

Introduction to NASA Earth Observations for Vegetation and Rangeland Monitoring



Optical Surface Reflectance for Agriculture



Optical Surface reflectance is particularly useful for agriculture because it a **direct, measurable signal**, that can be used to quantify vegetation greenness and moisture for monitoring:

1. Crop and soil characterization
2. Vegetation health assessment
3. Phenological monitoring

Spectral Signatures for Vegetation



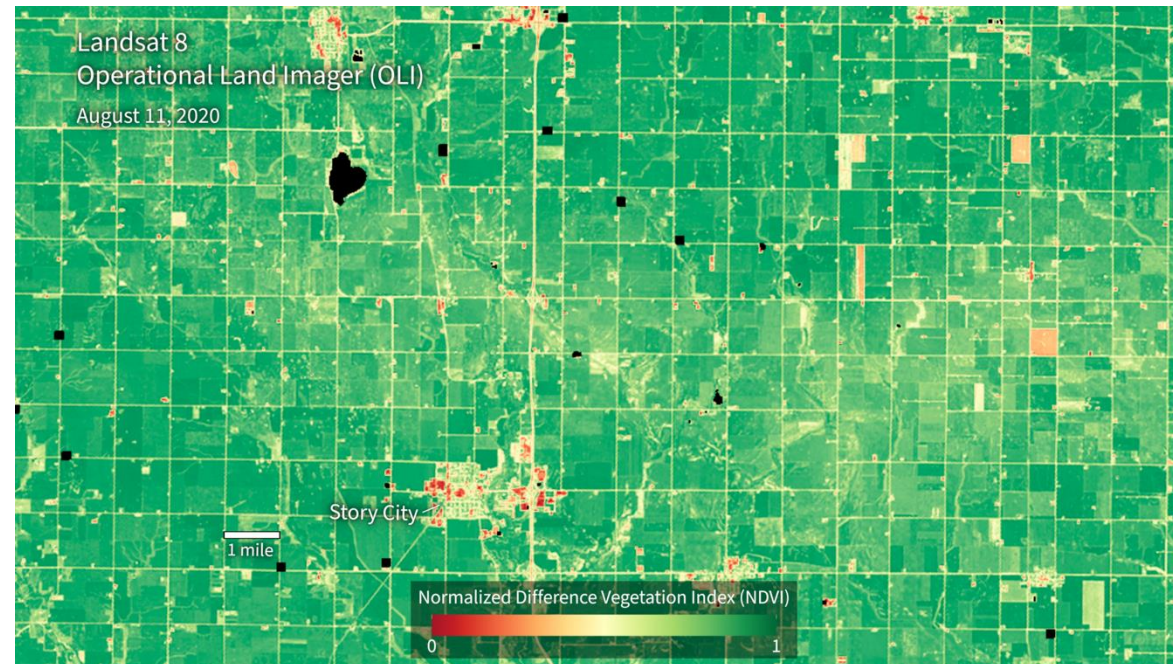
- **VIS:** Reflected radiance peaks at **green** wavelengths. Most incoming radiation in the visible range is absorbed through photosynthesis
- **NIR:** The highest reflectance occurs in the near infrared region. This range also has low absorption
- **SWIR:** The short-wave region has high reflectance and low absorption

How we can use this information:

- Identify health of plants using NIR and SWIR
- Distinguish plants from other objects like soil and buildings

What is a Spectral Index?

- A mathematical **calculation performed on each pixel** using values from multiple spectral bands of an image
- Enable consistent comparisons across time and space, typically normalized **between -1 and +1**
- Fundamental tools in remote sensing that **transform** complex multispectral data **into meaningful, interpretable information** about Earth's surface conditions and processes



Surface Reflectance – MODIS

- Moderate Resolution Imaging Spectroradiometer (MODIS)
- Operates on both the Terra and Aqua Spacecraft
- Active: *(concluding late 2026/early 2027)*
 - Terra 1999 – present
 - Aqua 2002 – present
 - Temporal Resolution: 1-2 Days
 - Spatial Resolution: 2330 km, 250 m to 1 km
- 36 bands including Visible, Near IR, Middle IR, Thermal IR
- Access: [Worldview](#)



