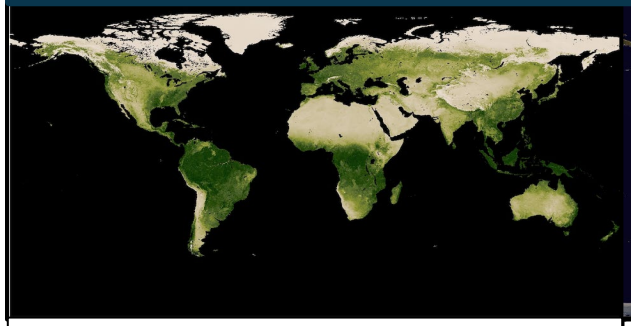
Part 2: Satellites and Sensors for Vegetation-Based Wildfire Applications (Pre-Fire)

Zach Bengtsson, Juan Torres-Pérez, & Amber McCullum

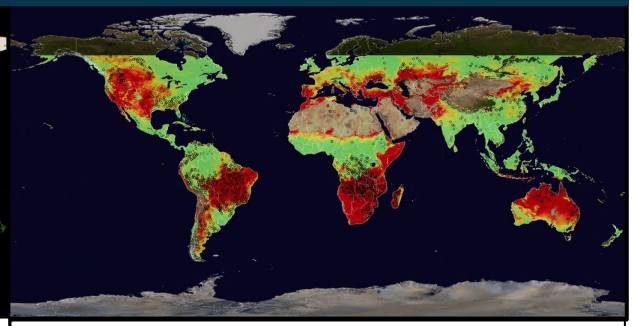
May 13, 2021

Webinar Agenda

Pre-Fire

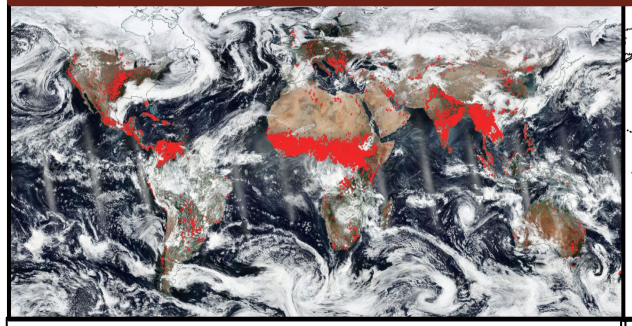


Session 1:
Climate and Hydrology

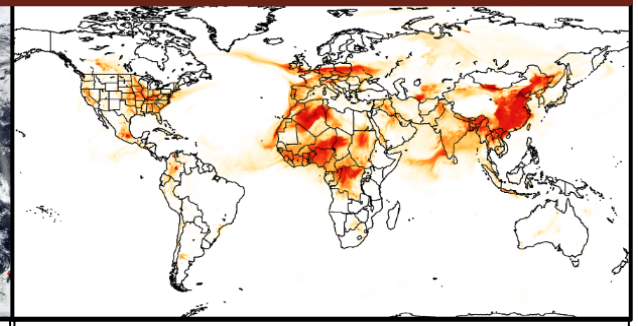


Session 2:
Vegetation

During Fire

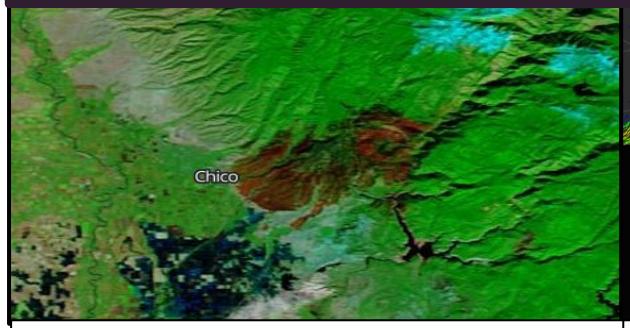


Session 3:
Active Fires and Smoke

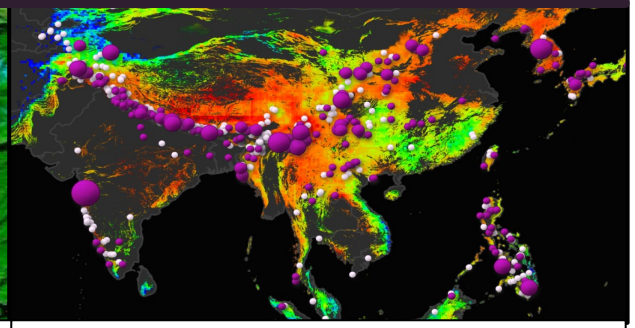


Session 4:
Smoke Forecasting

Post-Fire

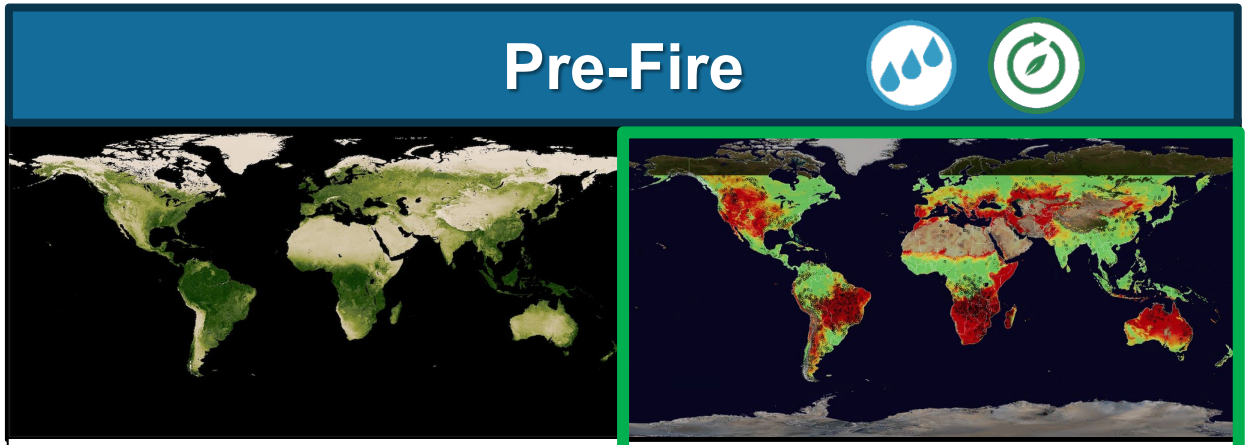


Session 5:
Climate & Hydrology



Session 6:
Vegetation

Webinar Agenda



Juan Torres-Pérez

Zach Bengtsson

Amber McCullum

Course Structure and Materials

- 6, 2-hour sessions on May 11, 13, 18, 20, 25, & 27
- The same content will be presented at two different times each day in English or Spanish:
  - English: 11:00-13:00 EDT
  - Spanish: 15:00-17:00 EDT
  - **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/arset-satellite-observations-and-tools-fire-risk-detection-and
  - Q&A following each lecture and/or by email at:
    - juan.l.torresperez@nasa.gov or
    - bengtsson@baeri.org

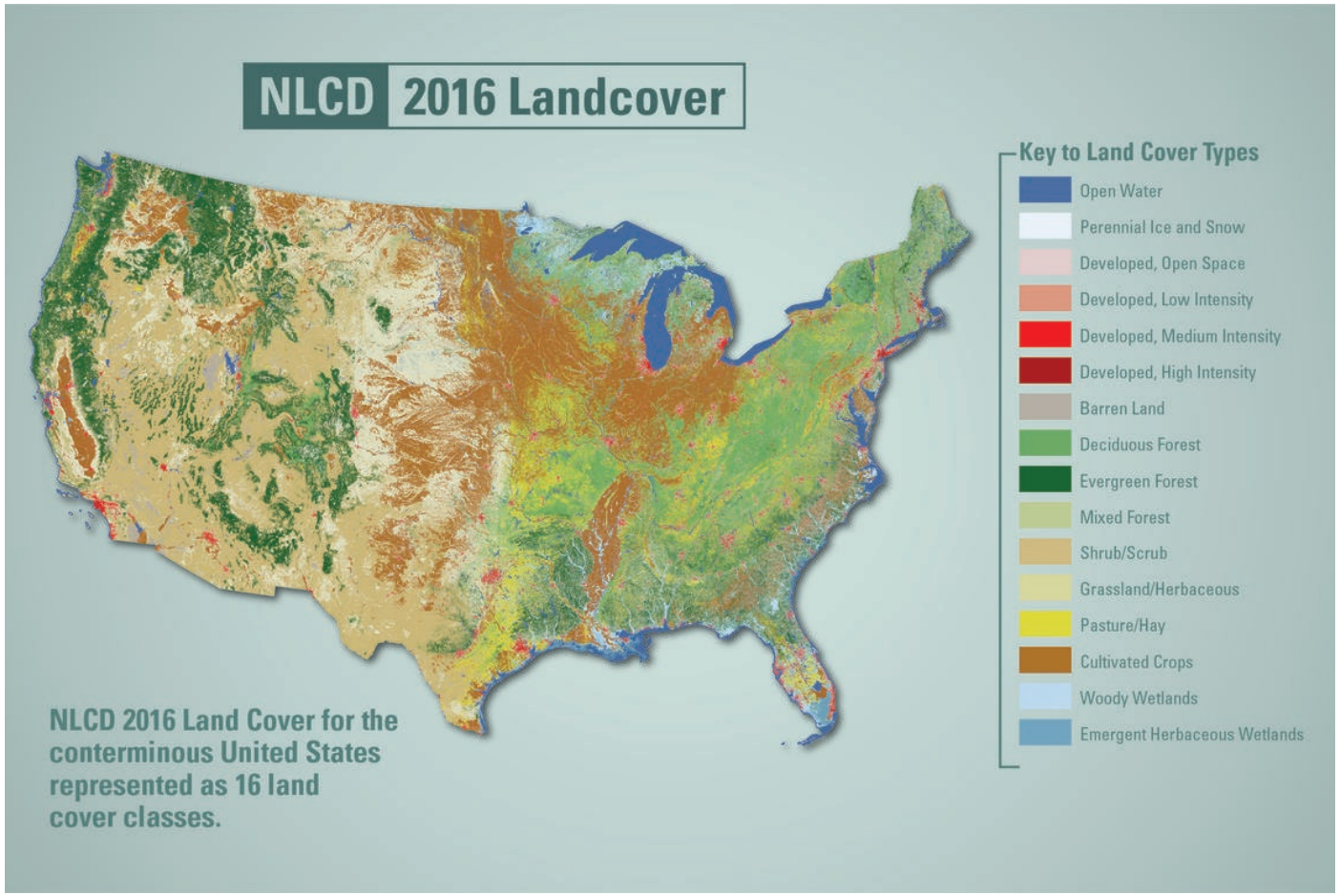
Vegetation from a Fire Science Perspective

- **This session will discuss vegetation as fuel for fire ignition, spread, and intensity.**
- Anything that can burn is fuel for a fire. During a wildland fire all kinds of plant material can act as fuel, including grasses, shrubs, trees, dead leaves, and fallen pine needles.
- Evaluation of vegetation at the pre-fire stage provides information about the availability and condition of fire fuels.

Vegetation fuels buring in a wildland fire in Montana. Image Credit: USGS, USFS, John McColgan

Landscape-Scale Mapping and Monitoring of Fuels

- Remote sensing data products provide an opportunity to analyze metrics like vegetation health, extent, moisture, and density, all of which impact fire ignition and behavior.
- Land cover and vegetation indices are a means to identify and evaluate fire fuels at a landscape scale.
- This information provides a fuels-based input into fire risk assessment.



Land cover classifications, like the National Land Cover Database, can provide information about fuel type and location. Image Credit: USGS

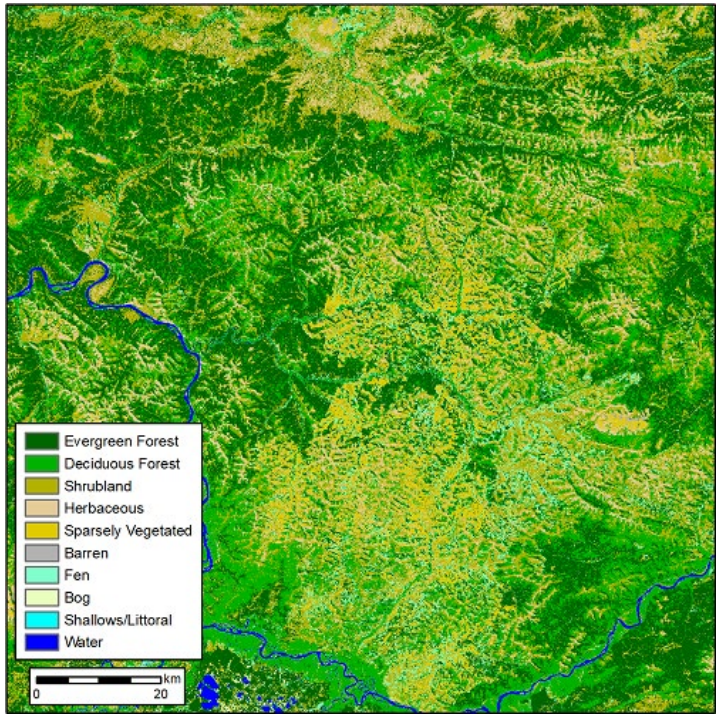
Session Outline

- The role of vegetation assessment in fire risk mapping
- Landscape mapping and monitoring of factors relevant to fire risk
  - Vegetation
    - Type and Extent
    - Stage and Health
    - Moisture
    - Structure
  - Topography
- Overview of satellites and sensors for vegetation-based fire applications
- Tools for pre-fire monitoring
- California case study review

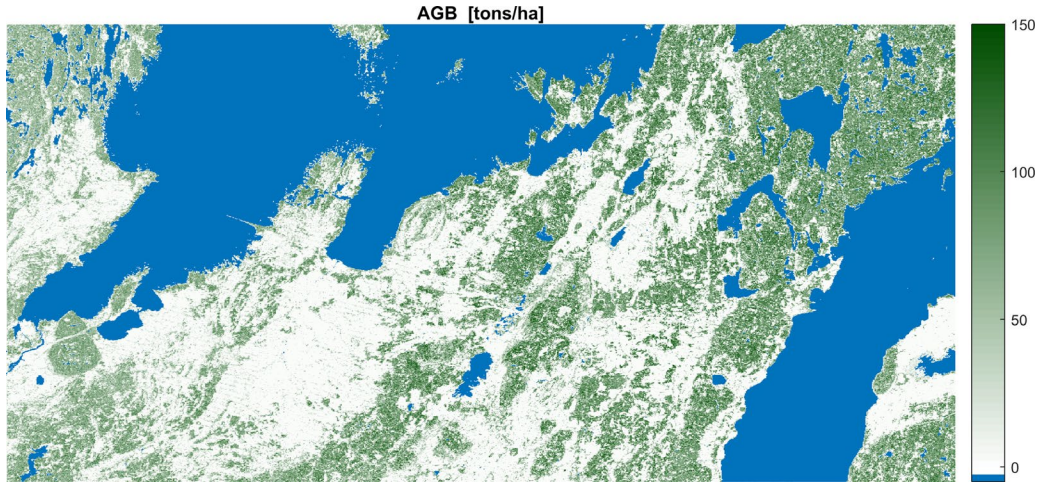
Fire Risk Mapping

Terminology

- **Fuels:** Physical characteristics of the live and dead biomass that contribute to the spread, intensity, and severity of wildland fire.
  - Loading (weight per unit area), size (particle diameter), and bulk density (weight per unit volume)
- **Fuel Types:** "An identifiable association of fuel elements of distinctive species, form, size arrangement, and continuity that will exhibit characteristic fire behavior under defined burning conditions" (Merrill and Alexander, 1987).



Vegetation type classification using Landsat data in Alaska. Image Credit: NASA ABoVE



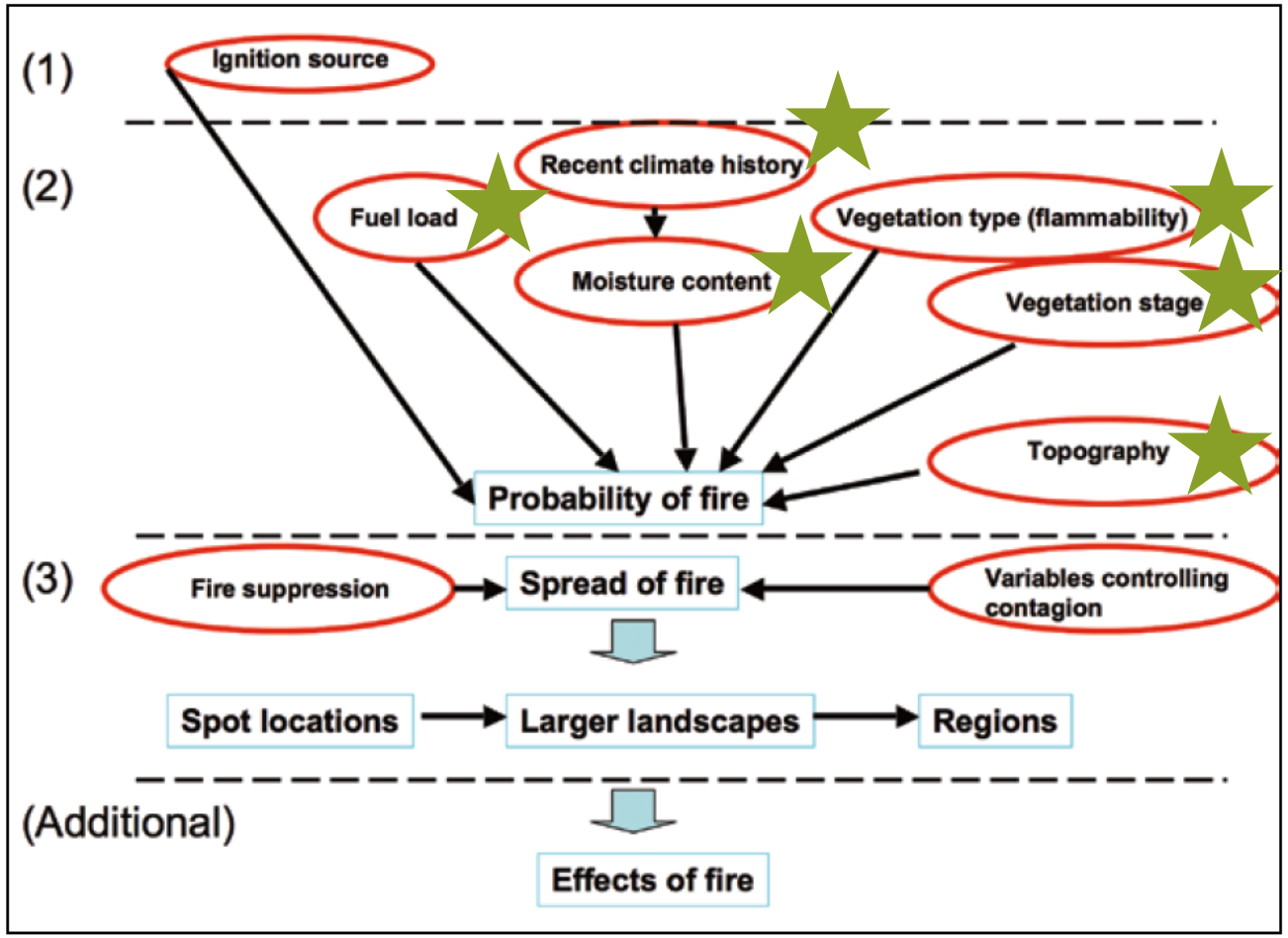
Forest biomass measured by Copernicus Sentinel-1. Image Credit: ESA

Terminology

- **Fire Risk**: The probability that a fire might start in a certain area. Risk is determined by compiling relevant factors that influence fire ignition and behavior.
- **Fire Regime:** Temporal variability in the physical characteristics and subsequent effects of wildland fire. Fire regimes are usually defined in terms of fire frequency, severity, size, and pattern. A fire regime is a general description of the role of fire for a specific area or ecosystem; it refers to the "nature of fires occurring over an extended period of time."
- **Fire Model**: Mathematical relationships that describe the potential characteristics of a fire.
- **Fuel Models:** Sets of parameters required by the associated fire model.
  - Fire models are equations and fuel models are numerical inputs that describe the fuel types as required by the fire model.

