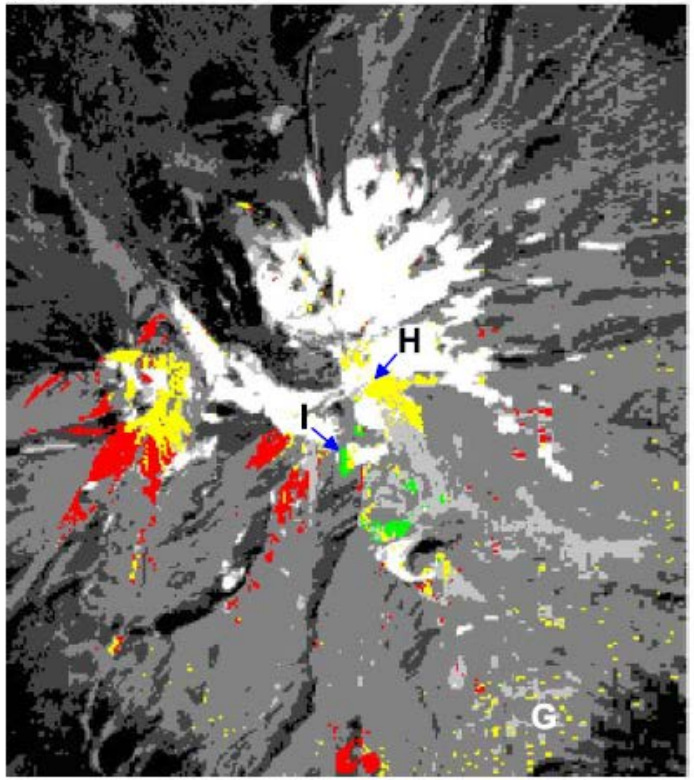
(a)



AVIRIS Mineral Map:

- Fe-Oxide
- Kaolinite
- Alunite +- Kaolinite +- Gypsum
- Red Banks Oxide
- Hydrous Silica
- Amphibole-rich Flows

(b)



Hyperion Mineral Map:

- Fe-Oxide
- Kaolinite
- Amphibole-rich Flows

N

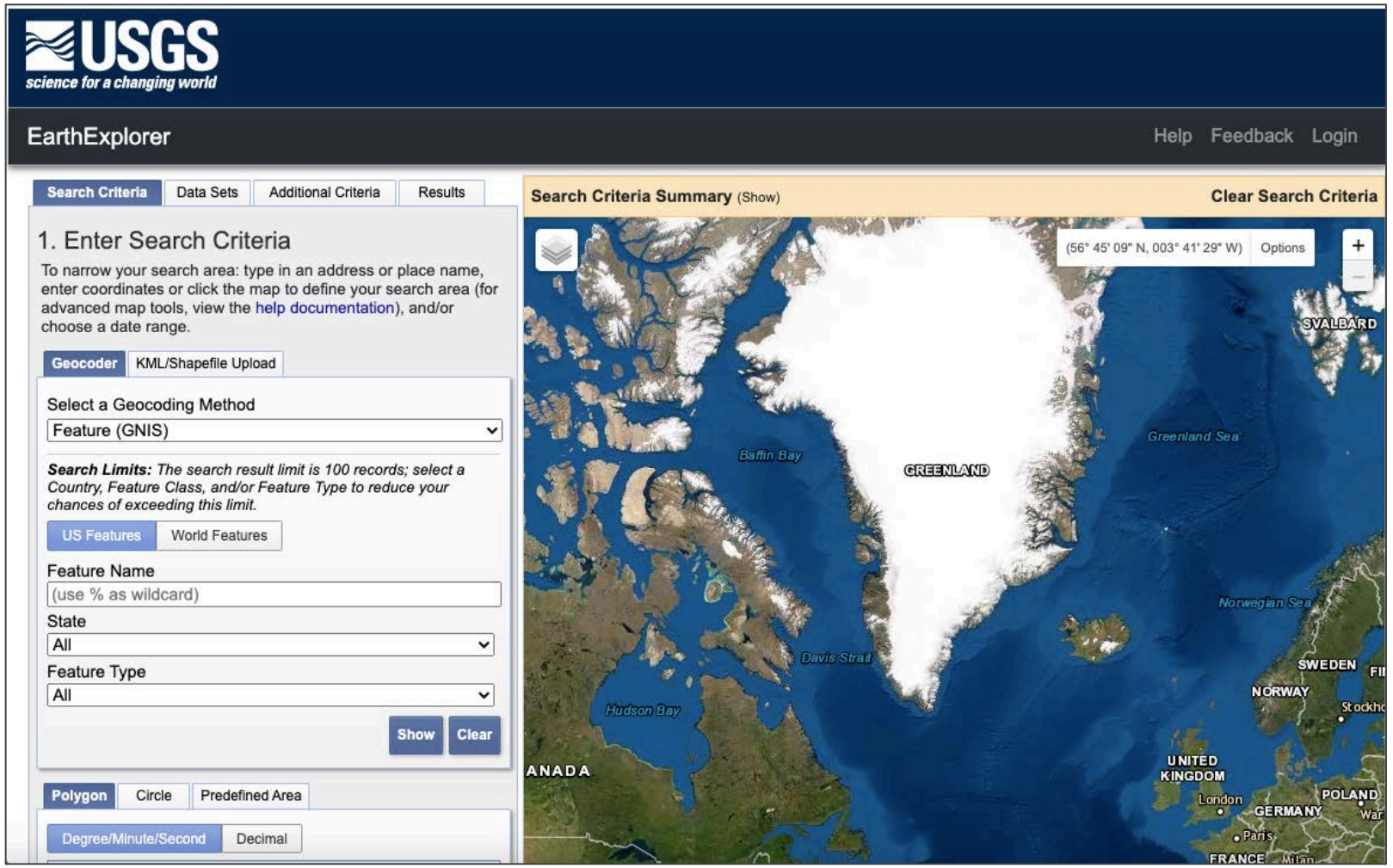
Scale
2 km

Crowley, et al 2003

Data Access and Display Demonstration

USGS EarthExplorer

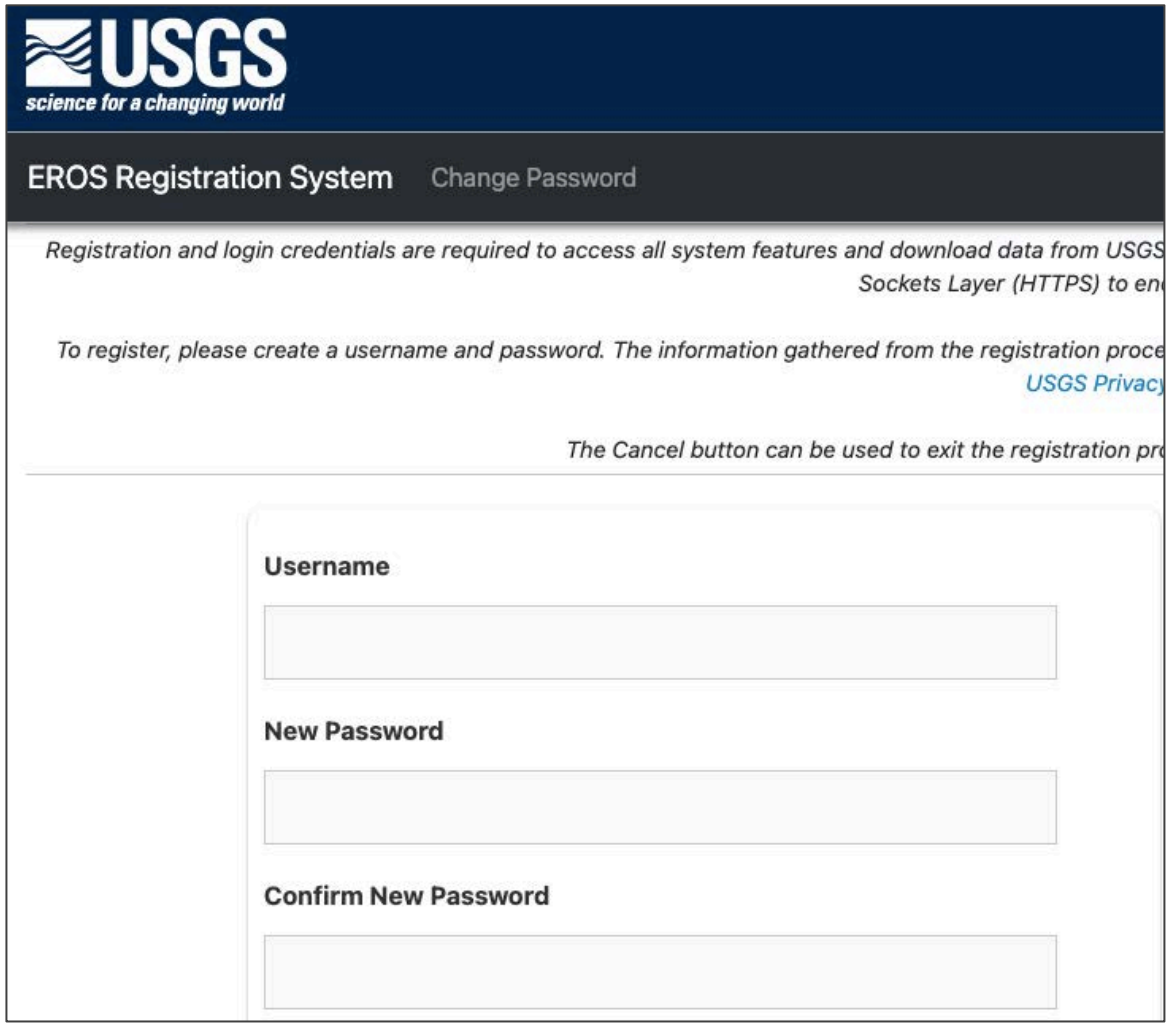
- EarthExplorer can be used to filter and access data from Hyperion and other sensors.
- Data search criteria requirements include:
  - Data Product Type
  - Sensor
  - Spatial Extent
  - Date Range
  - Cloud Cover