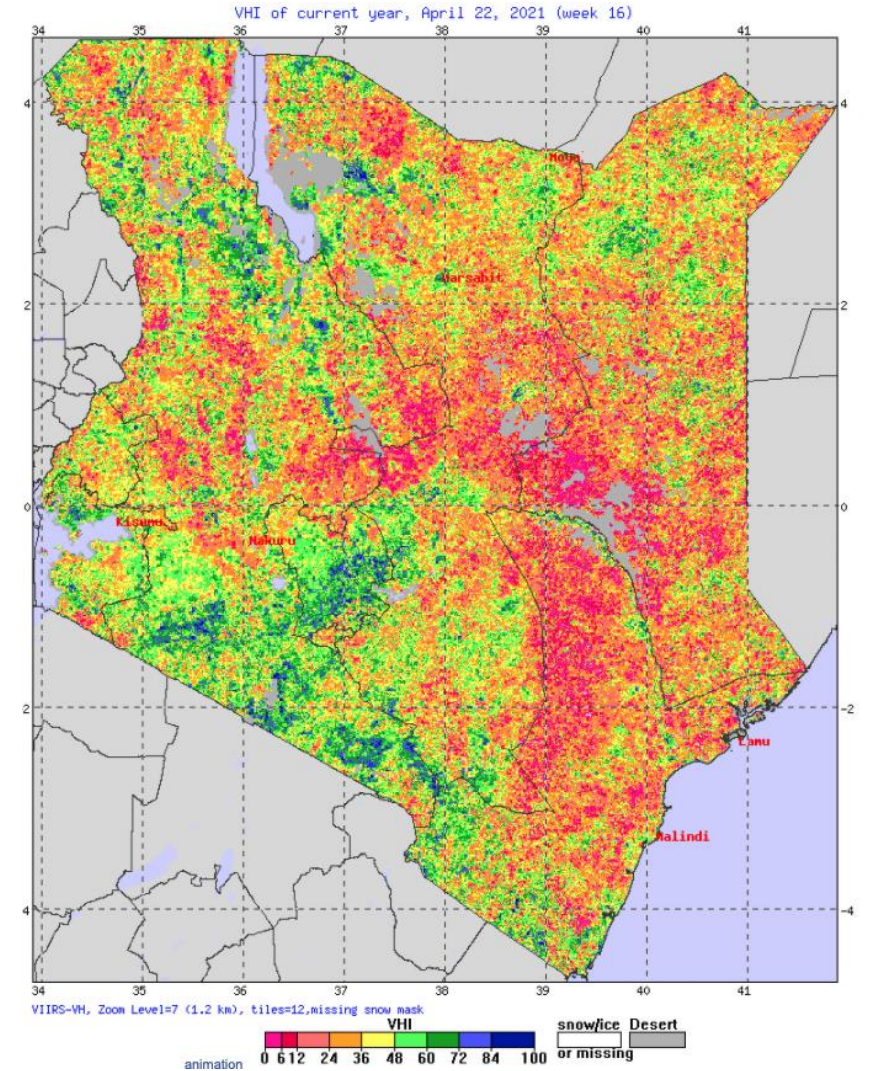
This composite image over the continental United States is a map of the fraction of the photosynthetically available radiation that was absorbed by land vegetation for photosynthesis
Credit: [MODIS FPAR](#)

Surface Reflectance – VIIRS

- Suomi National Polar-orbiting Partnership (NPP)
- Sensor: Visible Infrared Imaging Radiometer Suite ([VIIRS](#))
- Active: 2012 – present
- Temporal Resolution: Daily

Spatial Resolution:

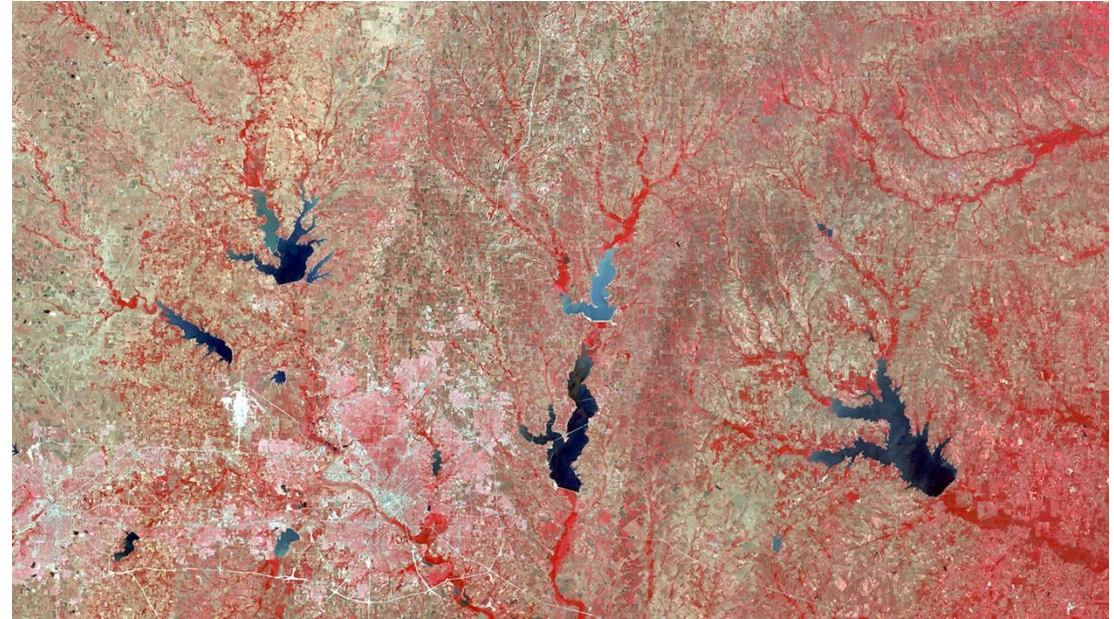
- 5 moderate resolution bands: 375 m
- 16 coarse resolution bands: 750 m
- Access: Worldview