Fire Risk Mapping Framework

Where remotely sensed data can be used independently or with ground-based observations



Calculation of fire risk. There are three aspects to predicting fire: (1) the probability of ignition; (2) the biophysical influences on fire, such as fuel load, moisture content, flammability of the vegetation, and topography; and (3) the spread of fire once it gets established.

Image Credit: Weinstein and Woodbury, USFS

- Comprehensive fire risk maps are challenging to produce due to the many factors that impact the probability of fire.

Vegetation-Based Contributions to Fire Risk Mapping

- Remotely sensed observations can assist with the estimation of biophysical influences on fire.
- **In this training, we will be exploring topics related to fuel load, moisture, vegetation type and stage, and topography.**
- The parameters covered can be used as inputs into fire models and risk assessments to incorporate the influence of fuels and topography on likelihood and behavior.

Image Credit: USFS

Landscape Mapping and Monitoring

Elements of Vegetation-Based Landscape Monitoring

Vegetation Type and Extent

- Land Cover Classification
- Fractional Cover (FC)

Vegetation Stage and Health

- Phenology
- Vegetation Health Indices

Vegetation Moisture Content

- Moisture Indices
- Radar Measurements

Vegetation Structure

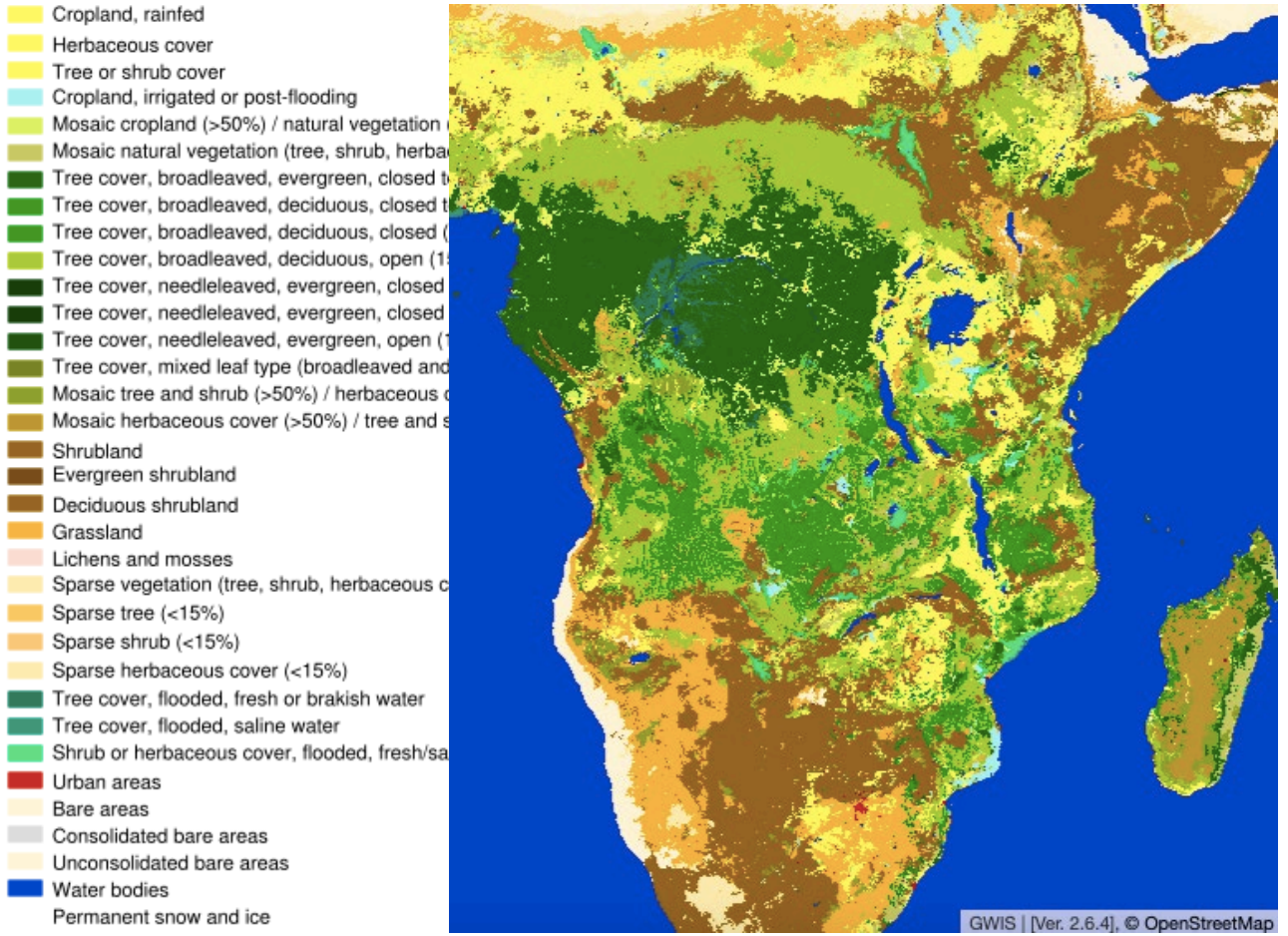
- Density
- Height

Topography

- Elevation
- Slope
- Aspect
- Features

Land Cover Classification

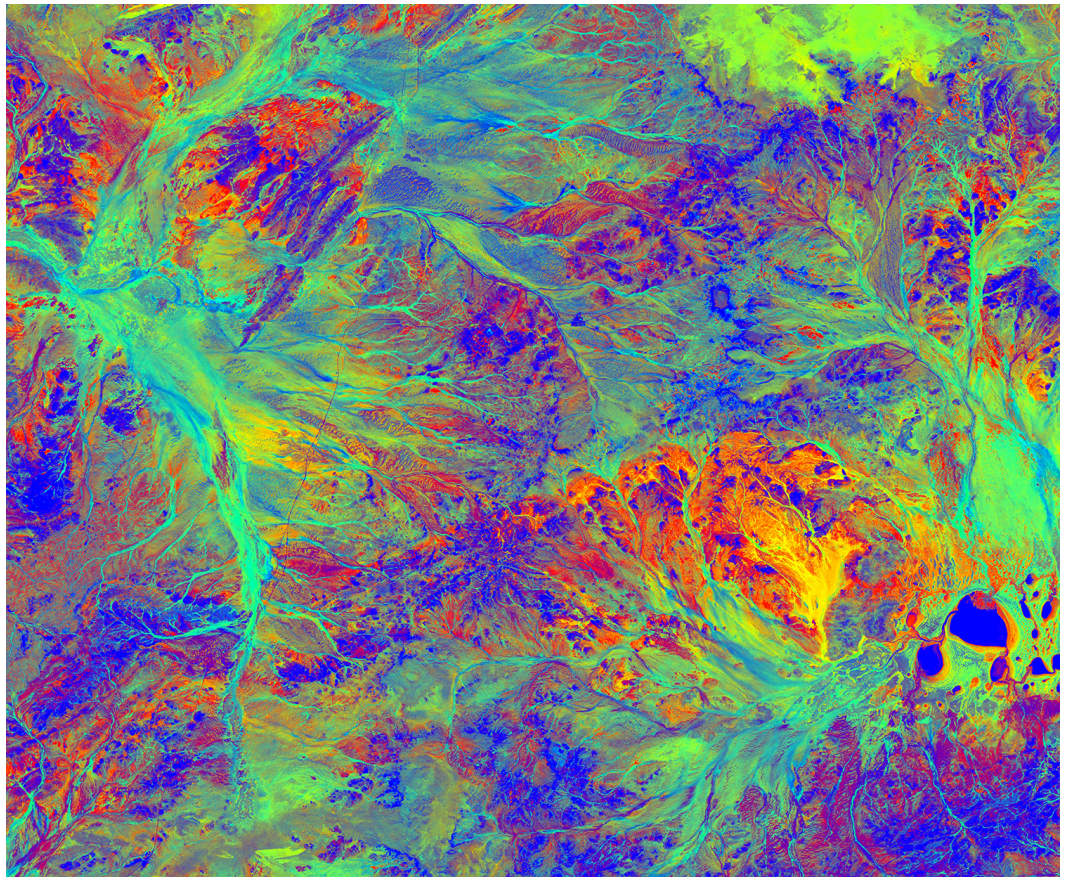
- Grouping of spectrally similar pixels in remote sensing imagery based on land cover class (forest, shrubland, agriculture, etc.).
- Fuel behavior varies with vegetation type.
  - Example: Forests contain more biomass to sustain burning, but shrubland vegetations often ignites easier.
- Classification of a landscape differentiates available fuel types and maps their spatial extent.
- ARSET Trainings
  - Land Cover Classification
  - Forest Mapping and Monitoring with SAR Data



Global Wildfire Information System (GWIS) land cover classification layer for Sub-Saharan Africa.
Image Credit: GWIS

Fractional Cover (FC)

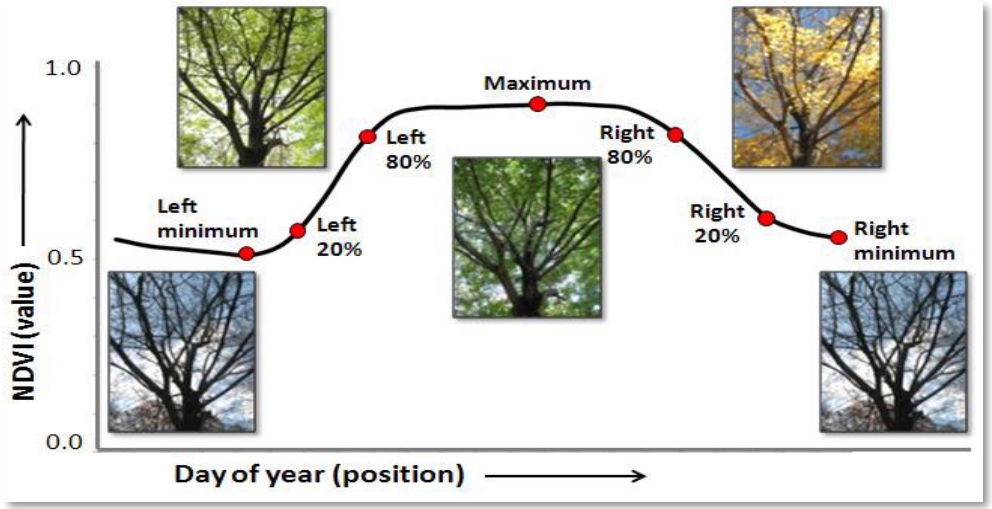
- Estimation of the proportion of an area that is covered by each member of a pre-defined set of vegetation or land cover types
- Calculated from a land cover classification
- Provides regional or countrywide estimates of vegetation fuel types
- Useful for aggregation of fuel types with similar burn potential

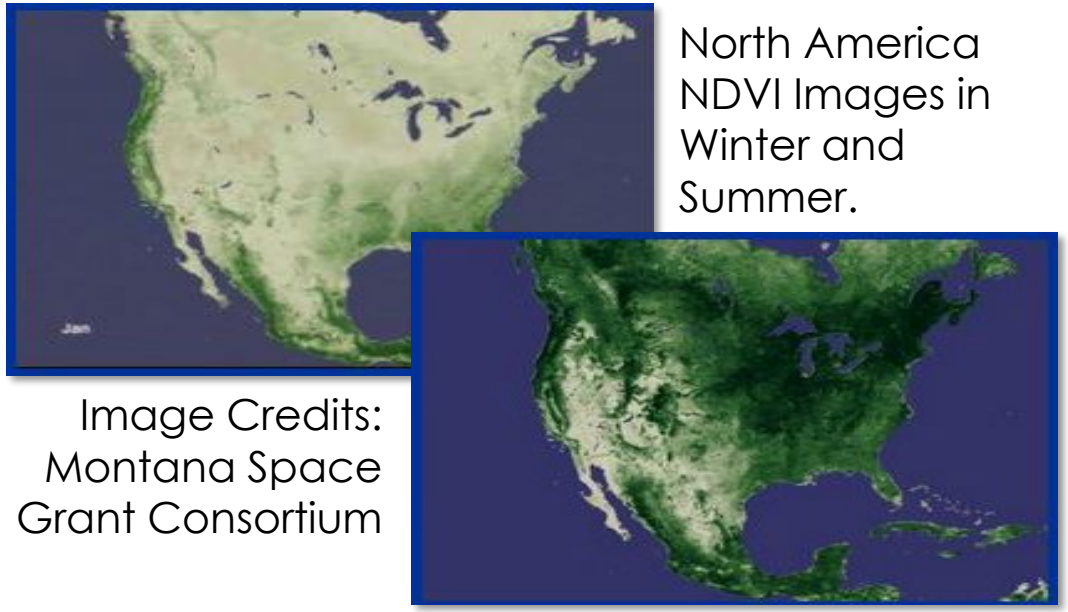


Fractional Cover (FC) from Australia: Green (leaves, grass, and growing crops), brown (branches, dry grass or hay, and dead leaf litter), and bare ground (soil or rock).
Image Credit: Digital Earth Australia

Vegetation Stage and Health

- Unhealthy vegetation has a higher percentage of dead branches and leaves, providing easier to burn fuel for fires. The stage of vegetation also dictates the amount and type of fuel available for fires.
- Vegetation Stage – Land Surface Phenology (LSP):
  - Use of satellites and sensors to track seasonal patterns of variation in vegetated land surfaces
  - ARSET Phenology Training
- Monitoring Stage and Health – Indices:
  - NDVI - Normalized Difference Vegetation Index
  - EVI - Enhanced Vegetation Index
  - SAVI - Soil-Adjusted Vegetation Index
  - Vegetation index anomalies





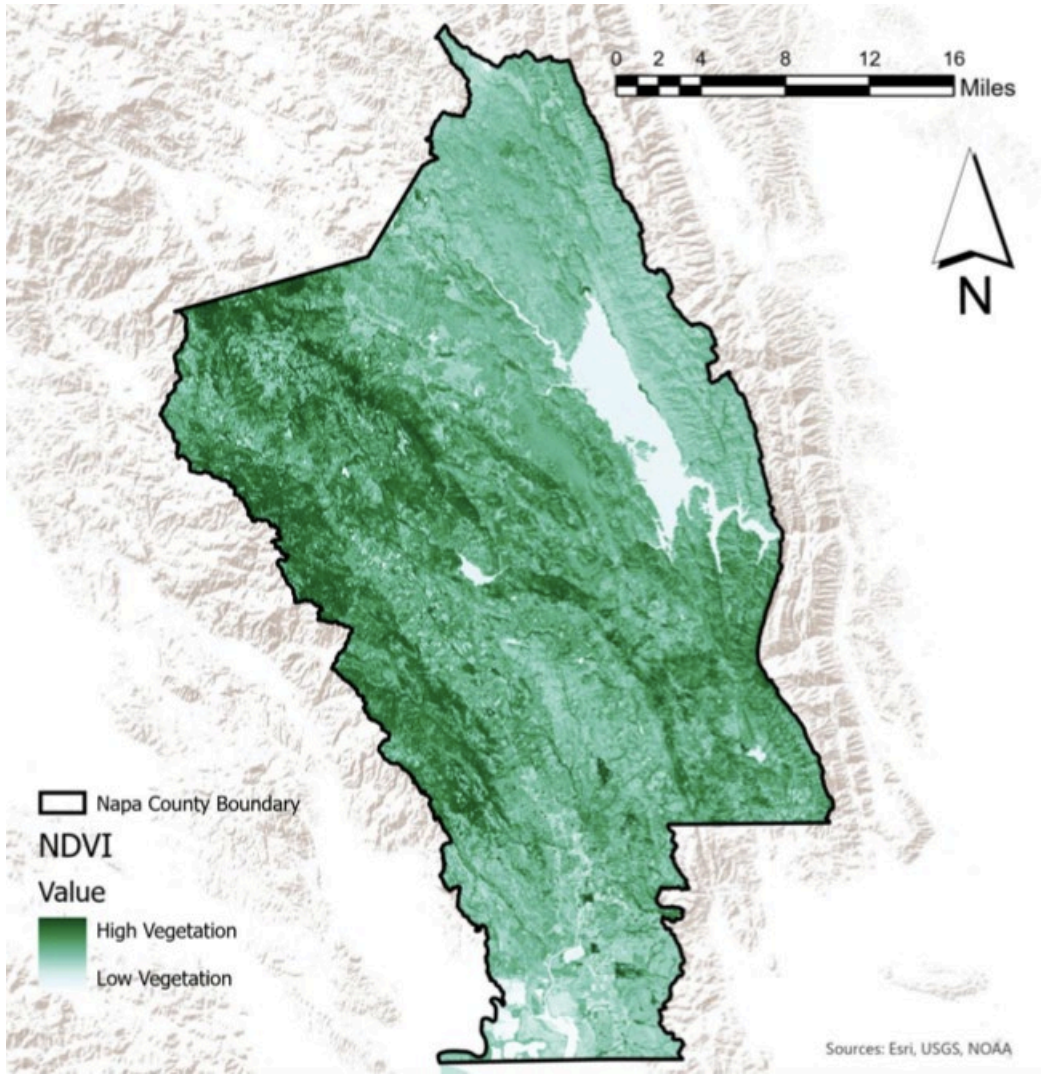
North America NDVI Images in Winter and Summer.

Image Credits: Montana Space Grant Consortium

Normalized Difference Vegetation Index (NDVI)

- NDVI is widely used as a metric for vegetation health and phenology.
- A measure of vegetation greenness
- Values range from -1.0 to 1.0
  - Negative values to 0 mean no green leaves.
  - Values close to 1 indicate the highest possible density of green leaves.
- NDVI Formula:

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



NDVI in Napa County, CA on July 8th, 2020.

Additional Vegetation Indices

Enhanced Vegetation Index (EVI)

$$EVI = G * \left(\frac{(NIR-R)}{(NIR+C1*R-C2*B+L)}\right)$$

Constants
$G = 2.5$
C1 = 6
C2 = 7.5
L = 1

- Can be used in place of NDVI to examine vegetation greenness
  - More sensitive in areas with dense vegetation, making it better for fuels assessment in dense forests
- Adjusts for canopy background and some atmospheric conditions

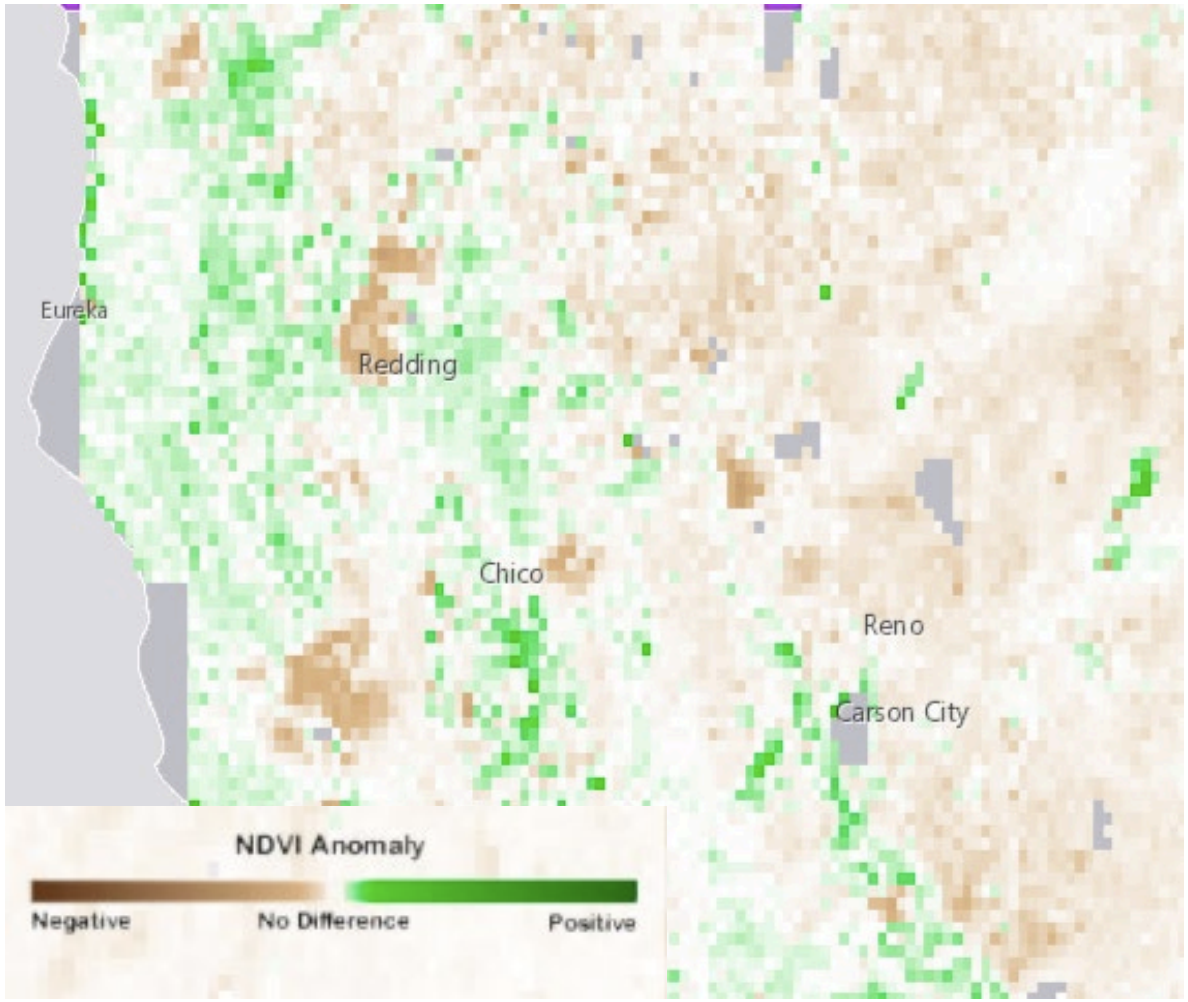
Soil Adjusted Vegetation Index (SAVI)

$$SAVI = \left(\frac{(NIR-R)}{(NIR+R+L)}\right) \times (1+L)$$

- Used to correct NDVI for the influence of soil brightness in areas where vegetative cover is low
  - Better index for areas with sparse vegetation and high bare soil coverage
- Contains a soil brightness correction factor (L)

Vegetation Index Anomalies

- Anomalies are a departure of a vegetation index from the long-term average and are generated by subtracting the long-term mean from the current value for that month of the year for each grid cell.
- These departures can indicate changes in vegetation health (due to drought high temperatures, etc.).