Link: https://earthexplorer.usgs.gov/

EarthExplorer Login Requirements

- You will need to sign up for an account through the USGS EROS Registration System to access data from EarthExplorer.
- Once registered with your preferred email, you will be able to log into EarthExplorer and directly download data products.



Link: https://ers.cr.usgs.gov/register

EO-1 Hyperion Review

- Hyperspectral satellite data from **November 21st, 2000 – February 22nd, 2017**
- Spatial **resolution of 30 meters** for all bands
- **220 unique spectral channels** ranging from 0.357 to 2.576 micrometers with a 10-nm bandwidth
- Full data archive available online

Image Credit: NASA

Available Hyperion Data Products

- Level 1Gst
  - Radiometric and systematic geometric corrections derived from spacecraft ephemeris data have been applied while employing a 90-meter Digital Elevation Model (DEM) for topographic accuracy.
  - Provided in **GeoTIFF format**
- Level 1T
  - Radiometric and systematic geometric corrections incorporating ground control points have been applied while employing a 90-meter Digital Elevation Model (DEM) for topographic accuracy.
  - Provided in **GeoTIFF format**
- Level 1R
  - Radiometric corrections have been made to compensate for variations due to detector sensitivity.
  - Provided in **HDF format**

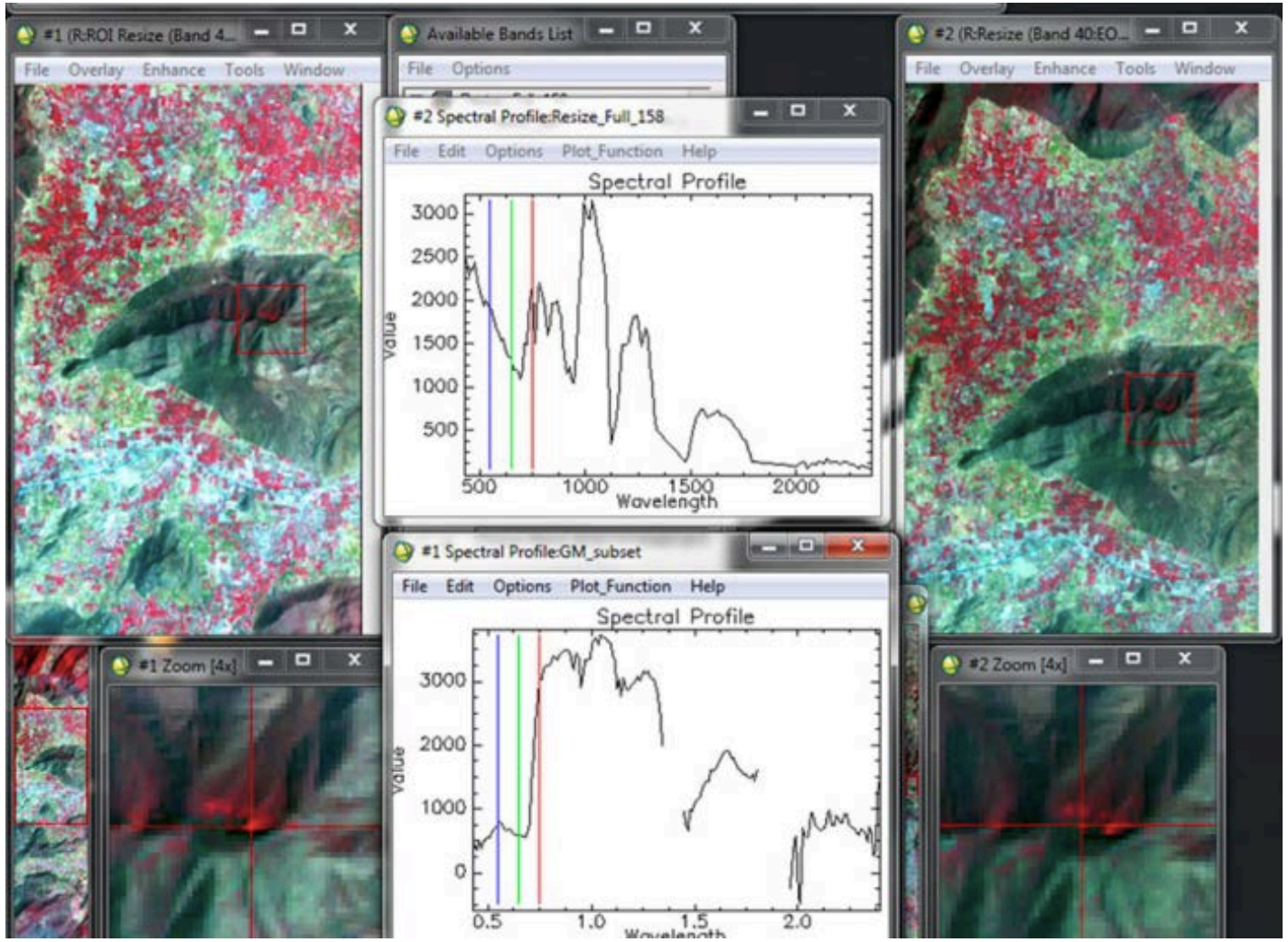
Data Processing

- Level 1 Hyperion products contain **radiance values**.
- To obtain **surface reflectance** values for analysis, data products must undergo atmospheric correction.
- There are many atmospheric correction models available:
  - **FLAASH** (Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes)
  - **ACORN** (Atmospheric Correction Now)
  - **ATREM** (Atmosphere Removal Program)

Full Resolution Hyperion Images within the San Francisco Bay Area from L1T Data Products