VIIRS Vegetation products include Vegetation Condition Index, Temperature Condition Index, and Vegetation Health Index. Credit [NOAA NESDIS](#)

Surface Reflectance – Landsat 8/9

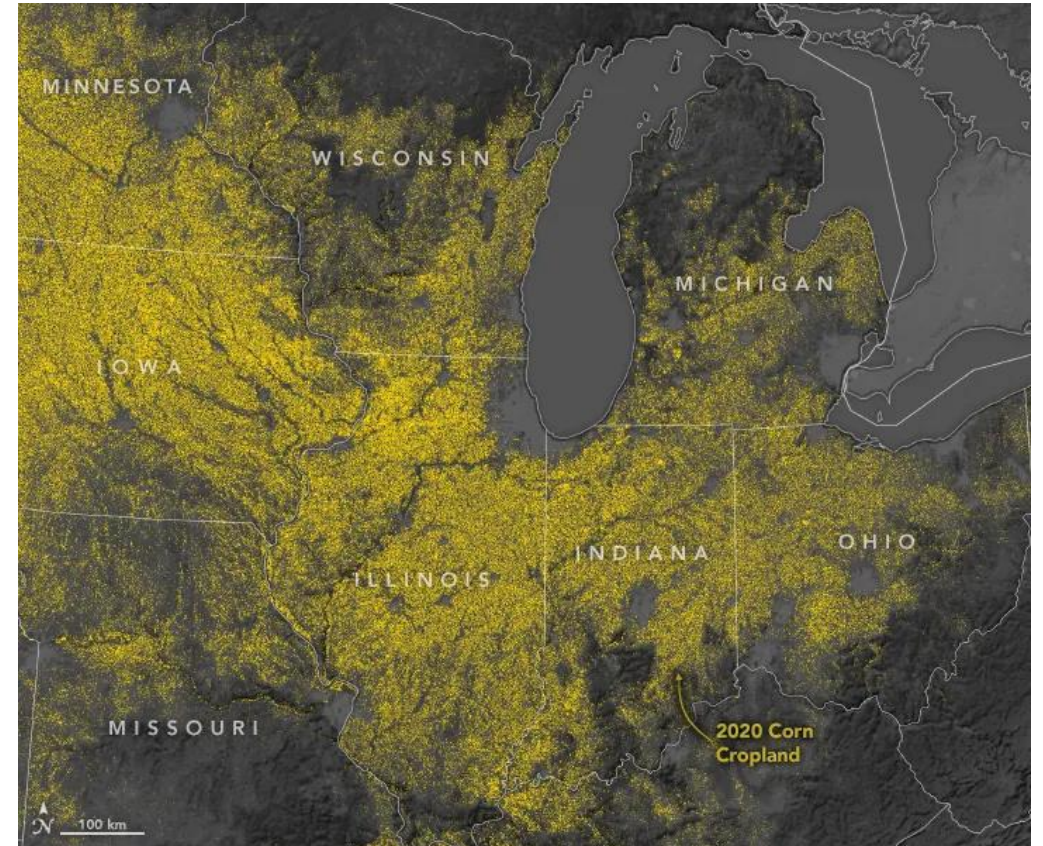
- Landsat 8/9 Operational Land Imager (OLI & OLI-2)
- Active:
 - Landsat 8 OLI - 2013 – present
 - Landsat 9 OLI-2 – 2021 – present
- Temporal Resolution: 16 days (8 days combined)
- Spatial Resolution: 30m
- Visible, Near IR, Middle IR, Thermal IR
- 9 spectral OLI bands Includes three bands in the 'red edge'
- Access: [Earthdata Search](#), [Worldview](#), & [AppEEARS](#)



This is the First Light image from Landsat 1 over Dallas-Fort Worth, Texas – July 25, 1972. First light refers to the first image collected by a sensor after it's turned on.