VIIRS NDVI anomaly product for July 3, 2020 shows negative anomalies in northern California prior to August fires, indicating potential impacts to vegetation from dryness and high temperature.
Image Credit: Crop Monitor

Vegetation Moisture

- Low moisture vegetation (drier fuel) is more likely to ignite and contribute to the spread of fire. Dry vegetation can also influence the moisture content of the surrounding environment.
- Live Fuel Moisture Estimation:
  - Absolute measurement of plant water content, through the Fuel Moisture Content (FMC)
    - FMC: The ratio of leaf water content to leaf dry-matter content
    - Also quantified indirectly via Evapotranspiration (ET)
- Vegetation Indices:
  - Normalized Difference Water Index (NDWI), Normalized Dry Matter Index (NDMI), Evaporative Stress Index (ESI)
- Radar remote sensing of vegetation moisture

Normalized Difference Water Index (NDWI)

- Measure of vegetation moisture
  - Also called the "wetness" index or the "moisture" index
- Frequently used in drought and wildfire monitoring
  - Detects more subtle changes in vegetation moisture
  - Used to assess Live Fuel Moisture (LFM)
- NDWI = (NIR – SWIR)/(NIR + SWIR)

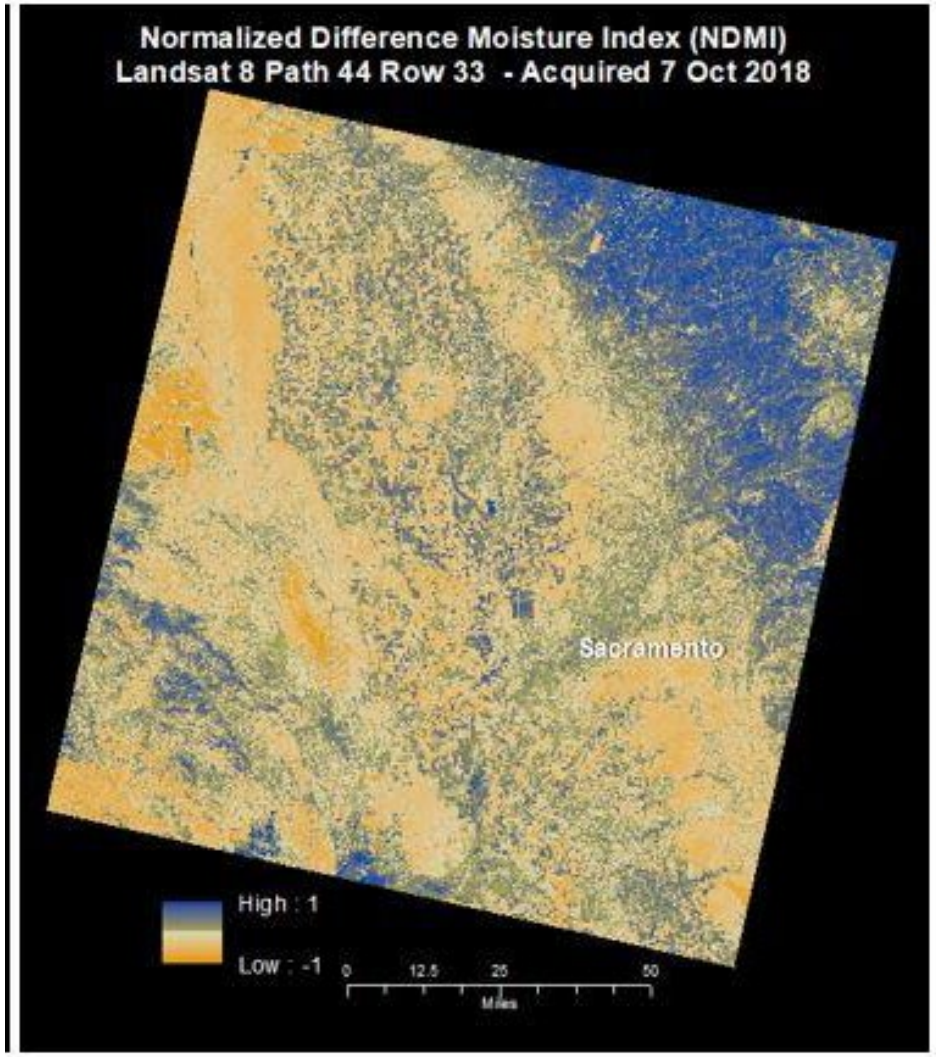
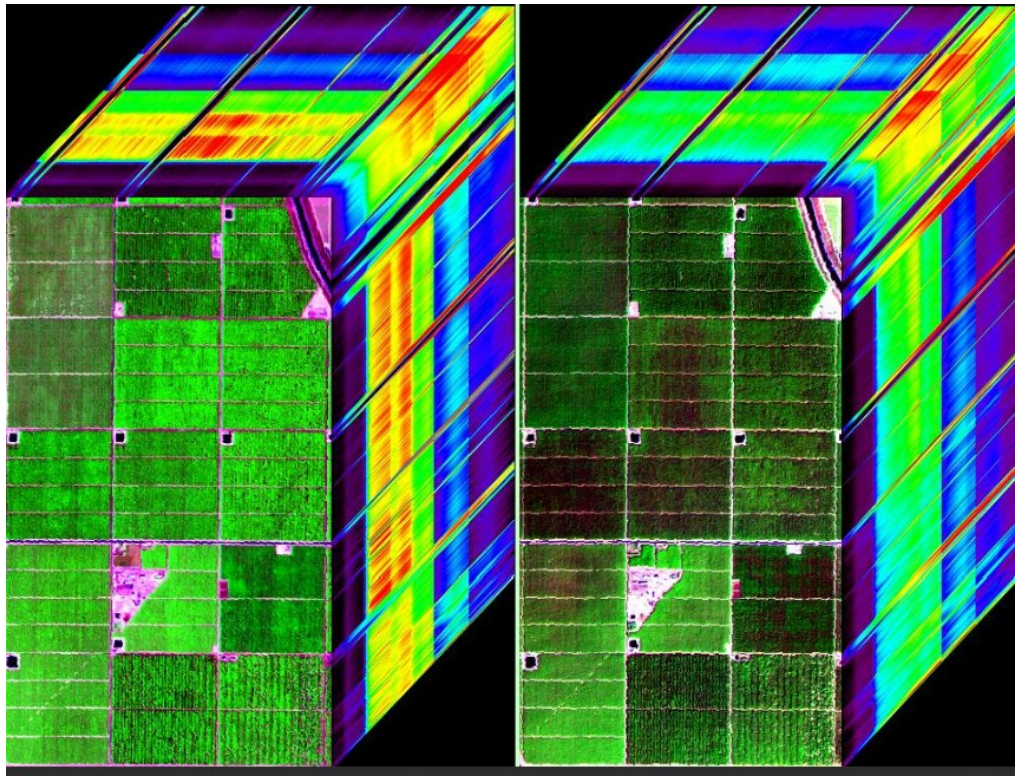


Image Credit: USGS

Normalized Dry Matter Index (NDMI)

- Evaluates dry matter content of potential fuels; can assist in fuel moisture content assessment
- Derived from the relationship between spectral reflectance and dry matter content of fresh leaves across a wide range of species
- A narrow-band, normalized index combining two distinct wavebands centered at 1649 nm and 1722 nm was found to best estimate the dry matter content in green leaves
- Only possible with hyperspectral data (e.g., AVIRIS)

$$\mathrm{NDMI} = (R_{1649} - R_{1722}) / (R_{1649} + R_{1722})$$



AVIRIS images from May (left) and November (right) 2011, of orchard water stress in California to evaluate NDMI.
Image Credit: Hunt et al

Evaporative Stress Index (ESI)

- ESI is based on satellite observations of land surface temperature, which are used to estimate water loss due to evapotranspiration (ET) – the loss of water via evaporation from soil and plant surfaces and via transpiration through plant leaves.
- Can be used as a measure of vegetation dryness prior to and during the fire season

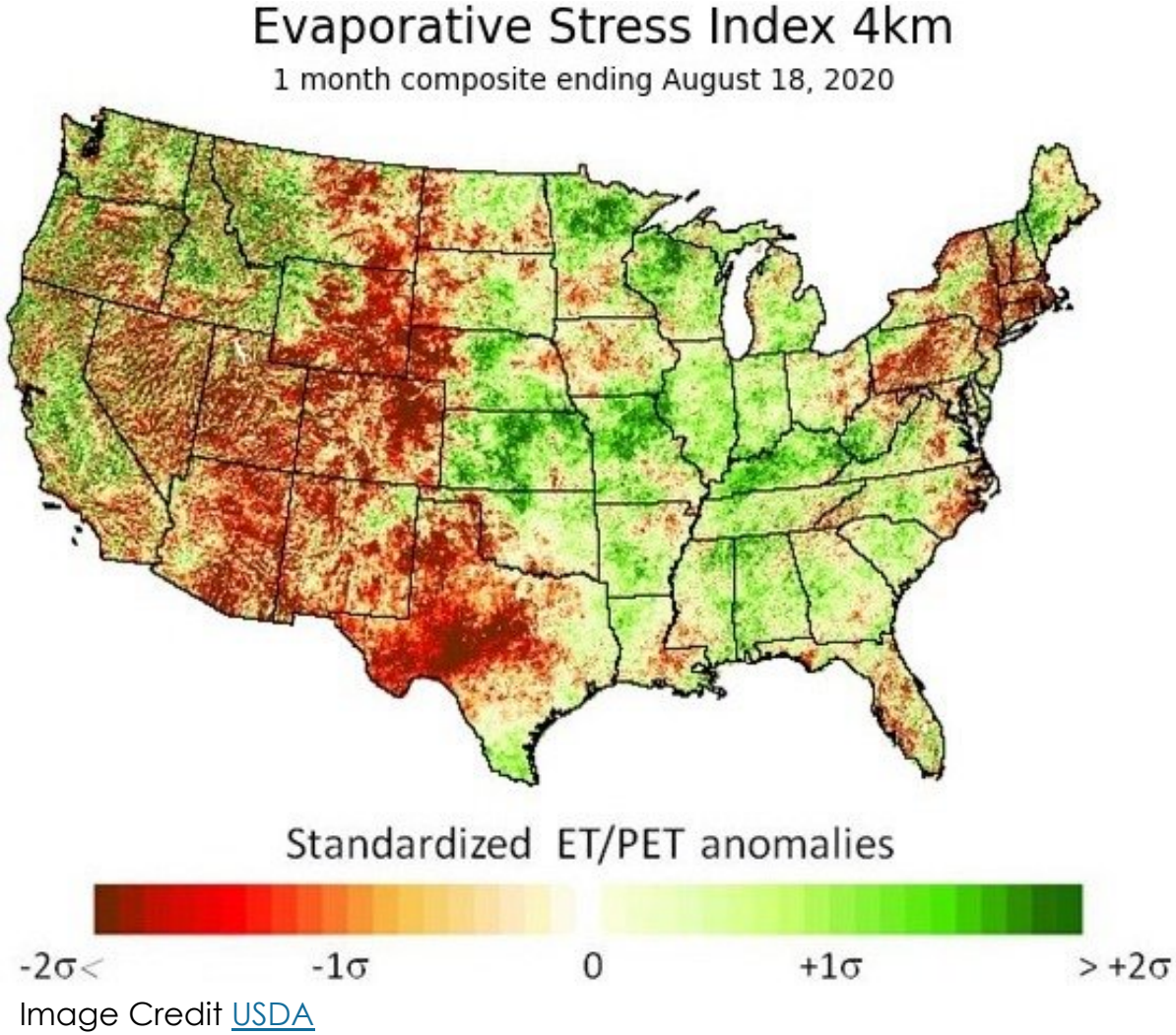


Image Credit USDA

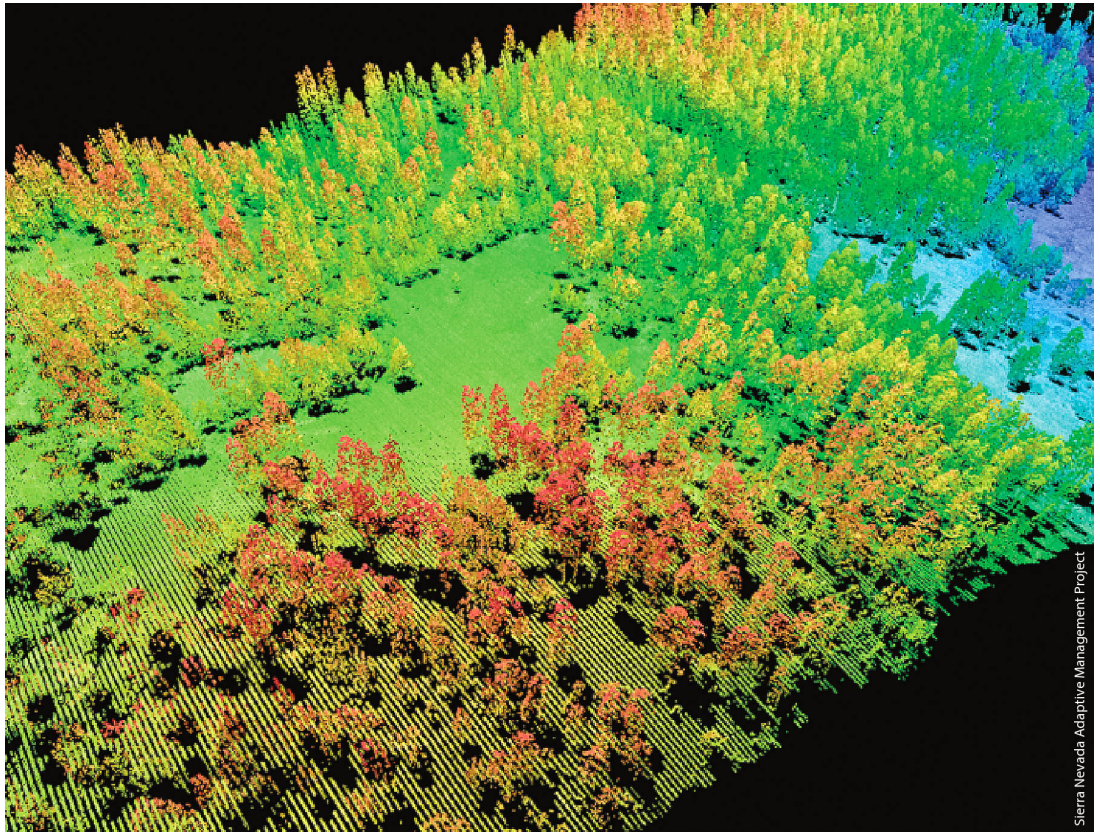
Vegetation Structure

- Radar and LiDAR remote sensing of structure: canopy height and vegetation density (canopy gaps and clumping), 3D structure of vegetation
- USGS 3DEP LiDAR Explorer

High-resolution photographs employed to assess changes in forest canopy density.
Image Credit: Garcia et al, 2016

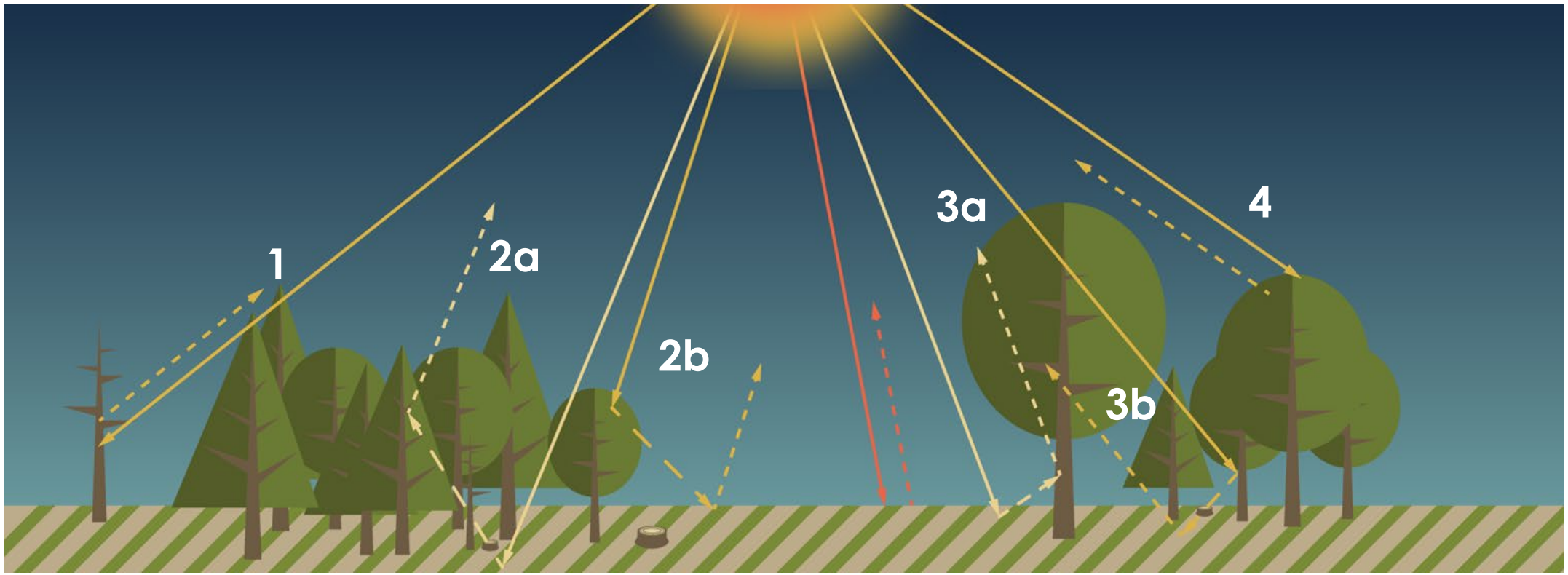
Canopy Height and Density

- The vertical and horizontal distribution of plant material in a forested ecosystem is a driver of fire spread.
- Canopy structure influences fire dynamics directly as fuel and indirectly through its influence on other variables in the fire environment, like fuel moisture below the canopy.
- Synthetic Aperture Radar (SAR) and Airborne Light Detection and Ranging (LiDAR) data can assess canopy structure over large areas.