FLAASH Surface Reflectance in ENVI

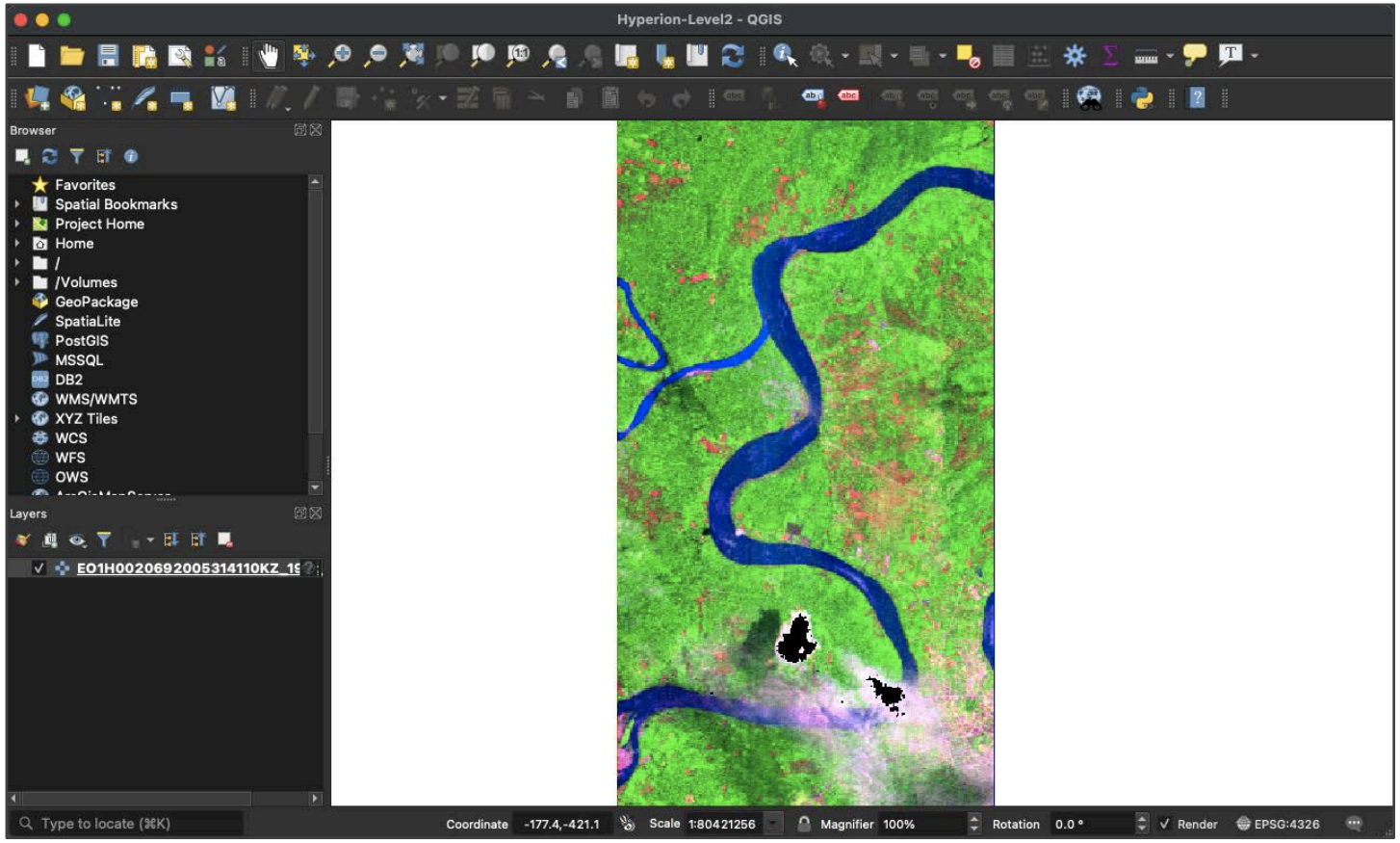
- Level 1 data products in HDF or GeoTIFF format downloaded directly from EarthExplorer can be loaded into ENVI.
- ENVI FLAASH can be used to complete further radiometric calibration and obtain surface reflectance values.
- Files can be exported in GeoTIFF format and manipulated to complete environmental analysis on other GIS platforms.



ENVI FLAASH vegetation assessment with Hyperion data. Credit: Poovalinga Ganesh et al. 2012

QGIS

- QGIS is a free and open-source GIS platform with many remote sensing data processing capabilities.
- Features include raster calculation, band manipulation, and visual data display.
- Relevant Plugins for Hyperspectral Data:
  - Spectral Library Tool
  - RasterDataPlotting
  - Semi-Automatic Classification Plugin



QGIS interface displaying Hyperion surface reflectance data from the Amazon Basin

Download Link: https://qgis.org/en/site/forusers/download.html

EarthExplorer and QGIS Demonstration

Summary

- Many land-based applications of hyperspectral data
- Benefits include the ability to:
  - Differentiate between vegetation species
    - Agriculture, forest health/restoration, invasive species
  - Distinguish between small differences in vegetation health/chlorophyll content
    - Drought, forest health
  - Identify and map mineral deposits
    - Geologic mapping, hazard potential
- Hyperspectral data accessed via multiple data portals, including the popular EarthExplorer
  - Requires processing to account for geometric and atmospheric influences, and to convert radiance into surface reflectance
- Next Session: Coastal and Ocean Applications


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!