Surface Reflectance – Sentinel-2

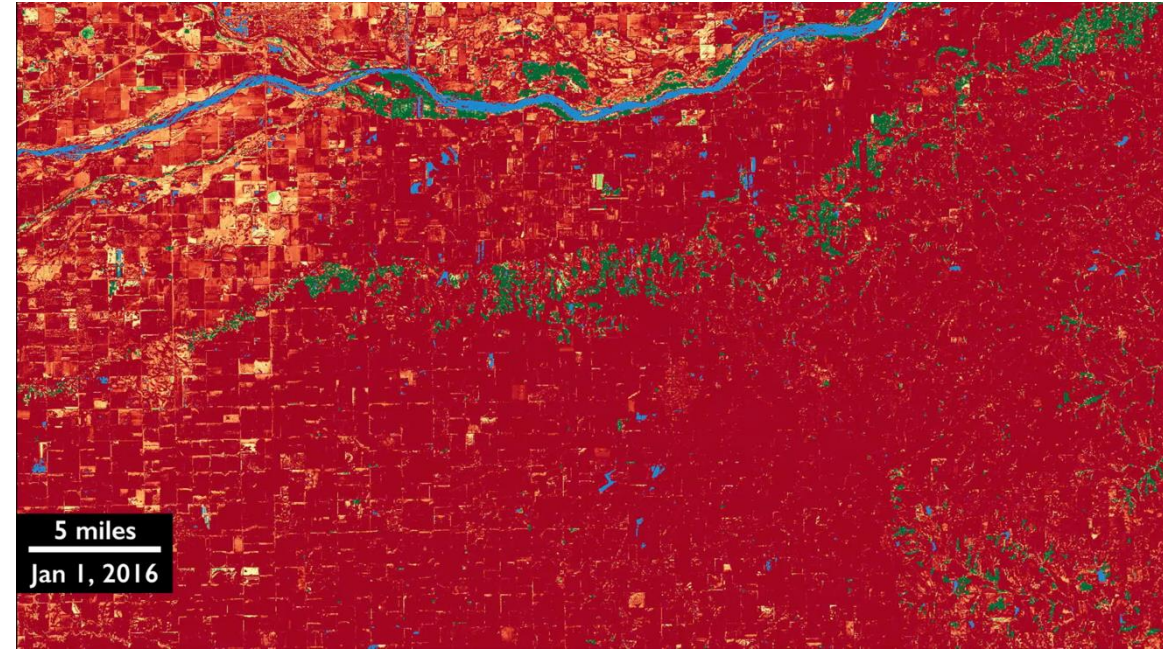
- Sentinel-2 ([MSI](#))
- Active: 2015 – present
- Temporal Resolution: 5 days
- Sentinel-2 A/B/C Level 2A Surface Reflectance (ESA)
- 13 spectral bands with varying resolutions: 10 m (4 bands), 20 m (6 bands), 60 m (3 bands)
- Includes three bands in the 'red edge'
- Access: [Copernicus Browser](#) & [Worldview](#)



Yellow areas show 2020 corn fields mapped using the Cropland Data Layer (NASS), which combines USGS land cover data with Landsat 8, ResourceSat-2, and Sentinel-2 imagery. Image Credit: [NASA Earth Observatory](#)

Surface Reflectance & Vegetation Indices – HLS

- Harmonized Landsat and Sentinel-2 ([HLS](#))
- Active: 2013 – present
- Spatial Resolution: 30 m
- Temporal Resolution: 2–3 days
- Integrates Landsat 8/9 (NASA/USGS) and Sentinel-2 A/B/C (ESA) data
- Harmonized for seamless joint use
- Suite of [HLS vegetation index](#) (VI) products
- Access: [Earthdata Search](#), [Worldview](#), & [AppEEARS](#)



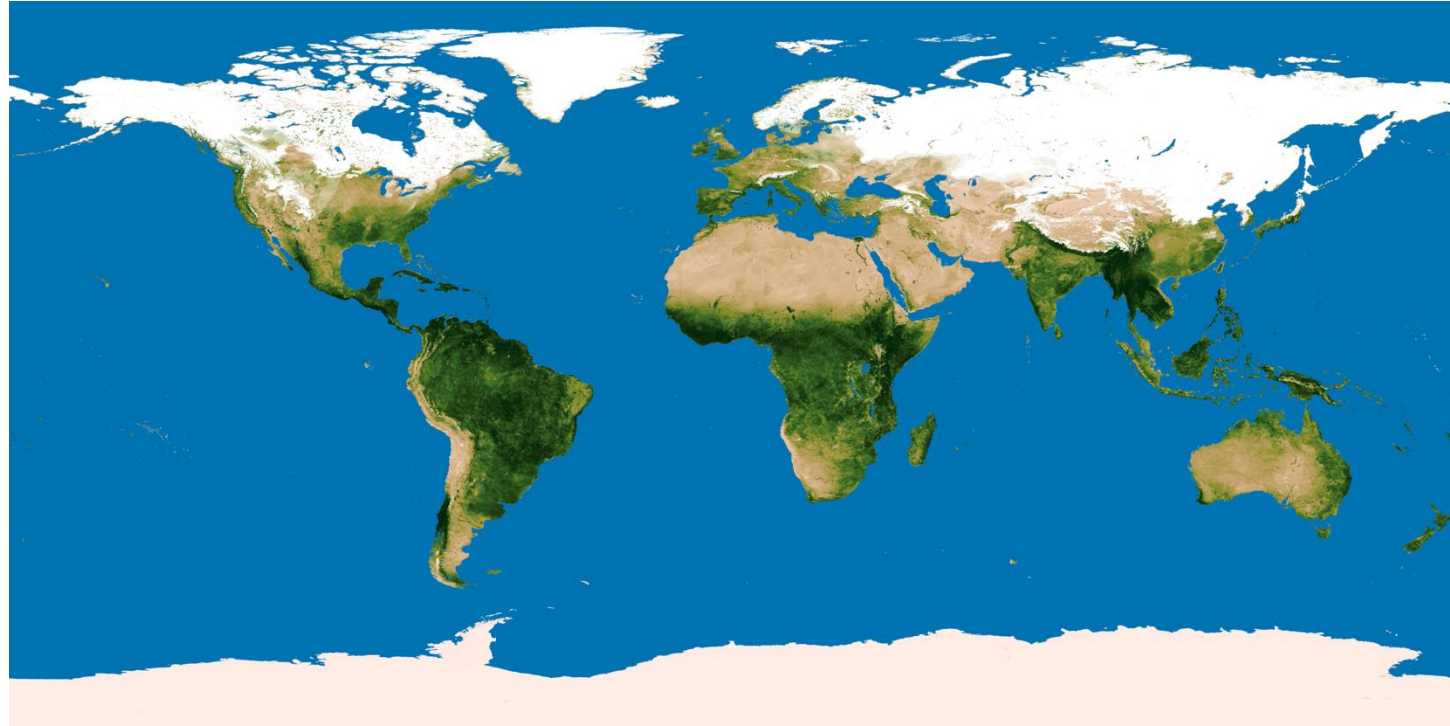
Annual NDVI data (2016) of farmland south of Columbus, Nebraska, with the Platte River across the top. Red shows bare soil; green indicates healthy vegetation.