Lidar points show trees in the Sierra National Forest, where much of the research on remote sensing has occurred. Image Credit: Keley and Tommaso, 2015

Canopy Height and Density with Radar



Dominant backscattering sources in forests: (1) direct scattering from tree trunks, (2a) ground-crown scattering, (2b) crown-ground scattering, (3a) ground-trunk scattering, (3b) trunk-ground scattering, (4) crown volume scattering.

See previous ARSET Training on Forest Mapping with SAR Data

Canopy Height

- Forest Stand Height (FSH): Average height of trees in a forest stand
  - Indicator of age of forest and structure, especially the amount of Above Ground Biomass (ABG)
  - Can be used pre-fire to assess initial fuel availability

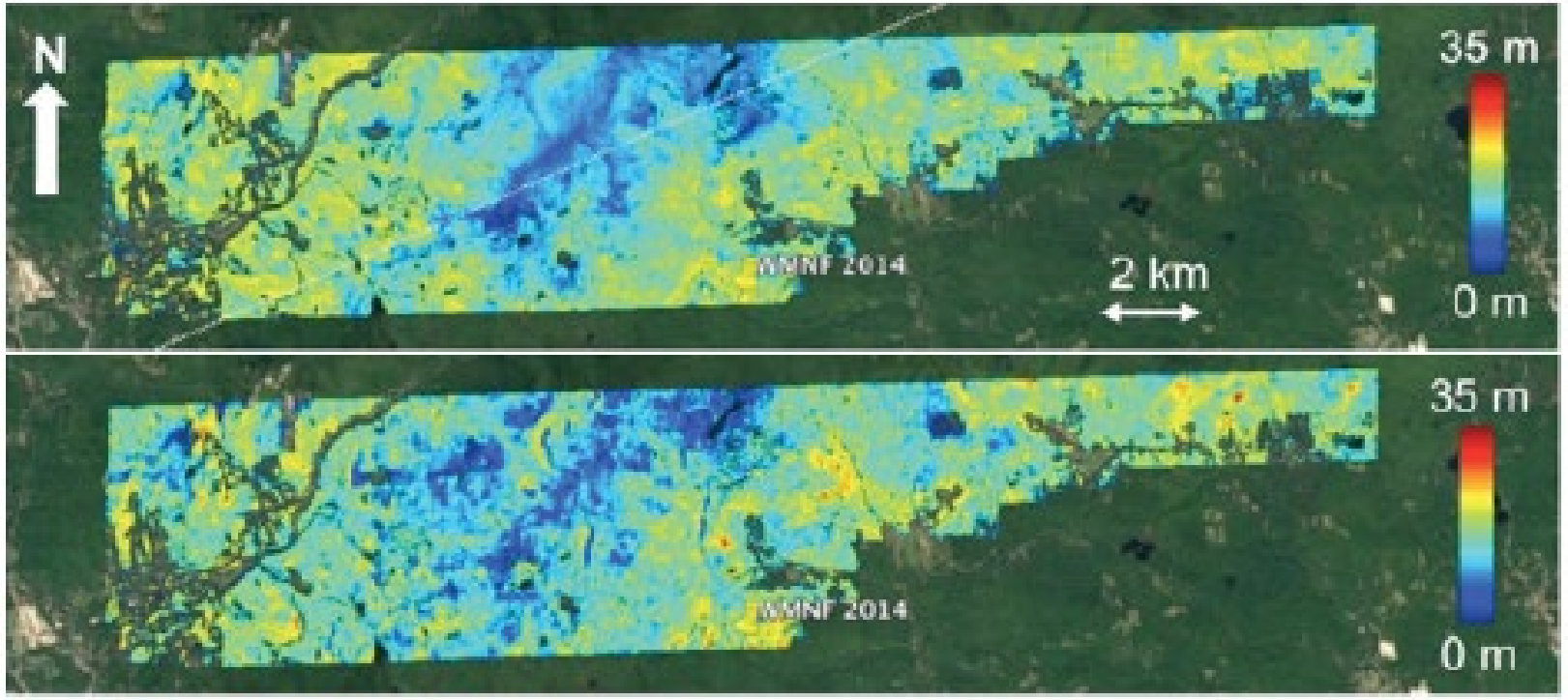
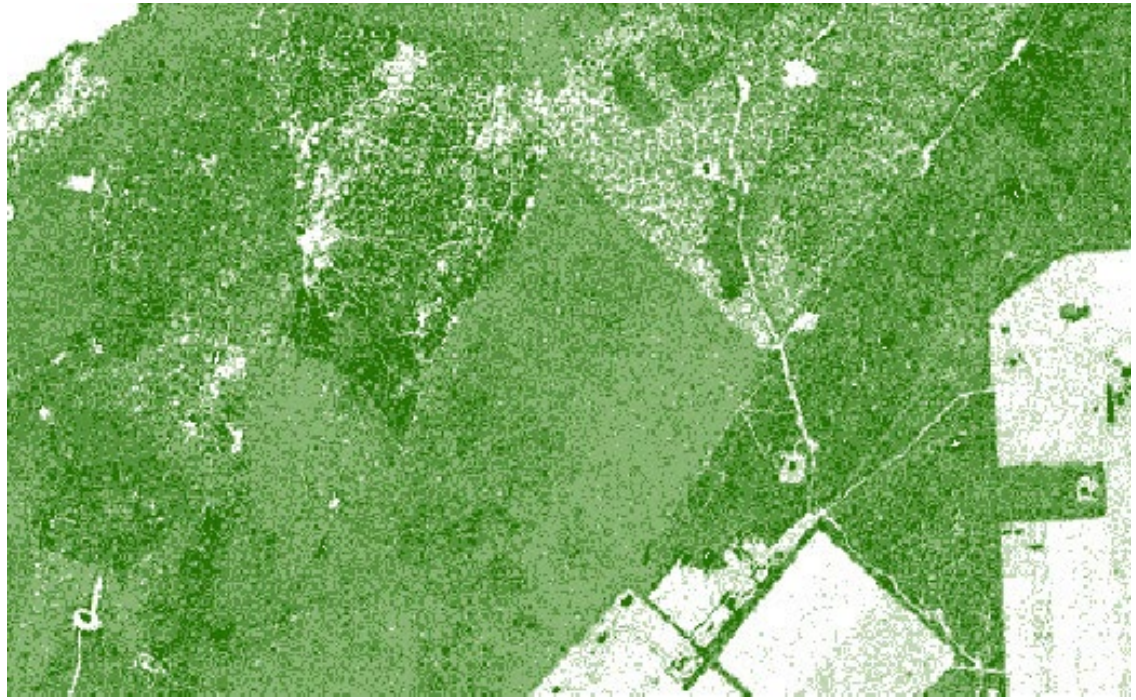


Image Credit: Li et al 2019

Canopy Density

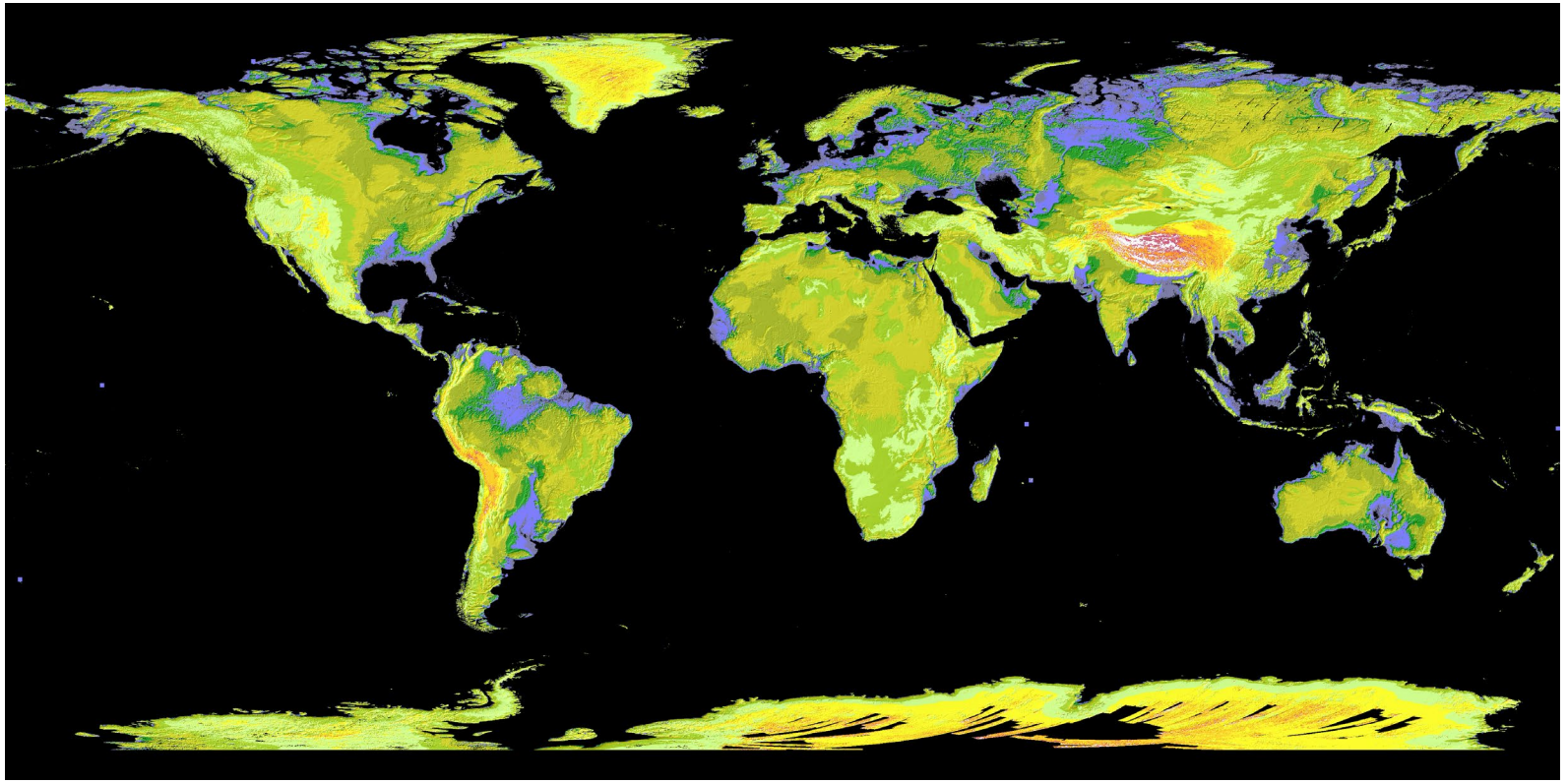
- Characteristic structure elements that can influence fire behavior:
  - Openings
  - Single trees
  - Clumps of trees with adjacent or interlocking crowns
- Once areas with dense vegetation catch fire, the fire is more likely to spread given access to high fuel load.
- Airborne Light Detection and Ranging (LiDAR) data can assess canopy structure over a large area.



Canopy density, where darker green indicates increasing density.
Image Credit: ArcGIS

Topography

- Topography: Relief and landforms of the Earth's surface
- Factors that affect fire:
  - Elevation
  - Slope
  - Aspect (direction of the slope)
  - Topographic Features (canyons, ridges, bowls, etc.)



Global Digital Elevation Model via ASTER. Image Credit: NASA

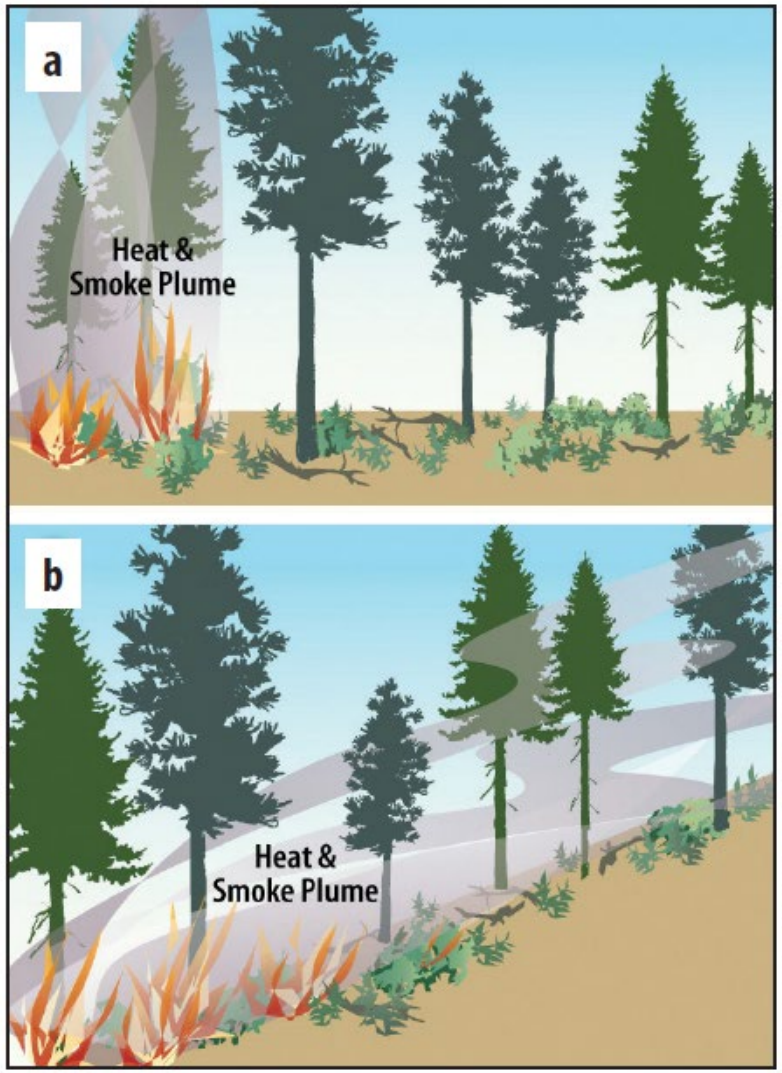
Elevation

- Elevation Impacts:
  - Amount and timing of precipitation
  - Wind exposure
  - Seasonal drying of fuels
  - Lightning strikes
- Examples: Lower elevations tend to dry out faster, thus they experience increased fire spread

This perspective view, combining a Landsat image with SRTM topography, shows topography. Image Credit: NASA

Slope

- Increased Slope = Faster Fire Spread
- Slope Position: Where does the fire have room to move?
  - Fires that start at the bottom of the slope have greater area to spread.
  - As heat rises in front of the fire, it more effectively preheats and dries upslope fuels, making for more rapid combustion.



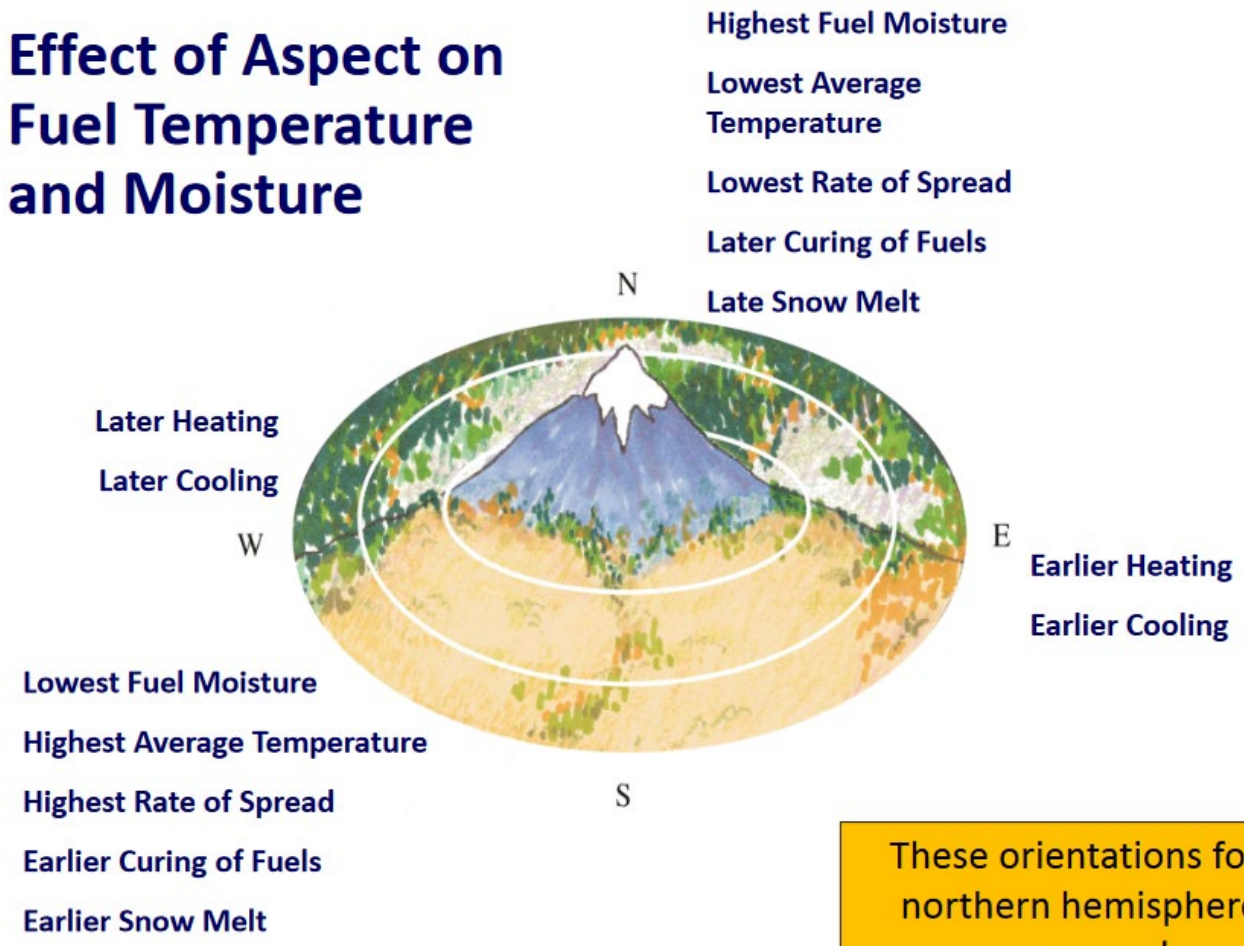
Fires spread more quickly uphill. Image Credit: Fitzgerald, Oregon State University

Stephen Fitzgerald, Oregon State University.

Uphill fire scars. Image Credit: University of Arizona

Aspect

- Direction of the Slope
  - Solar Radiation
    - Example: South-facing slopes have higher solar radiation and drier fuels.
  - Vegetation Type
    - Example: South and West facing slopes have less vegetation.

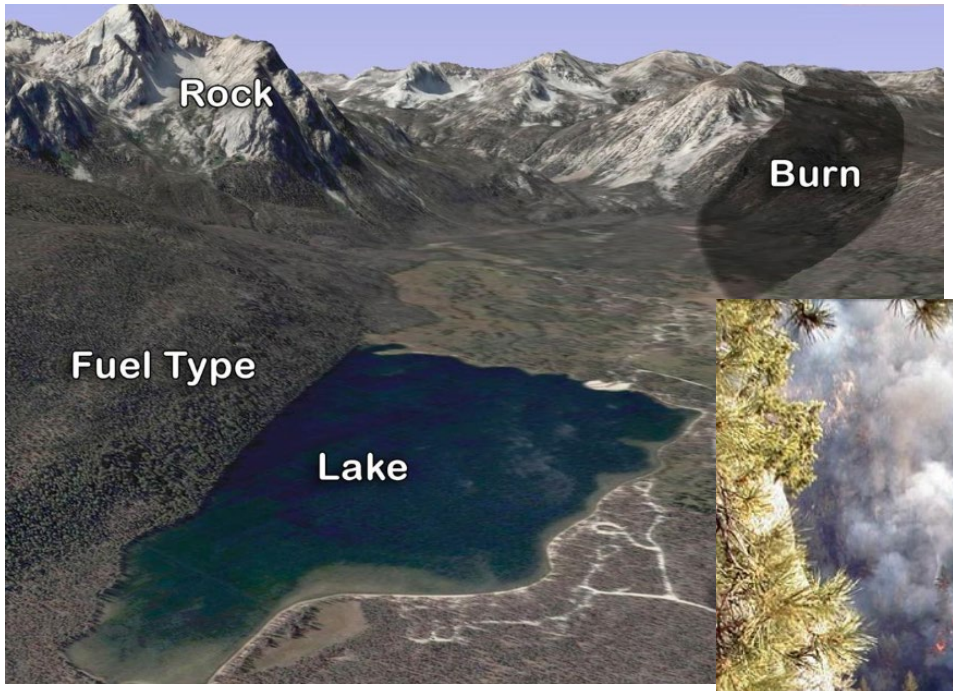


These orientations for the northern hemisphere, of course!

Image Credit: University of Arizona

Topographic Features

- Alter Fire Behavior
  - Increase Spread
    - Narrow and wide canyons increase wind and fire spread.
  - Decrease Spread
    - Rock outcroppings, rivers, lakes, etc. can act as barriers to spread.



Barriers to fire spread (top) and an example of a deep canyon fire (right). Image Credit: University of Arizona

Satellites and Sensors for Vegetation-Based Fire Applications

Landsat and Sentinel-2

- **Landsat**
  - First Landsat launched in 1972
  - Landsat 8 launched in 2013
  - Multispectral, 30-meter pixels, 15-meter panchromatic band, 16-day revisit
- **Sentinel-2**
  - Launched in June 2015
  - Multispectral, 10, 20, and 60-meter pixel bands, 2-5-day revisit

- **Vegetation-Based Fire Applications:**
  - Vegetation Extent and Type: Land cover classification
  - Vegetation Stage and Health: Variety of vegetation indices, including NDVI, EVI, SAVI
  - Vegetation Moisture: NDWI

Image Credits: USGS, ESA

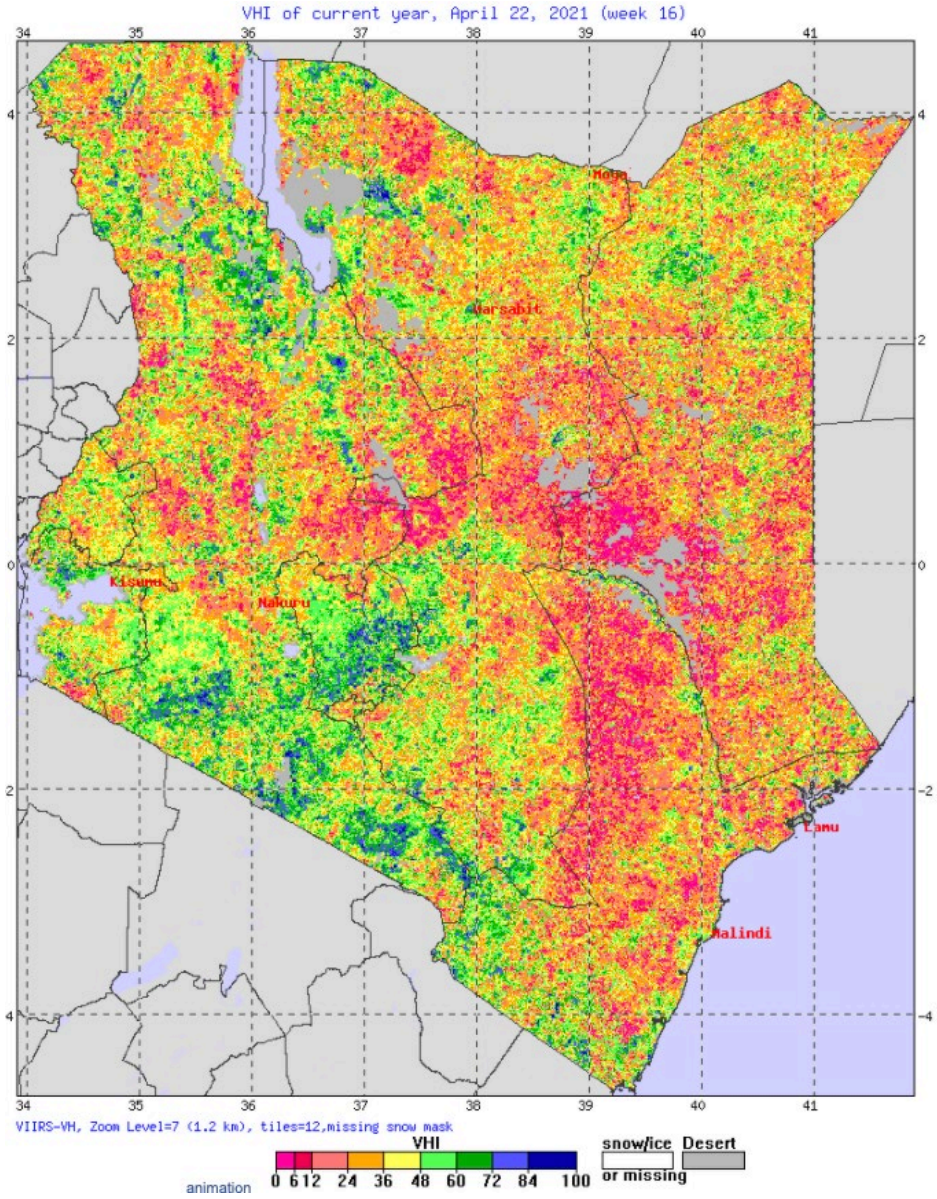
MODIS

- **Vegetation-Based Fire Applications:**
  - Vegetation Extent and Type: Land cover classification
  - Vegetation Stage and Health: NDVI, EVI, High Temporal Resolution Phenology
- Spatial Resolution:
  - 250 m, 500 m, 1 km
- Temporal Resolution:
  - Daily, 8-day, 16-day, monthly, quarterly, yearly
  - 2000–Present
- Spectral Coverage:
  - 36 bands

Time lapse of MODIS NDVI in Africa.
Image Credit: Google Earth Engine Developers

Visible Infrared Imaging Radiometer Suite (VIIRS)

- **Vegetation-Based Fire Applications:**
  - Vegetation Stage: VIIRS Vegetation Index include NDVI and EVI
  - Vegetation Health: VIIRS Vegetation Health product includes Vegetation Condition Index, Temperature Condition Index, and Vegetation Health Index
- Launched in 2012; collects visible and infrared imagery
- Daily temporal resolution and global coverage
- Spatial Resolution:
  - 5 high resolution bands: 375 m
  - 16 moderate resolution bands: 750 m



VIIRS Vegetation Health Index map of Kenya (April 22, 2021). Image Credit: NOAA NESDIS

Soil Moisture Active Passive (SMAP)

- **Vegetation-Based Fire Applications:**
  - Vegetation Moisture: Soil moisture acts as a proxy for vegetation moisture and evaporative stress.
  - Drought information can also identify areas with dry fuel.
- Measures the moisture in the top 5 cm of the soil globally every 3 days
- Launched in January 2015

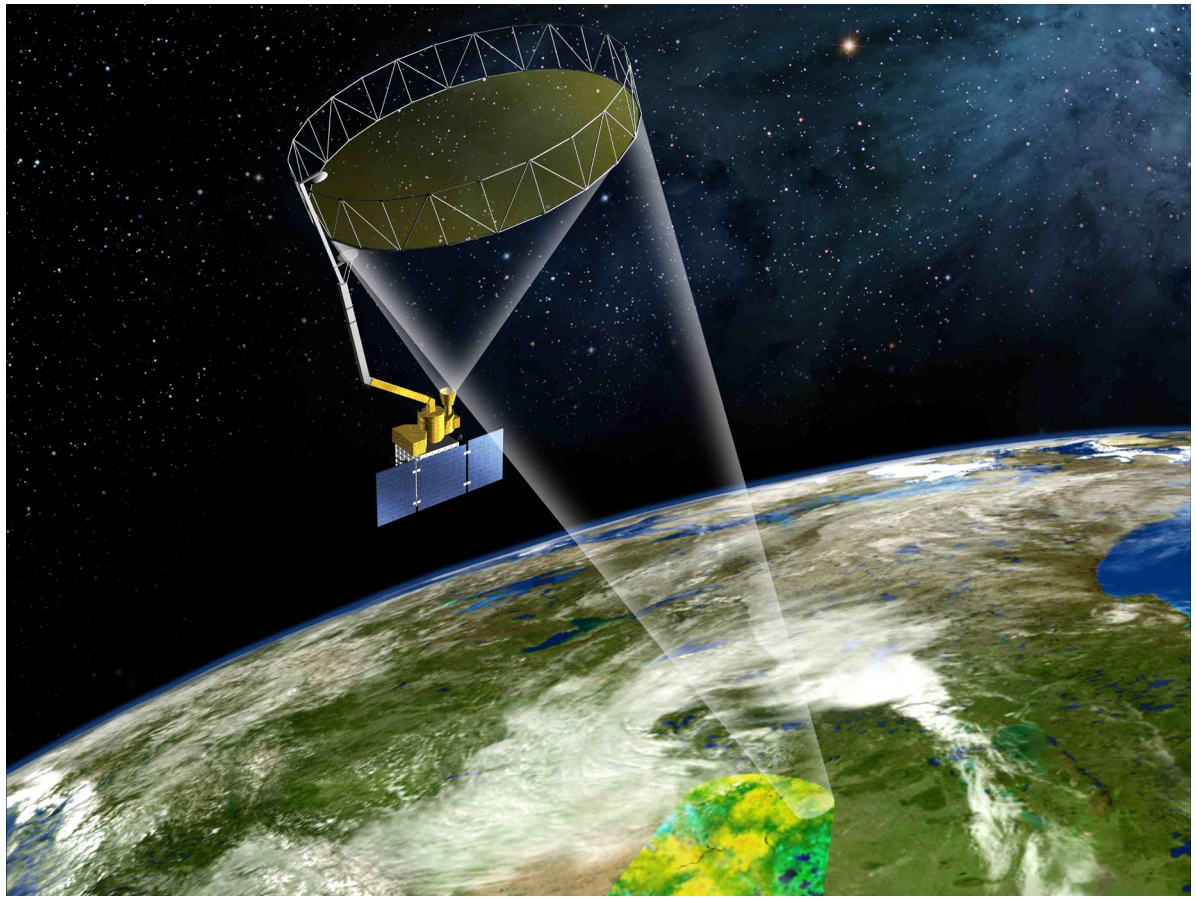
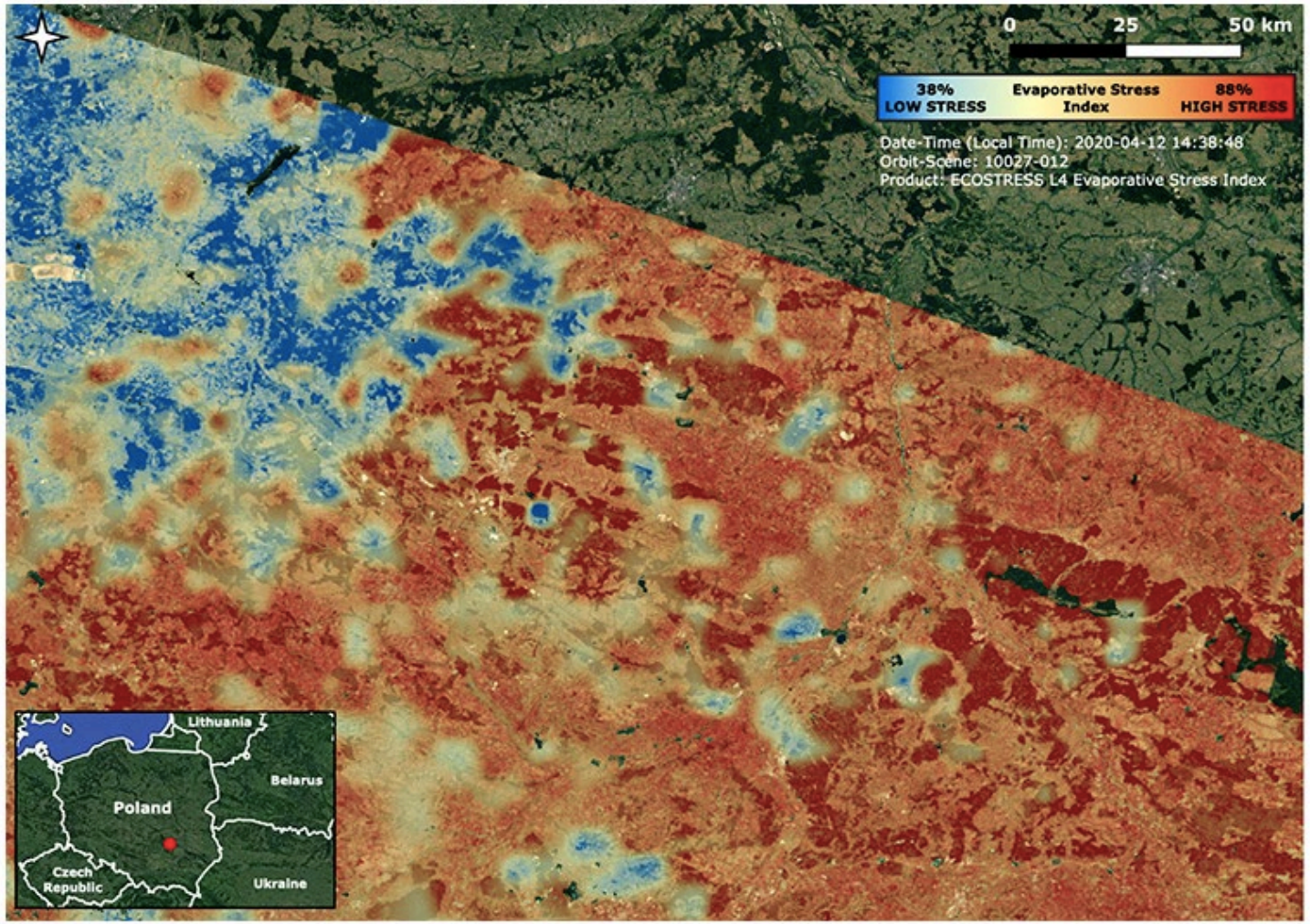


Image Credit: NASA

ECOSTRESS

- **Vegetation-Based Fire Applications:**
  - Vegetation Moisture: Evaporative stress due to temperature
- Data from Aug 2018-Present
- Spatial resolution of 70 m
- Spectral Resolution:
  - 6 bands (160-1200 nm)
- Range:
  - 53.6° N latitude to 53.6° S latitude

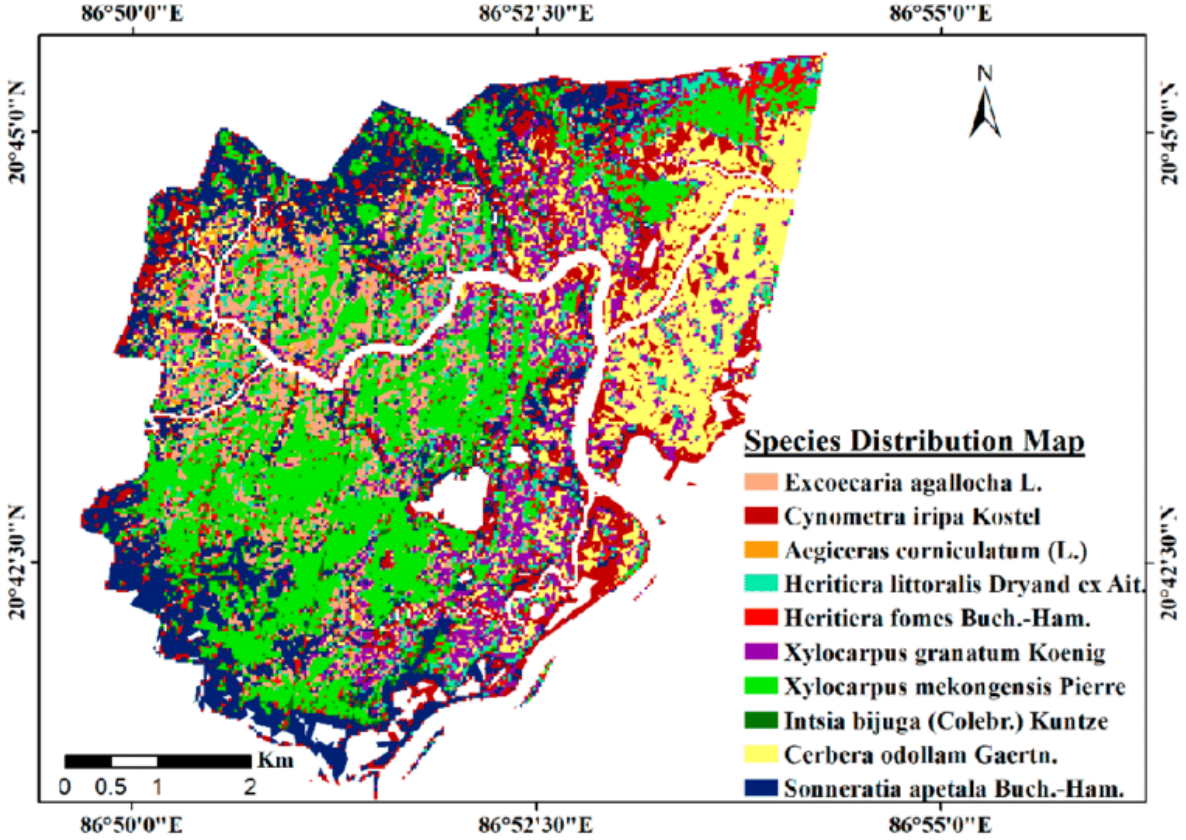
NASA's ECOSTRESS imaged a drought in Poland



Vegetation stress measurement in Poland using the ECOSTRESS Evaporative Stress Index. Vegetation under stress due to drought is more susceptible to ignition and sustained burning.
Image Credit: NASA JPL

EO-1 Hyperion

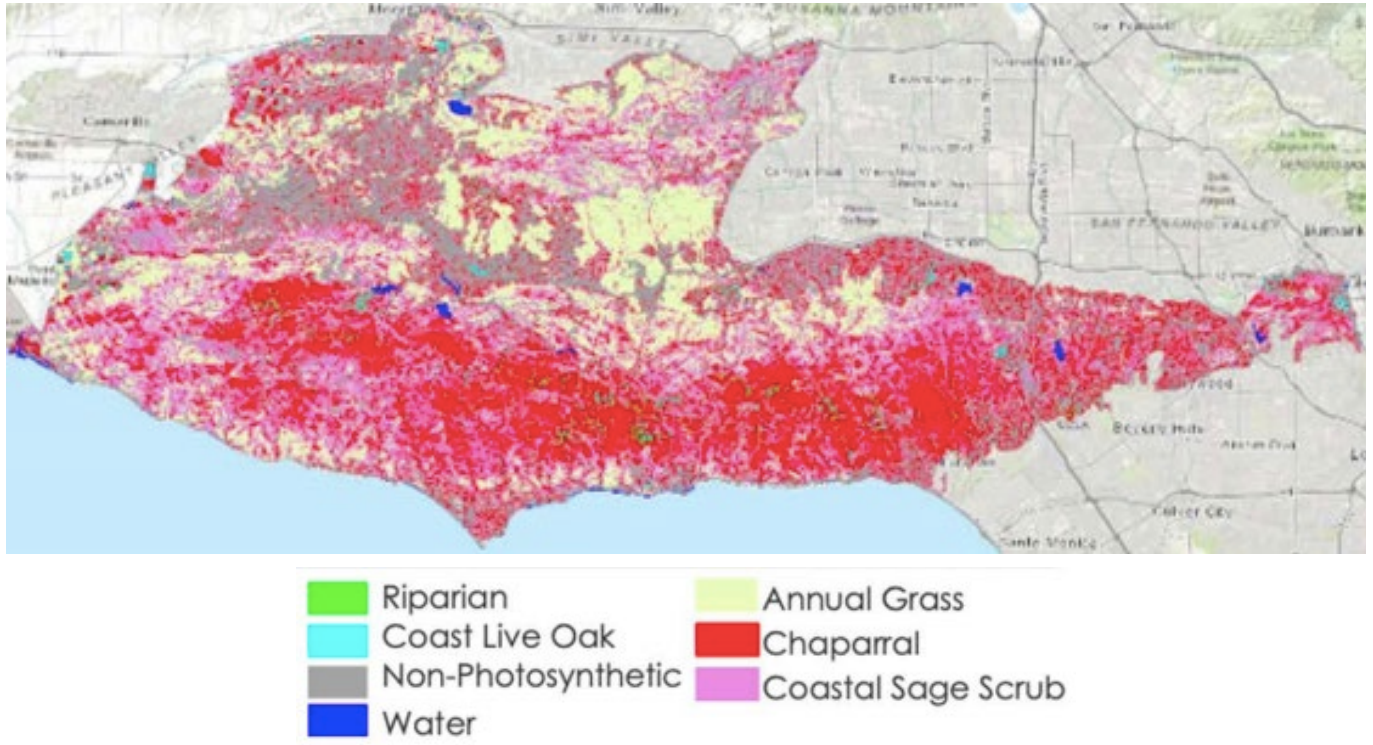
- **Vegetation-Based Fire Applications:**
  - Vegetation Type and Extent: Plant species identification and increased vegetation differentiation capabilities
  - Increased spectral resolution allows for more accurate characterization of fuel type and content
- Date Range: 2000-2017
- 220 spectral bands, 357 to 2567 nm
- 30 m spatial resolution