Image Credit: [NASA GSFC – SVS](#)

Introduction to Vegetation Indices

Common Indices

- **NDVI** - Normalized Difference Vegetation Index
- **EVI** - Enhanced Vegetation Index
- **SAVI** - Soil Adjusted Vegetation Index
- **NDMI** - Normalized Difference Moisture Index
- **NDWI** - Normalized Difference Water Index
- **NBR** - Normalized Burn Ratio

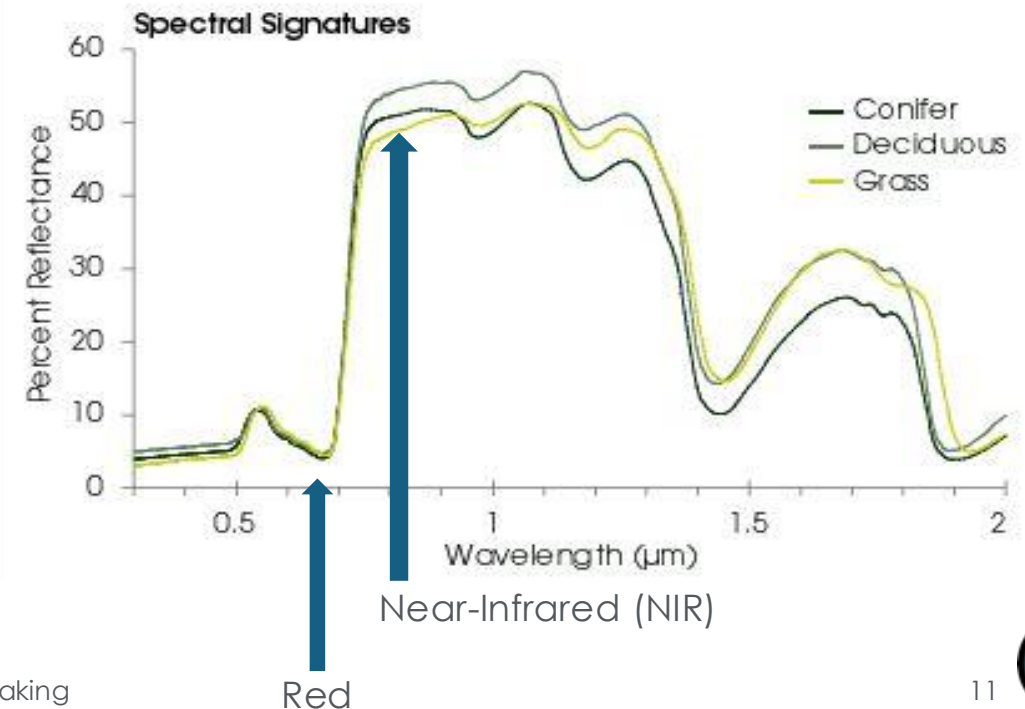
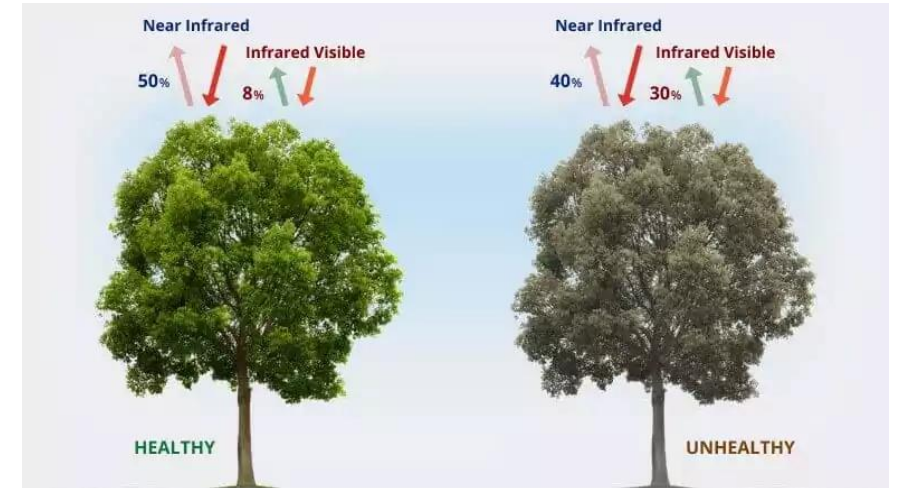


Credit: Near Real-Time [NDVI](#)

Normalized Difference Vegetation Index (NDVI)

- [NDVI](#) evaluates vegetation condition and chlorophyll content.
- Chlorophyll strongly absorbs visible light, and the cellular structure of leaves strongly reflects near-infrared light.
- NDVI values range from -1.0 to 1.0
 - -1.0 to 0.0: Water Bodies and Non-Vegetation
 - Values approaching 1 represent peak vegetation biomass
 - NDVI Formula:

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



Landsat 8 & 9 OLI and TIRS Bands (µm)			Landsat 7 ETM+ Bands (µm)		
Band 1	30 m Coastal/Aerosol	0.43–.045			
Band 2	30 m Blue	0.45–.051	Band 1	30 m Blue	0.44–0.51
Band 3	30 m Green	0.53–0.60	Band 2	30 m Green	0.52–0.60
Band 4	30 m Red	0.63–0.68	Band 3	30 m Red	0.63–0.69
Band 5	30 m NIR	0.85–0.88	Band 4	30 m NIR	0.77–0.90
Band 6	30 m SWIR-1	1.57–1.65	Band 5	30 m SWIR-1	1.55–1.75
Band 10	100 m TIR-1	10.60–11.19	Band 6	60 m TIR	10.40–12.50
Band 11	100 m TIR-2	11.50–12.51			
Band 7	30 m SWIR-2	2.11–2.29	Band 7	30 m SWIR-2	2.08–2.35
Band 8	15 m Pan	0.5–0.68	Band 8	15 m Pan	0.52–0.90
Band 9	30 m Cirrus	1.36–1.38			

Moderate Resolution Imaging
Spectroradiometer (MODIS)