Hyperion imagery used to differentiate mangrove forest species in Bhitarkanika Forest Reserve in India. Image Credit: Anand et al. 2020

Airborne Visible/Infrared Imaging Spectrometer (AVIRIS)

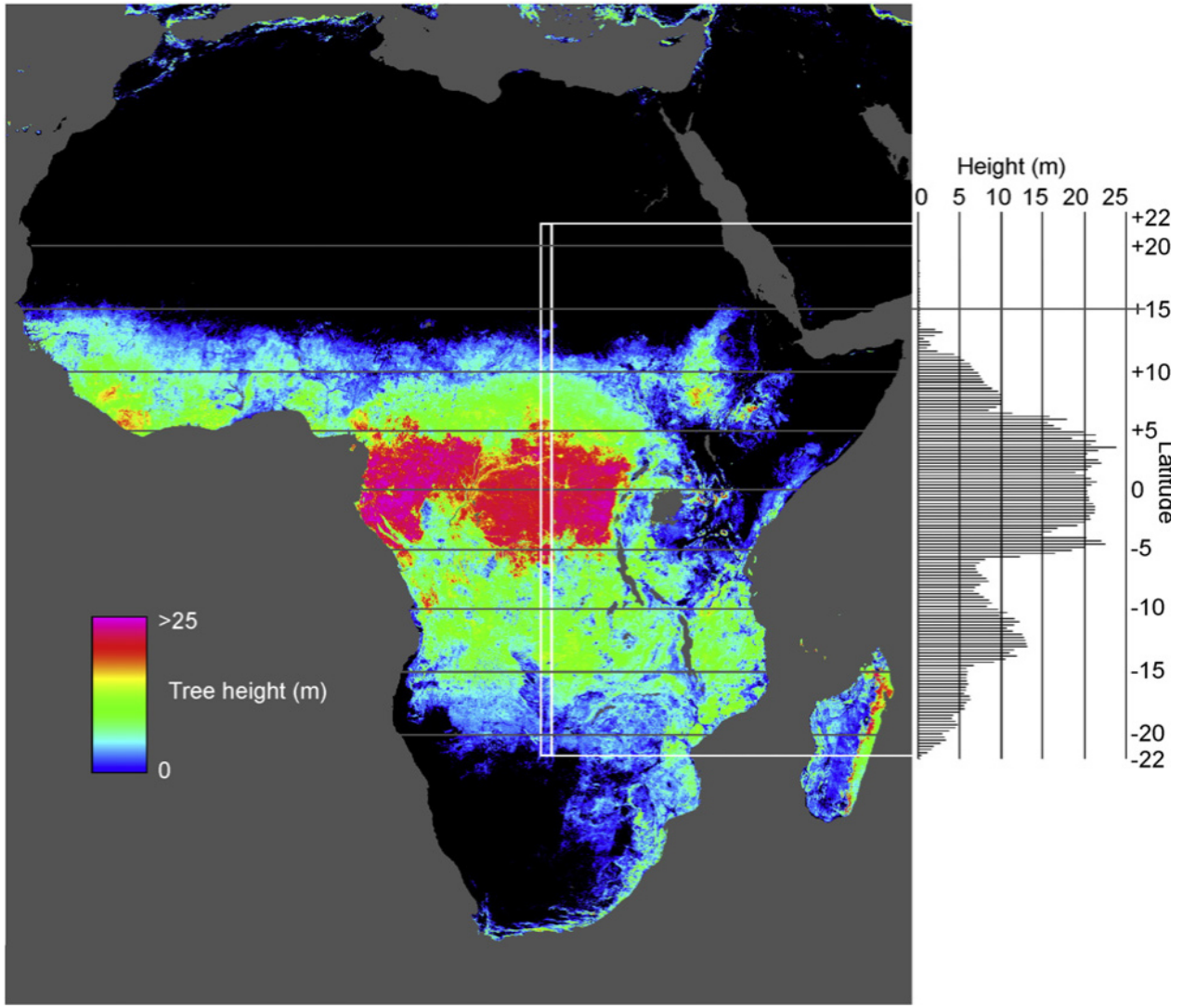
- **Vegetation-Based Fire Applications:**
  - Vegetation Extent and Type: Land classifications with increased vegetation type differentiation capabilities
  - Vegetation Moisture: NDMI
- Airborne missions flown on research aircraft in North America, Europe, portions of South America, and Argentina
- 224 continuous spectral bands, 400 to 2500 nm



Pre-fire vegetation classification of the Santa Monica Mountains in 2018 before the Woolsey Fire. Hyperspectral data records reflectance over more bands, making it easier to differentiate distinct vegetation types.
Image Credit: NASA DEVELOP

Global Ecosystem Dynamics Investigation (GEDI)

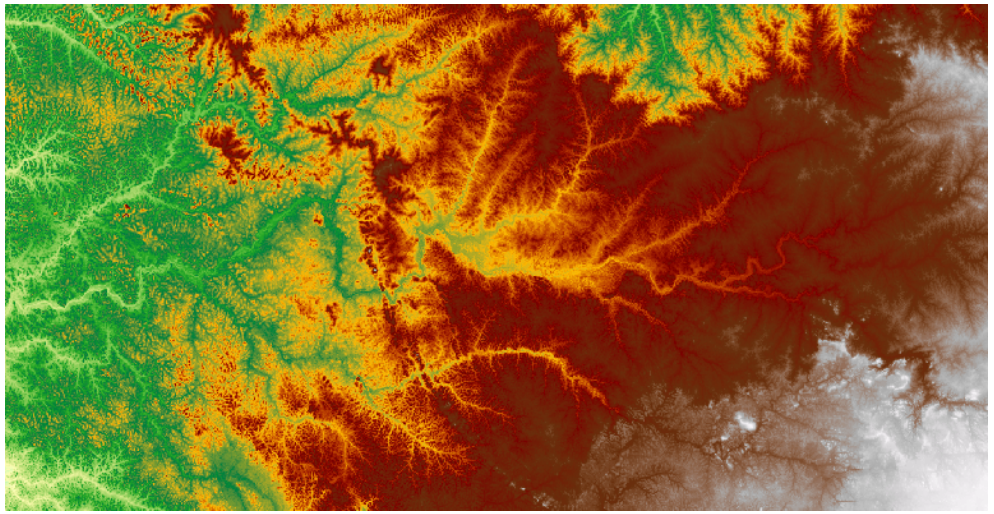
- **Vegetation-Based Fire Applications:**
  - Vegetation Structure: Canopy height metrics and 3D structure data for fuel load estimation and characterization
  - Topography: Surface altimetry
- High resolution laser ranging (LiDAR) of Earth's forests and topography, launched in April 2019
- 3 lasers, 8 data tracks, 25 m spatial footprint



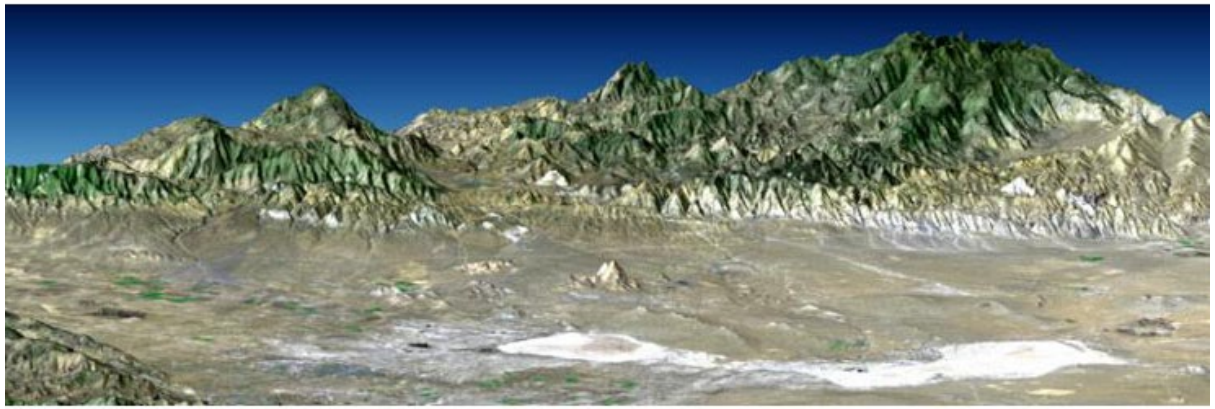
GEDI-derived tree height map for Africa.
Image Credit: GEDI

Shuttle Radar Topography Mission (SRTM)

- **Vegetation-Based Fire Applications:**
  - Topography: DEM data includes slope, aspect, elevation, and topographic feature data useful in the assessment of physical geography that influences fire risk
- Topographic (elevation) data of Earth's surface, SRTM used the technique of interferometry flown onboard the Space Shuttle Endeavour
- C-band and X-band, 30 m and 90 m spatial resolution



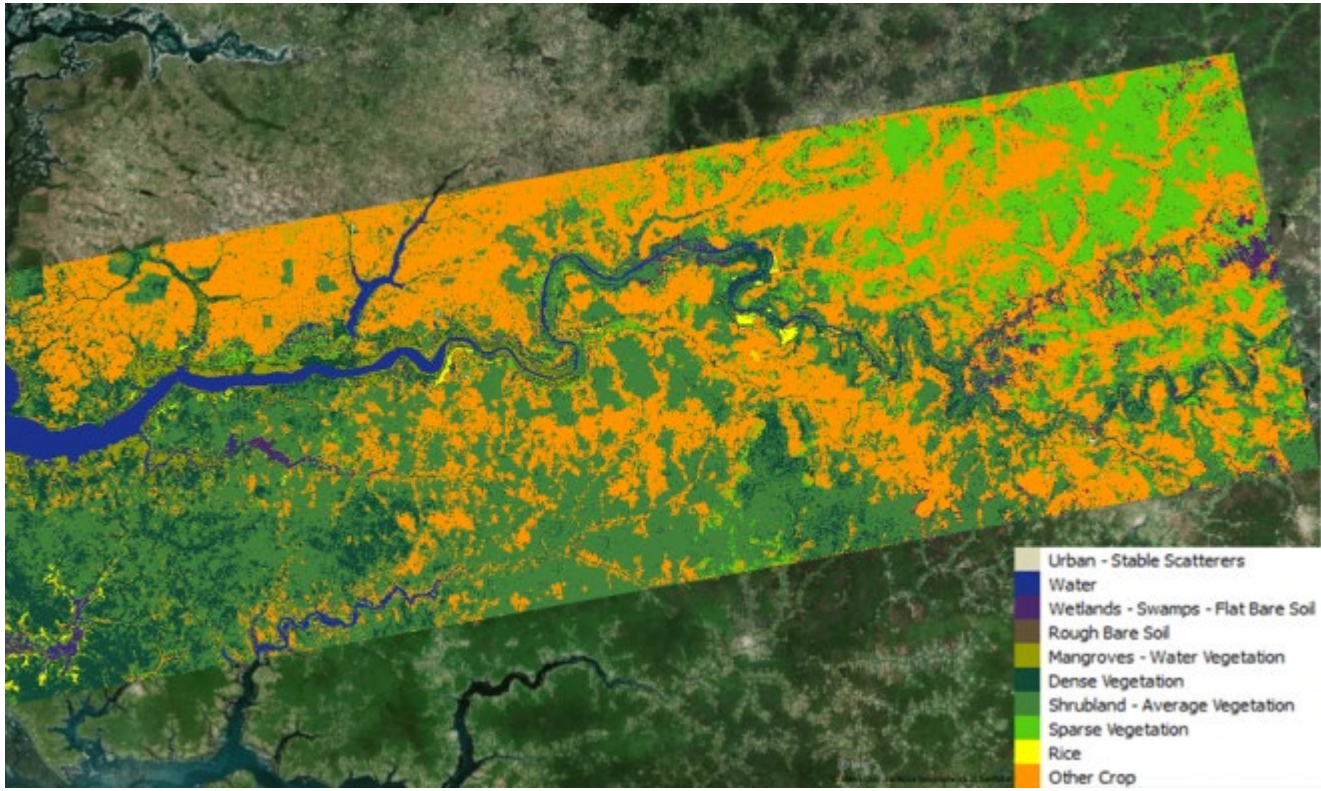
A sample elevation map of Central Africa at 90m spatial resolution (Tile 42_12).
Image Credit: ICGIAR CSI



Perspective with Landsat Overlay: Antelope Valley, California.
Image Credit: NASA

Sentinel-1

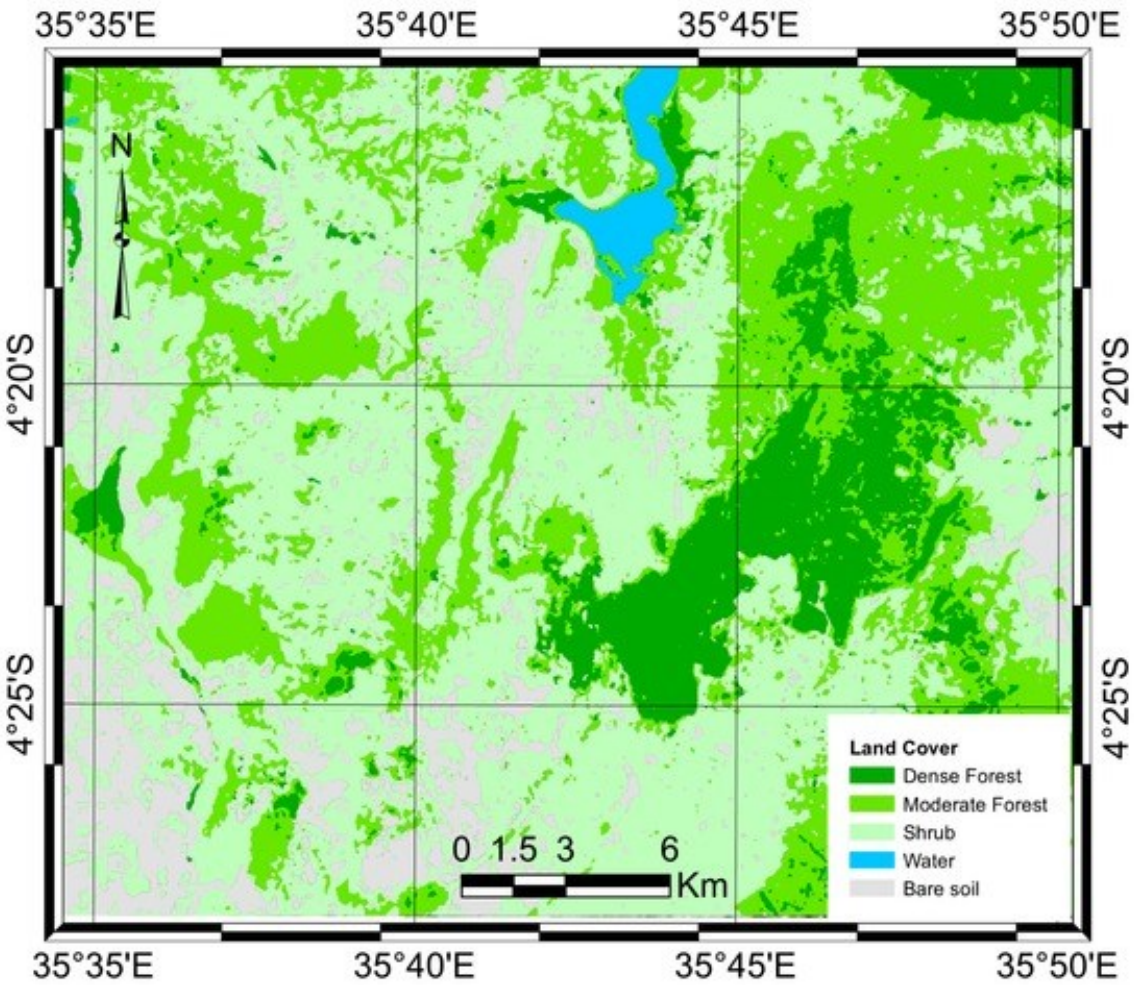
- **Vegetation-Based Fire Applications:**
  - Vegetation Type and Extent: Land classification, fuels mapping
  - Vegetation Structure: Density and height
  - Vegetation Moisture: Fuel moisture content and dryness
- European Radar Observatory for the Copernicus joint initiative of the European Commission and the European Space Agency, launched in April 2014
- C-band SAR data, 12-day revisit, Resolution: 5 x 20 meters



Sentinel-1 swath land cover assessment of Gambia study area.
Image Credit: ERMES

Advanced Land Observing Satellite (ALOS)

- **Vegetation-Based Fire Applications:**
  - Vegetation Structure: Radar measurements of canopy height and density
  - Topography: DEM including elevation, aspect, slope, and features
- Japanese Space Agency, Phased Array L-band Synthetic Aperture Radar (PALSAR)
- Dates: 2006 to 2011
- L-band SAR



Integration of Landsat and ALOS PALSAR data to map vegetation and forest density in Northern Tanzania.
Image Credit: Dorothea Deus 2016

Satellite/Sensor Overview

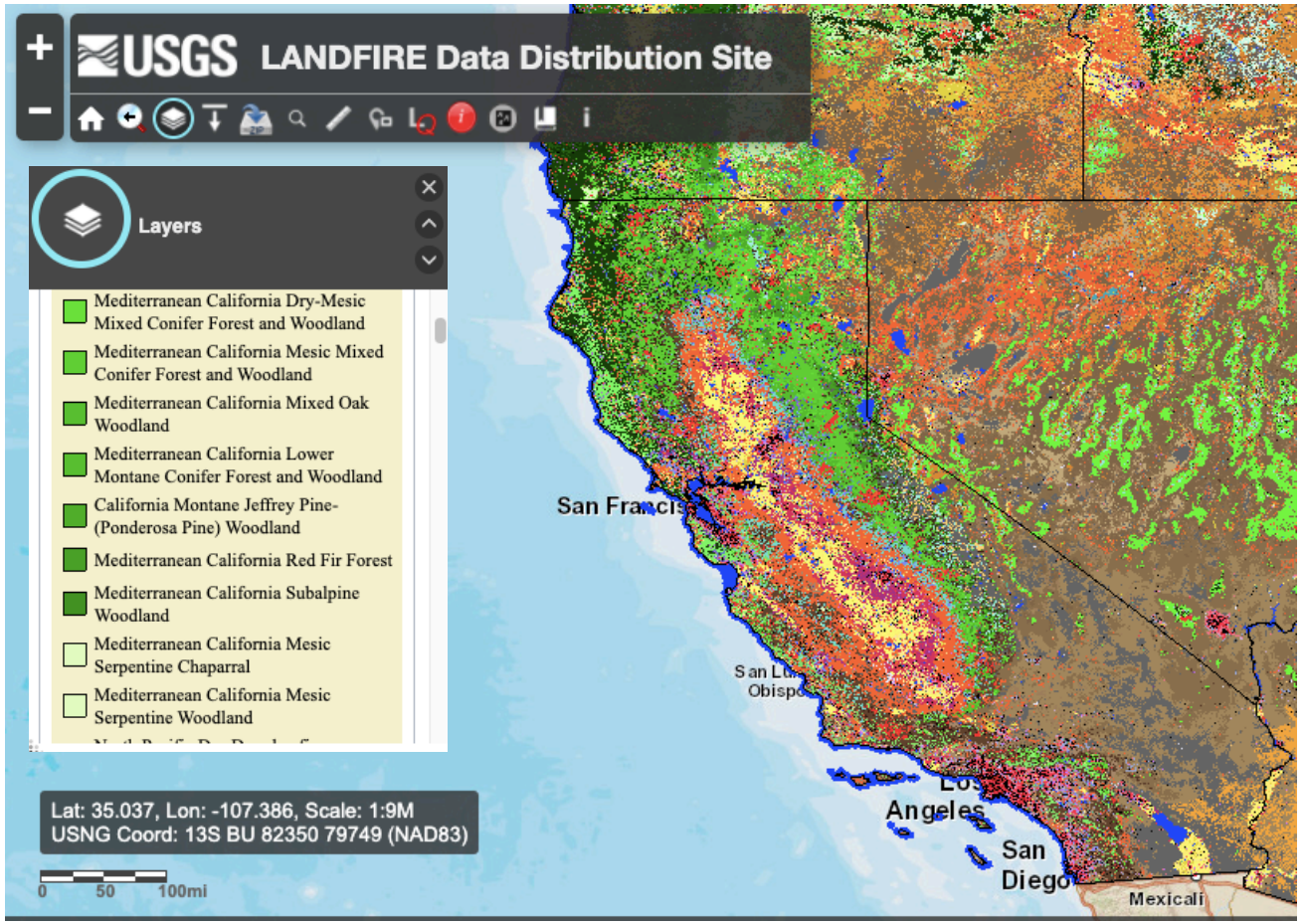
Satellite/Sensor	Vegetation-Based Fire Applications	Data Products
Landsat	Land Class, Vegetation Indices, Moisture	Imagery, NDVI, EVI, SAVI, NDWI
Sentinel-2	Land Class, Vegetation Indices, Moisture	Imagery, NDVI
MODIS	Land Class, Vegetation Indices	Imagery, NDVI & EVI
VIIRS	Vegetation Indices	Imagery, Vegetation Health
SMAP	Soil Moisture	Soil Moisture
ECOSTRESS	Moisture, Evaporative Stress	Thermal Data, ESI Documentation
EO-1 Hyperion	Land Class, Dry Matter Content	Hyperspectral Imagery
AVIRIS	Land Class, Dry Matter Content	Hyperspectral Imagery
GEDI	Vegetation Structure	LiDAR Data
SRTM	Topography	Topography (DEM)
Sentinel-1	Land Class, Structure, Moisture	Synthetic Aperture Radar Data
ALOS PALSAR	Structure, Topography	Synthetic Aperture Radar Data