August 09, 2020

Ft. Dodge

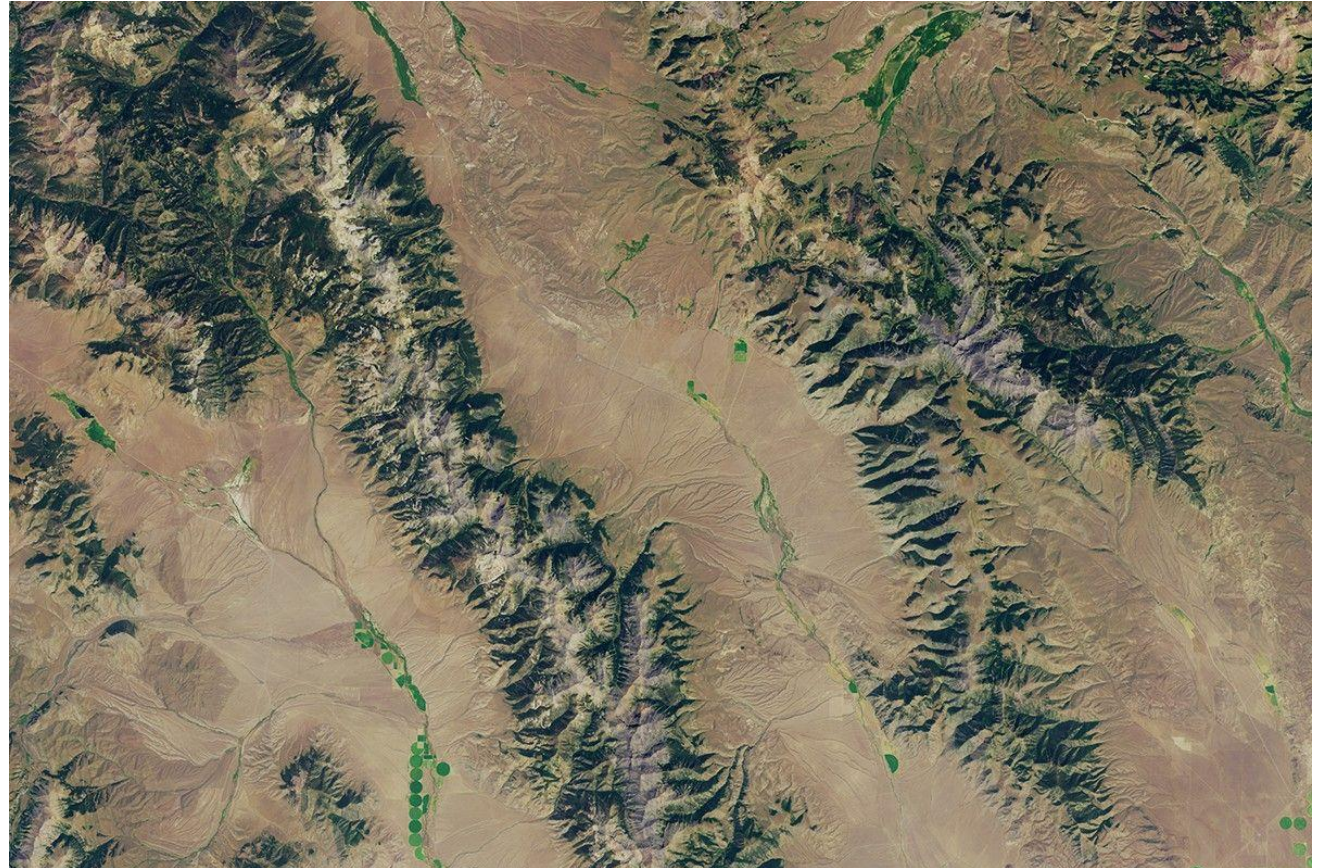
Ames

Des Moines

IOWA

Rangelands Monitoring

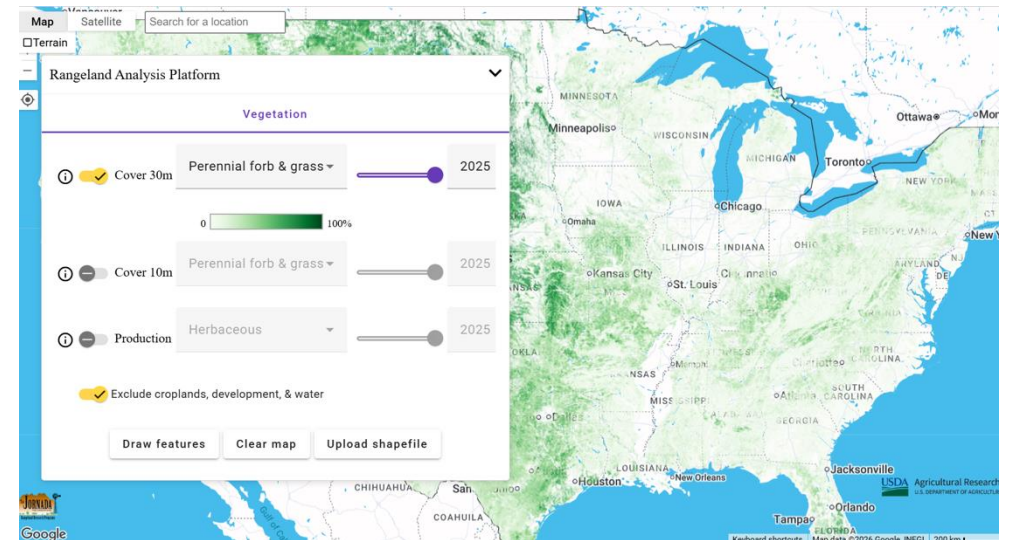
- Rangelands are vast areas of uncultivated land
- Largely characterized by native grasses, forbs, and shrubs
- Suitable for grazing by livestock and wildlife
- Cover 54% of the Earth's terrestrial surface
- Vegetation indices are a key tool for monitoring rangelands



This Landsat 8 image (Path 40 Row 29) shows a location in eastern Idaho. The valleys between the mountain ranges consist of rangelands and narrow riparian corridors. Credit: [NASA Rangeland Management](#)

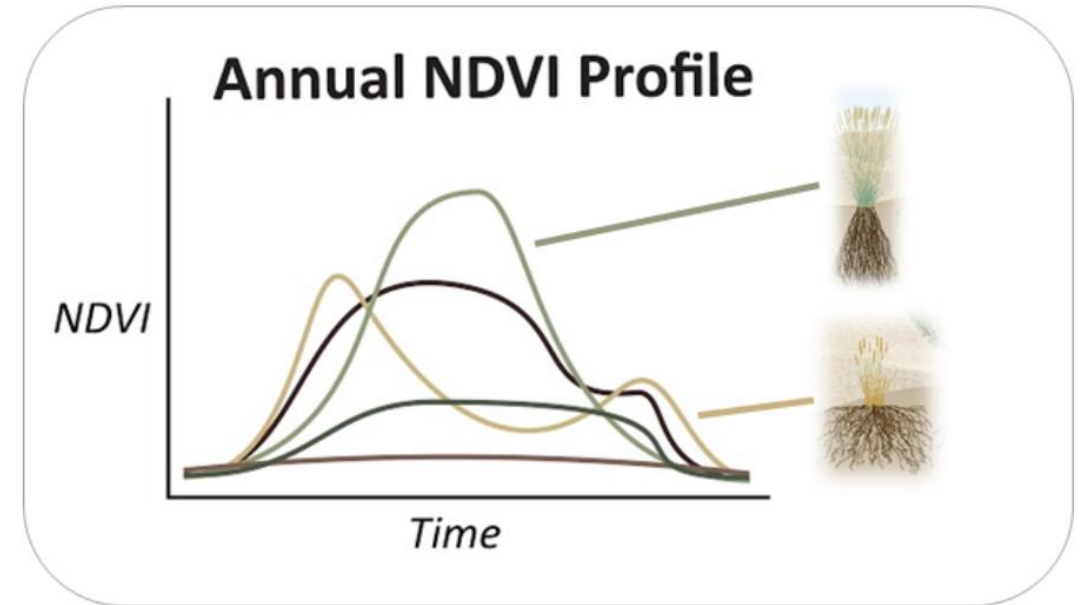
Rangeland Analysis Platform (RAP)