***This is not an inclusive list of all satellites/sensors useful for vegetation-based fire applications, and the suggested data products are just a sample of what is available for each satellite/sensor.**

Tools for Pre-fire monitoring

LANDFIRE Vegetation Products

- Existing Vegetation Type
  - Plant communities via NatureServe's terrestrial Ecological Systems Classification, through 2016
    - Mapped with models, field data, and Landsat
- National Vegetation Classification
- Existing Vegetation Cover
- Existing Vegetation Height

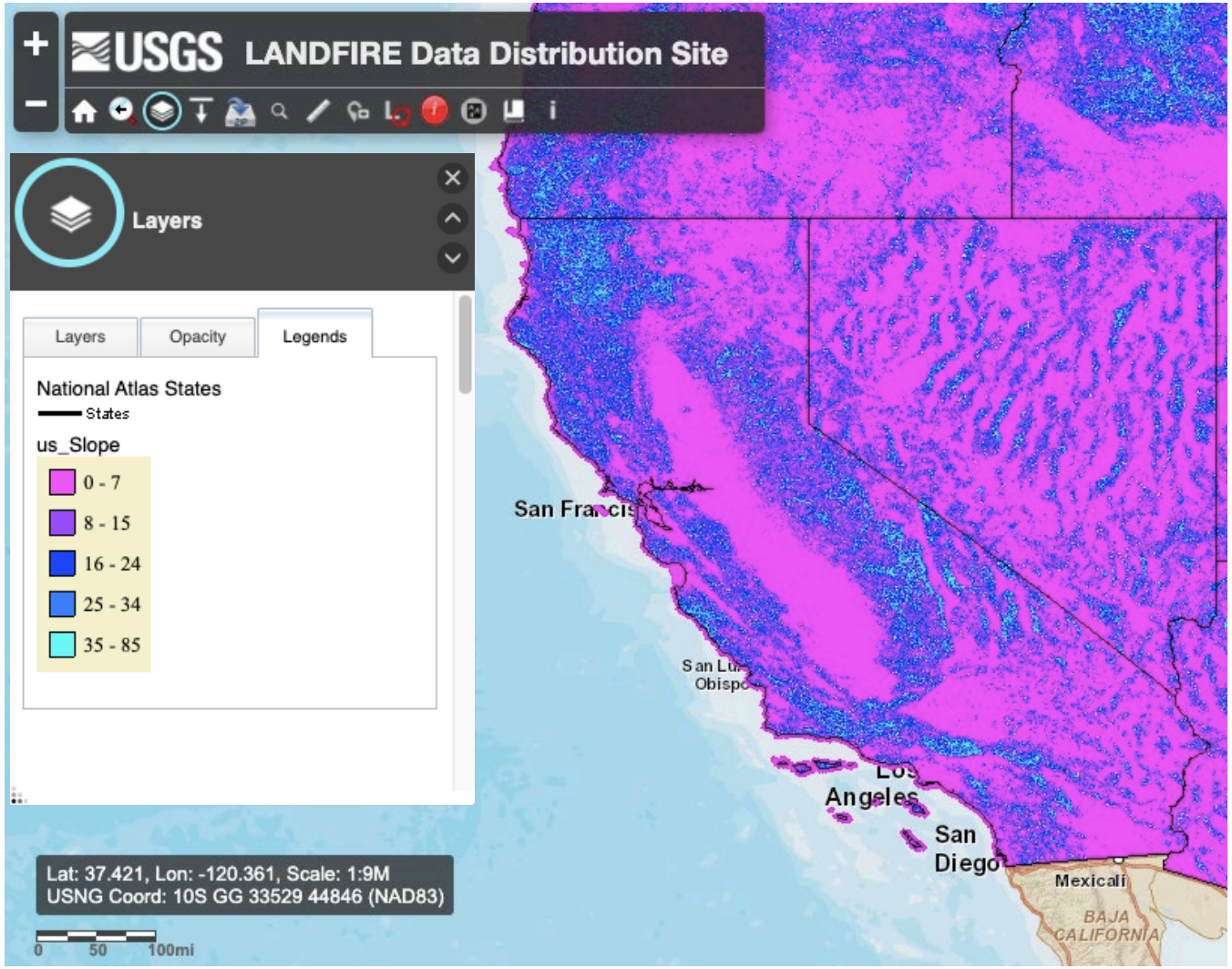


Plant community estimates providing detailed fuel type information across California. The viewer displays layers across the U.S.

Link: https://landfire.cr.usgs.gov/viewer/viewer.html

LANDFIRE Fuels, Fire Regime, and Topography Products

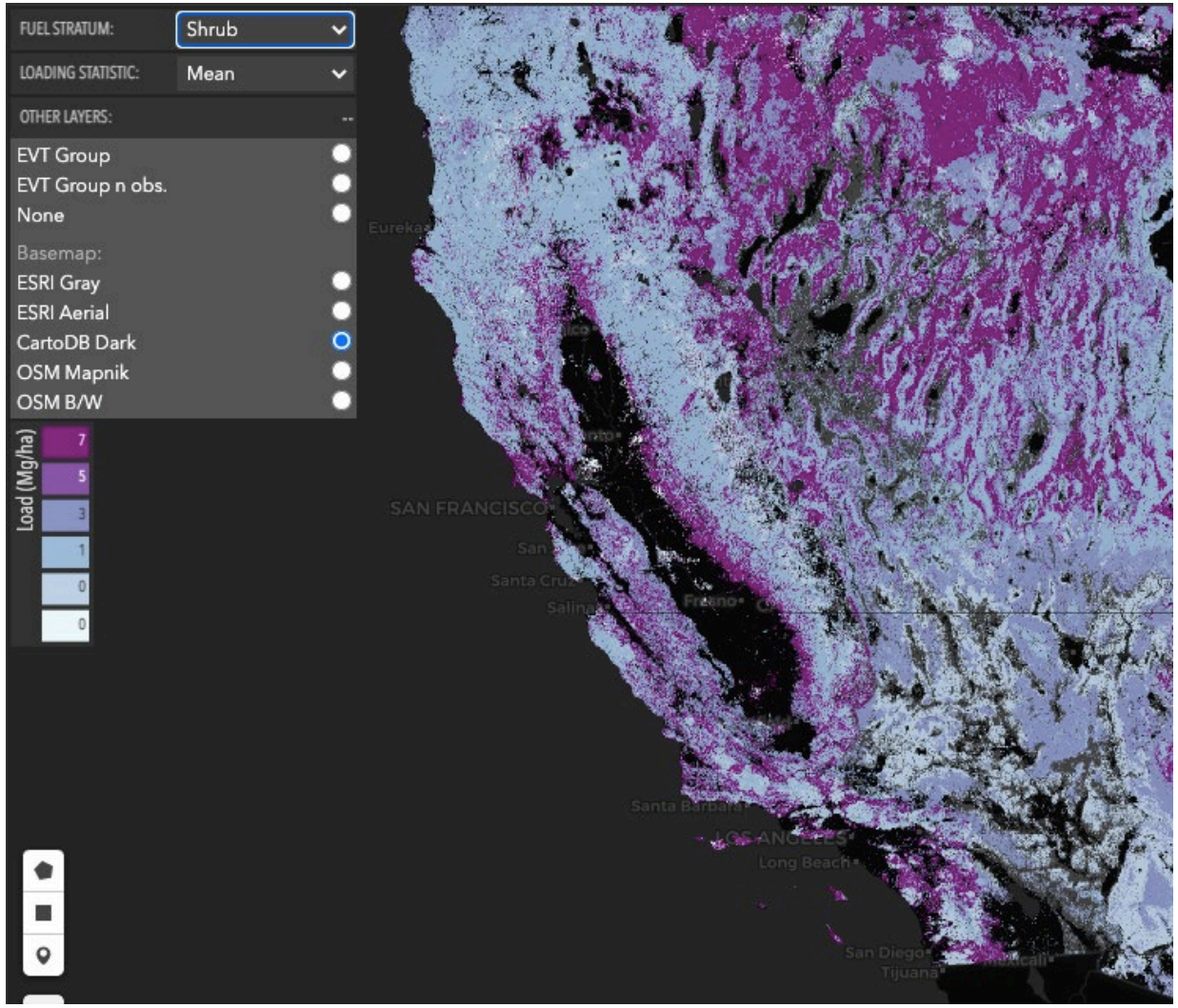
- Fuels
  - Fuel Models
  - Canopy Cover, Height, and Density
- Fire Regime
  - Groups
  - Return Interval
  - Vegetation Conditions
- Topography
  - Elevation
  - Slope
  - Aspect



Slope mapped across the U.S., zoomed to display California. Slope values are in degrees.
Link: https://landfire.cr.usgs.gov/viewer/viewer.html

North American Wildland Fuels Database (NAWFD)

- NAWFD aggregates fuel loading information from 26,620 field sites compiled from 271 data sources to provide fuel load estimates by vegetation type category.
- Fuel categories include trees, shrubs, litter, tree crown, etc.
- Fuel load estimates are given per hectare.



Shrub fuels mapped in metric tons per hectare for California.
Link: https://fuels.mtri.org/map

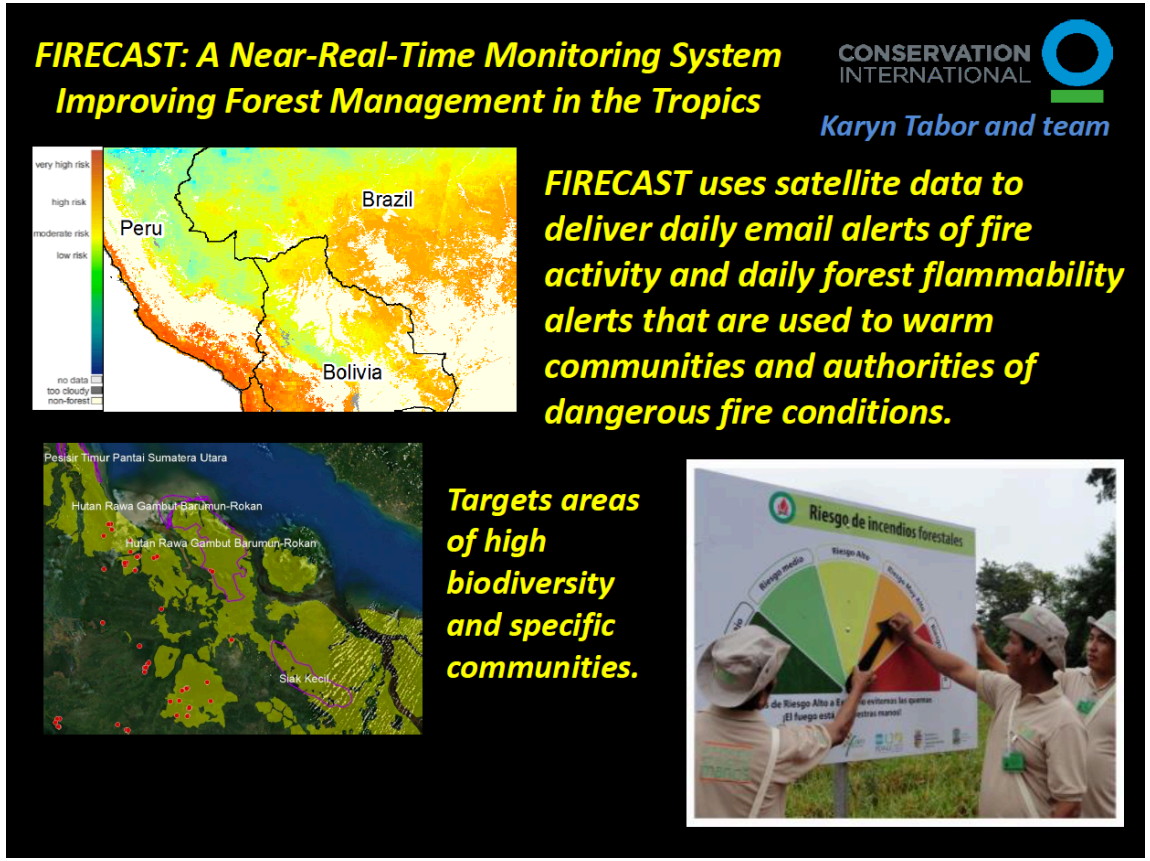
Forest Inventory Analysis Program (FIA)

- US Forest Service reports on status and trends in species, size, and health of trees and total tree growth, mortality, and removals by harvest
- Includes remote sensing classifications, field samples, and forest health indicators
- Can be particularly useful for field data points to ground-truth land cover classifications
- Provides specific vegetation information, tailored to region, about fuels in forested areas

Historical Forest Inventory Analysis Classifications for California.
Link:
USFS FIA

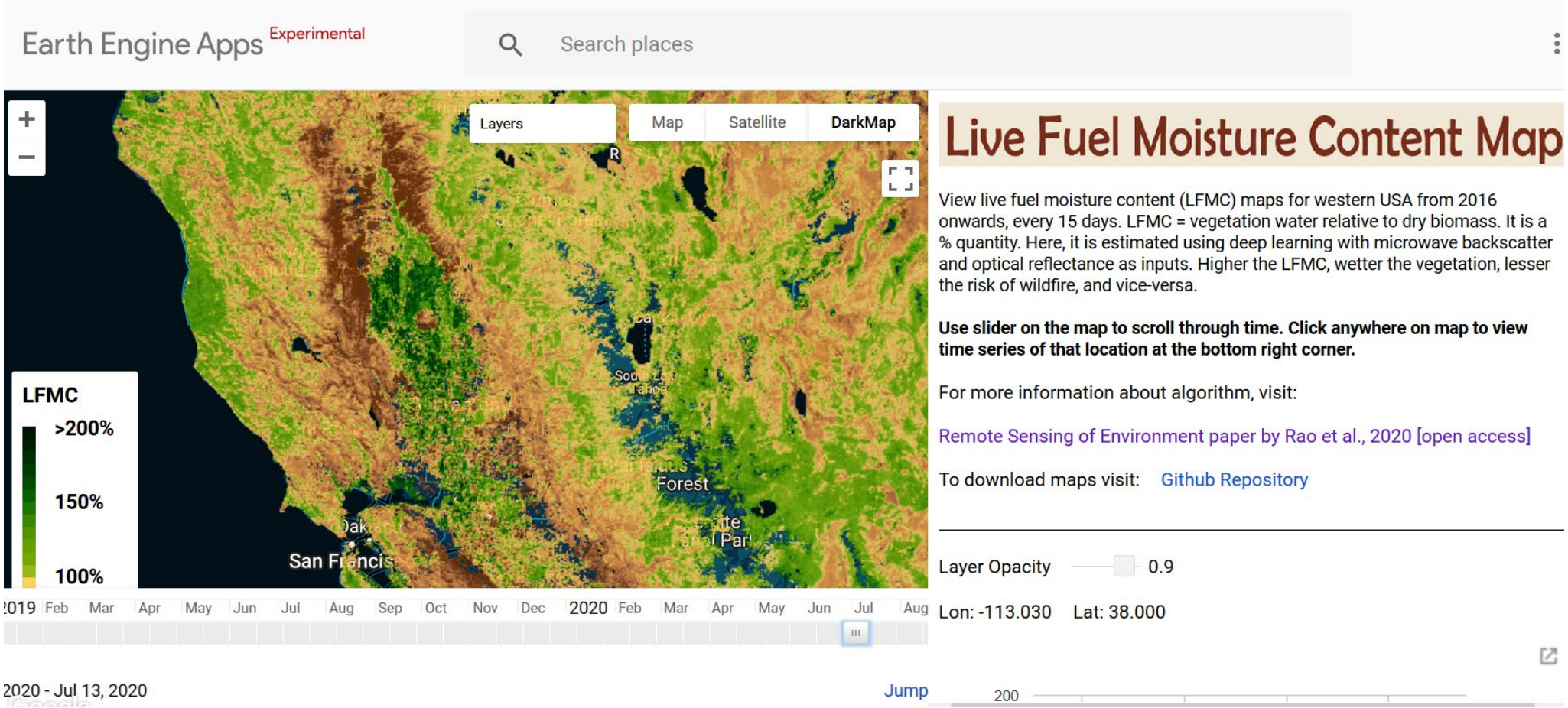
FIRECAST

- Analysis and alert system that delivers near real-time (NRT) monitoring products via email to users. Alerts include:
  - Risk of fire within a user's specified area of interest (i.e., protected areas, different vegetation and land cover types, or user-defined regions)
  - Map images depicting the locations of fires or risk of fires and KMLs for data import into Google Earth
- The system currently operates in many South American countries, Indonesia, and Madagascar



Link: https://firecast.conservation.org/

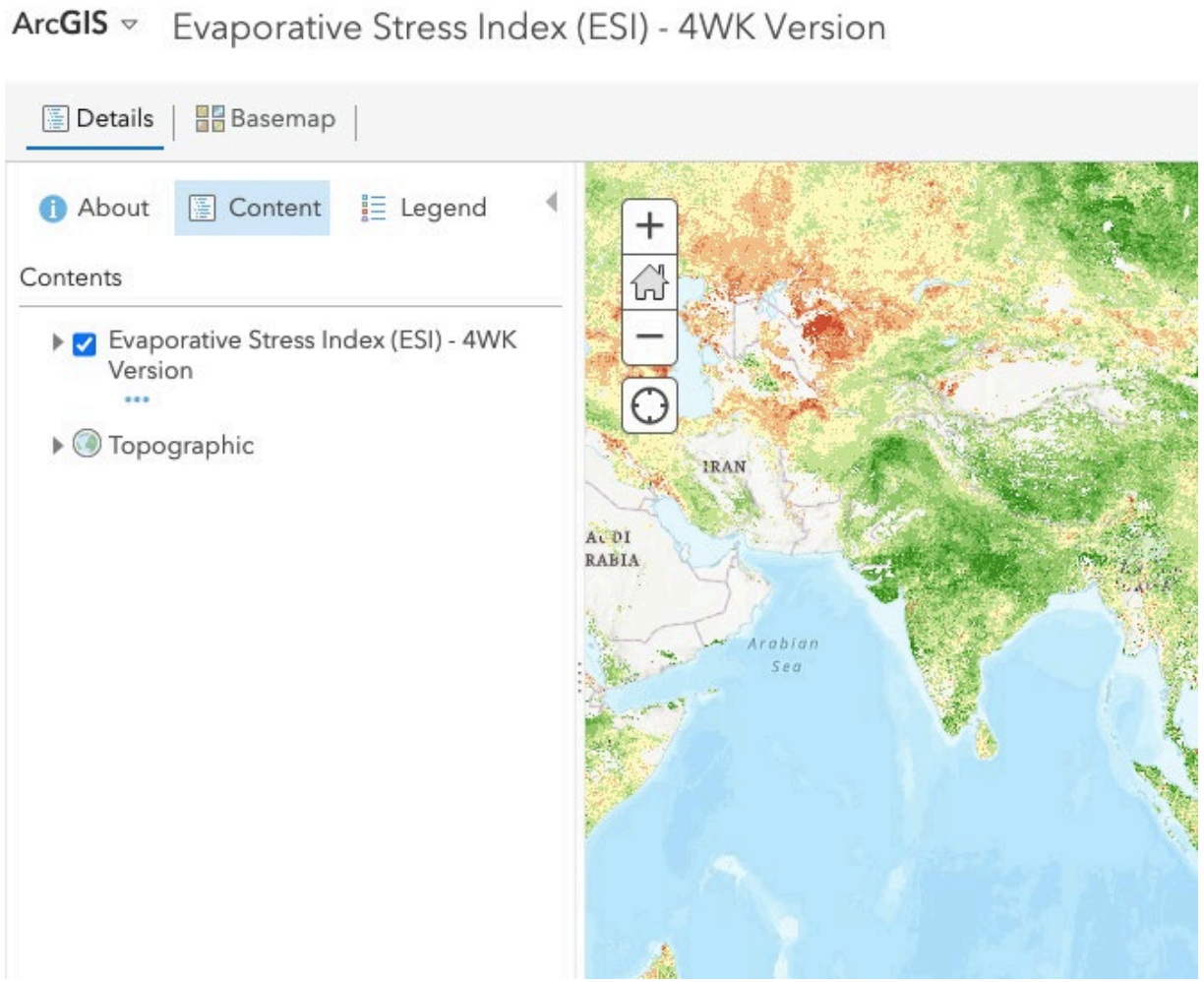
Earth Engine Apps: Live Fuel Moisture Content



Link: https://kkraoj.users.earthengine.app/view/live-fuel-moisture

Evaporative Stress Index Map Viewer

- Generally, healthy green vegetation with access to an adequate supply of water warms at a much slower rate than does dry and/or stressed vegetation.
- Weekly ESI data is based on variations in land surface temperature. The ESI indicates how the current rate of ET compares to normal conditions.
- ESI provides information about fuel dryness and health.



Link: [NASA/USDA ESI Product]

Global Wildfire Information System (GWIS)

- Joint initiative of the GEO 2017-2019 Work Programme and Copernicus, the European service that delivers near real-time data on a global level to meet user needs.
- Goal: Provide a comprehensive view and evaluation of fire regimes and fire effects at the global level
- Builds on the ongoing activities of the European Forest Fire Information System, The Global Terrestrial Observing System, the Global Observation of Forest Cover – Global Observation of Land Dynamics (GOFC-GOLD) Fire Implementation team, and the associated Regional Networks
- NASA recently funded several projects to enhance the current GWIS.
- GWIS Viewer: https://gwis.jrc.ec.europa.eu/

National Aeronautics and Space Administration

GWIS Demonstration for Land Cover and Fuels Visualization in Sub-Saharan Africa

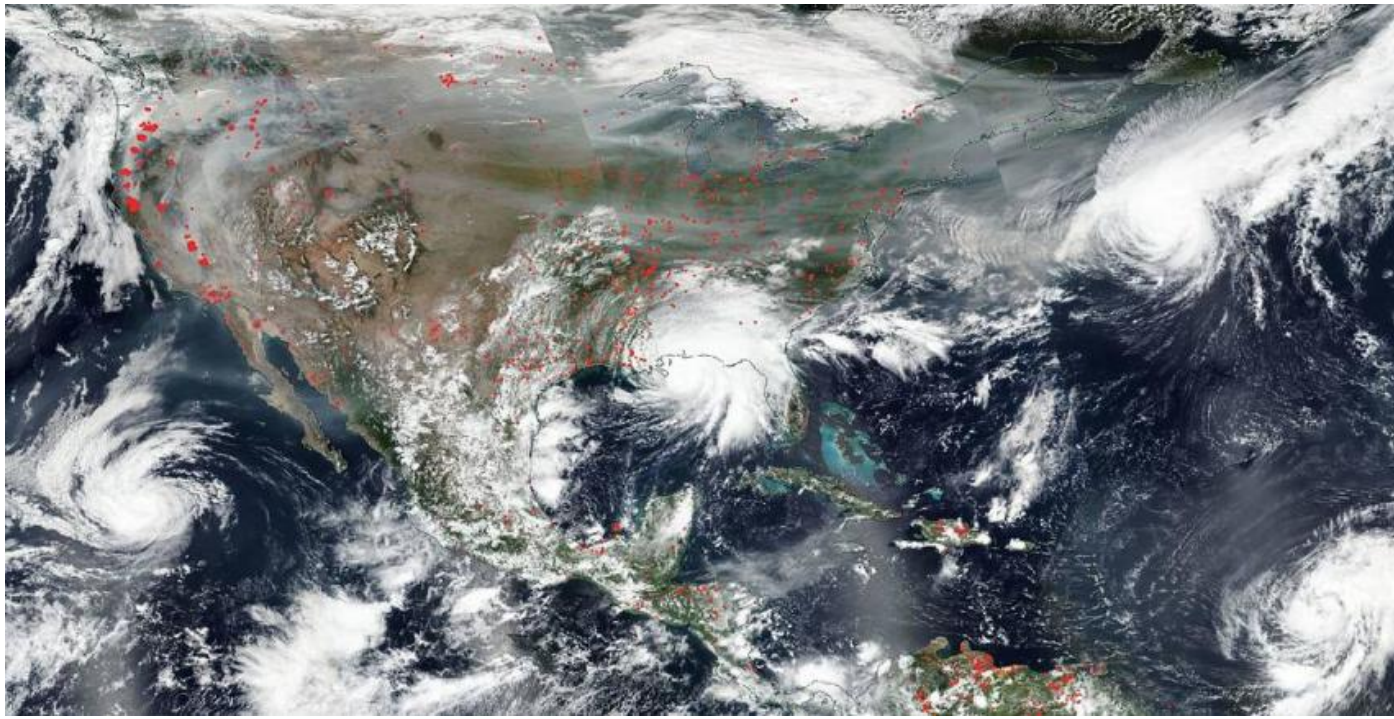
Additional Online Tools of Interest for Pre-Fire Monitoring

- **TOPOFIRE**
  - https://topofire.dbs.umt.edu
- **Wildland Fire Decision Support System (WFDSS)**
  - https://wfdss.usgs.gov/wfdss/WFDSS_Data.shtml
- **NASA Disasters Program Mapping Portal**
  - https://maps.disasters.nasa.gov/arcgis/apps/sites/#/home/pages/wildfires
- **USGS 3DEP LiDAR Explorer**
  - https://prd-tnm.s3.amazonaws.com/LidarExplorer/index.html#/

Western U.S. Fires in 2020: California

California 2020 Fires

- **Six of the top 20 largest fires in California occurred in 2020.**
  - Over 3 million acres burned, 2 dozen deaths, 4,000 homes destroyed, hundreds of thousands evacuated
- **Pre-Fire Conditions:**
  - Warmer and drier climate patterns, extensive build-up of fuels
  - Recording-breaking air temperatures with high winds; many events were lightning triggered



NASA's Aqua satellite captured this true-color image of the United States on Sep. 15, 2020, showing the fires in the West, the smoke from those fires drifting over the country, several hurricanes converging from different angles, and Hurricane Sally making landfall.
Image Credit: NASA

California 2020 Fires: Live Fuel Moisture Content

- Live Fuel Moisture Content (LFMC) - The mass of water per unit of dry biomass in vegetation - **exerts a direct control on fuel ignitability, fuel availability, and fire spread, and is thus an important parameter in assessing fire risk.**
- SAR data used to map dryness
- Data from National Fuel Moisture Database used in the model

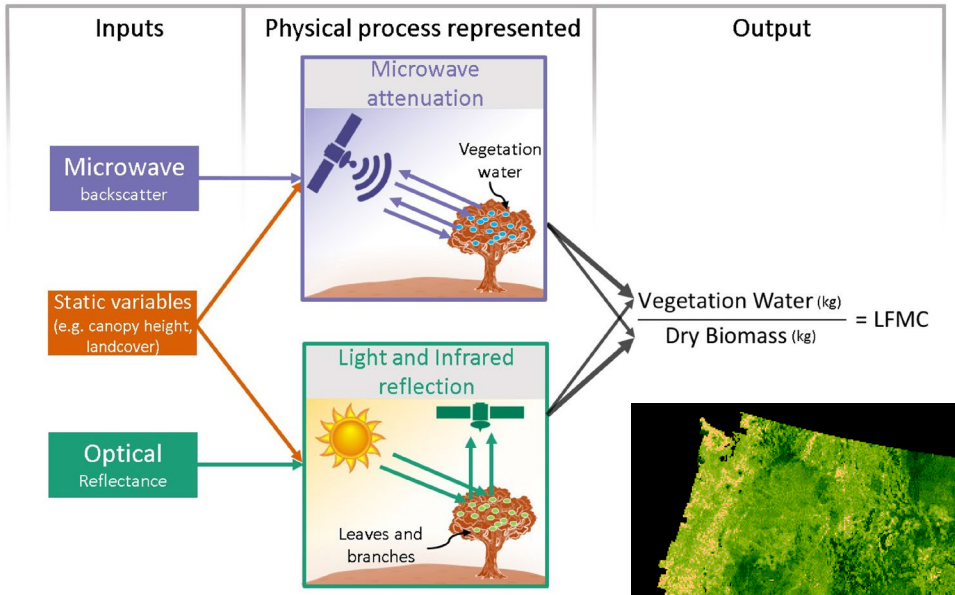
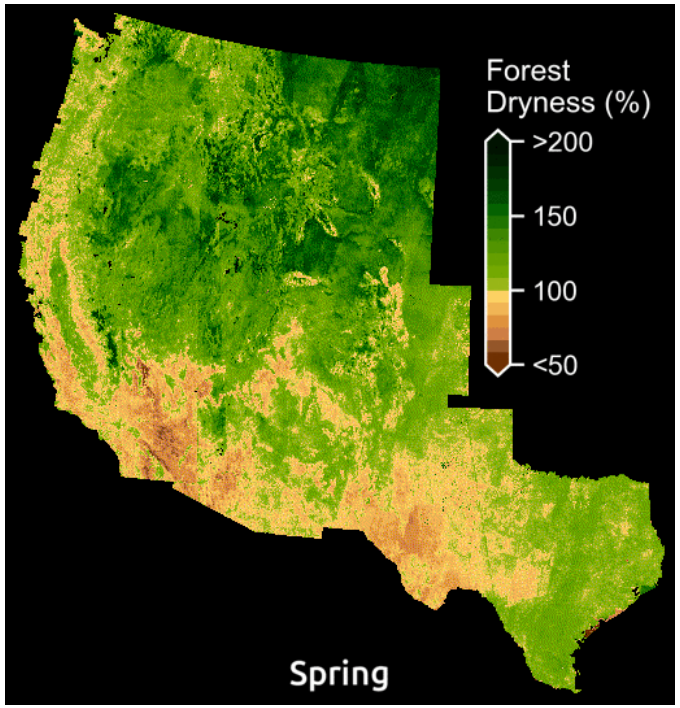
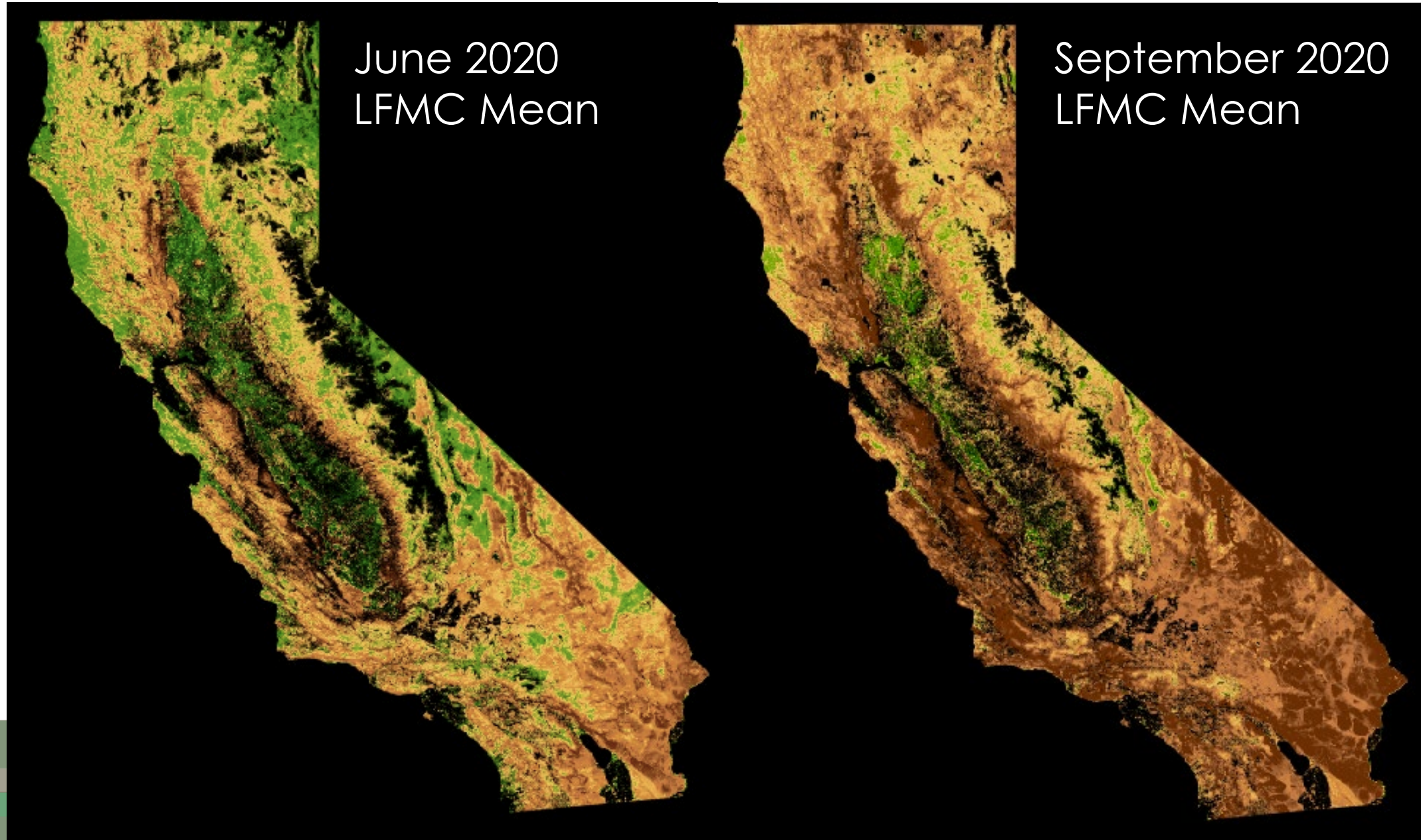


Image Credit: Rao et al 2020

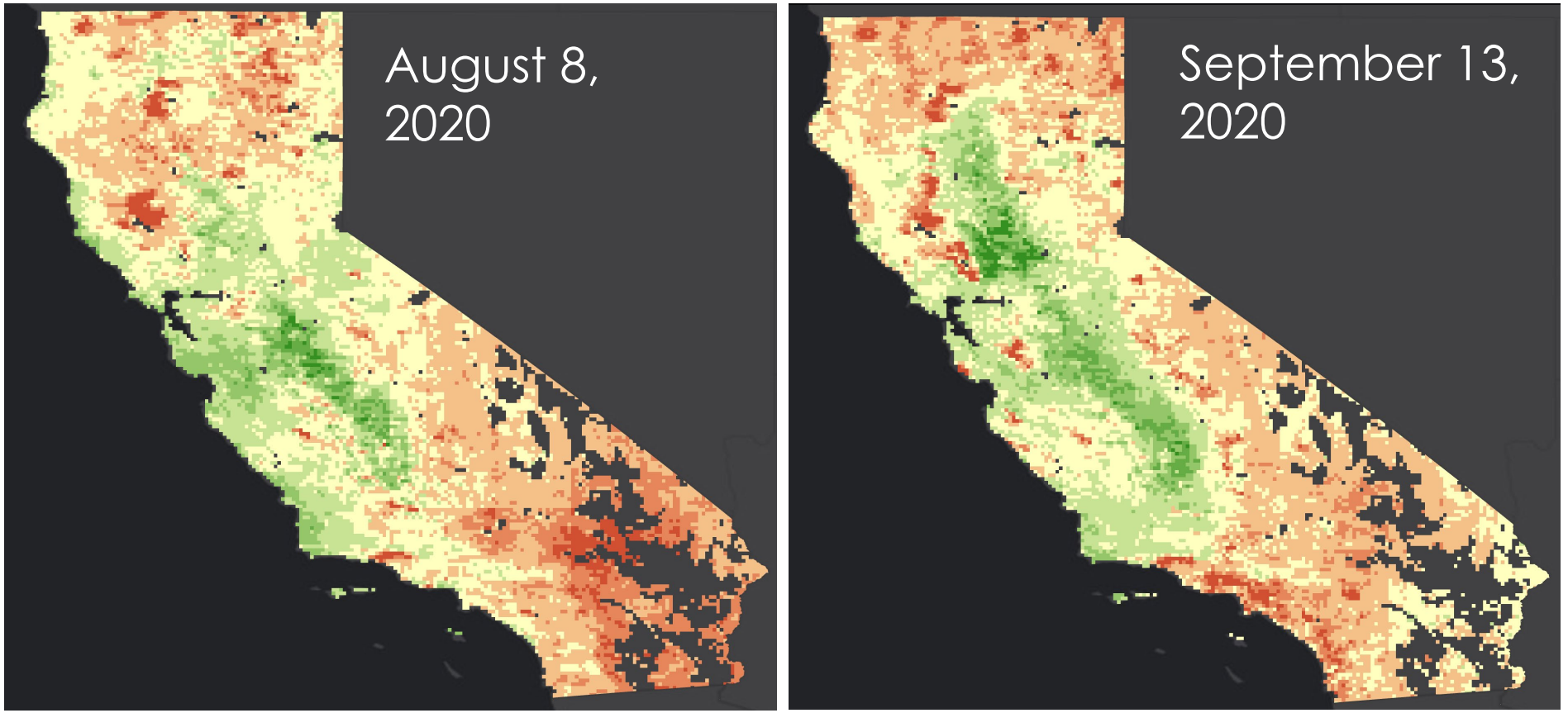


California 2020 Wildfires: Live Fuel Moisture Content



- **Notable decrease in fuel moisture over the course of summer months.**

California 2020 Wildfires: Evaporative Stress Index



Evaporative stress was particularly high in northern and southern California over the summer fire season of 2020. Note that evaporative stress in these areas is likely influenced by the presence of fires.

Summary

- Many satellite and airborne sensors have fire applications useful in the estimation of vegetation-based fire risk.
  - These sensors span multispectral, hyperspectral, lidar, and radar data sources.
  - Vegetation parameters include:
    - Type and Extent
      - Land Class and Fraction Cover
    - Stage and Health
      - NDVI, EVI, and SAVI
    - Moisture
      - FMC, ET, NDWI, NDMI, and ESI
    - Structure
      - Canopy Height and Density
- Data products (along with fire specific products) can be found on platforms such as EarthExplorer, GloVis, NASA Earthdata, and AppEEARS.
- Various online platforms exist to integrate parameters mentioned previously to provide fire risk and fuel estimate analysis.
- Next Session: Satellites and Sensors for Active Fire Monitoring


APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!