- Rangeland Analysis Platform is a free online application that provides geospatial vegetation data for U.S. rangelands
- Does not require an account
- Combines satellite imagery with thousands of on-the-ground vegetation measurements collected by BLM, NPS, and NRCS
- Computes different models for vegetation type and production estimates
- Offers cover type at two different spatial resolutions
 - 10m data from 2018-2024
 - 30m data from 1986-2025

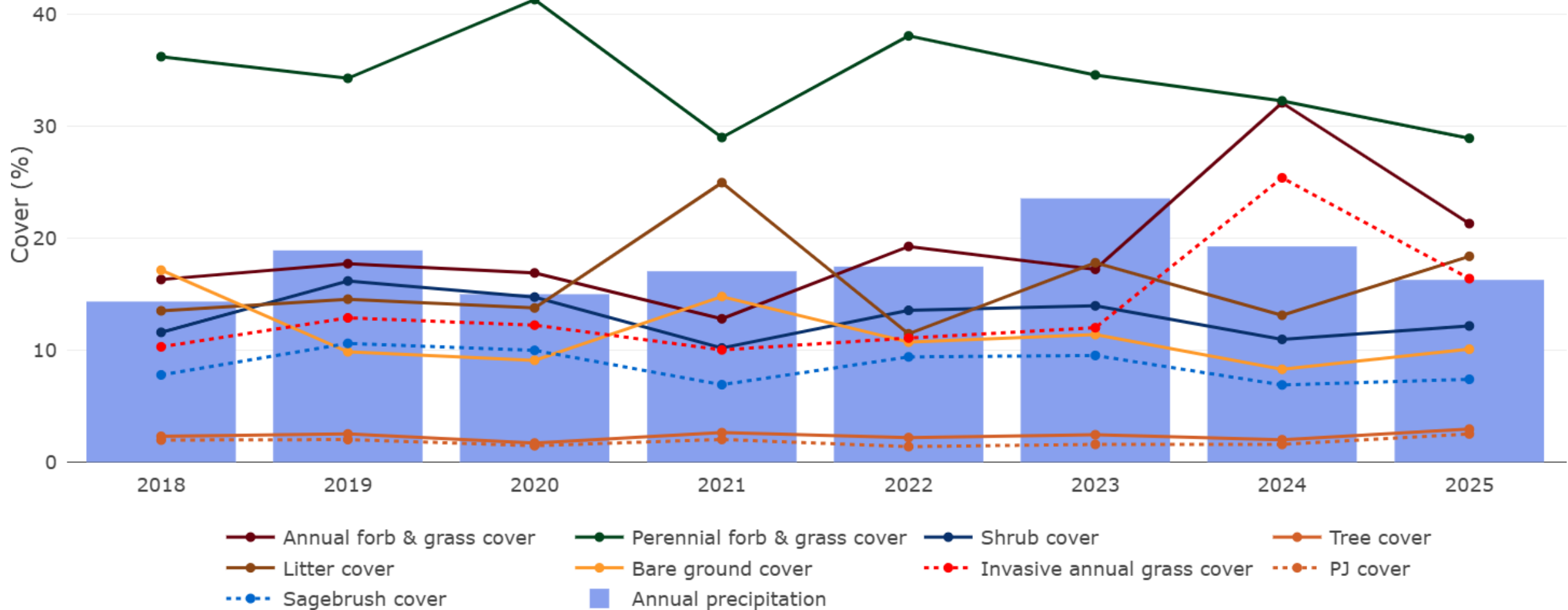


RAP Production Explorer

- RAP Production Explorer compares current year production to past years, quantifies the amount above or below a long-term average, and provides an interactive estimate of the stocking rate
- Provides 16-day estimates for selected years and historical reports
- Production dataset uses vegetation cover and NDVI to calculate production summaries



10 Meter Land Cover Type



Herbaceous Production Report

Map type ⓘ Year ⓘ Dates ⓘ Reference period ⓘ Production metric ⓘ

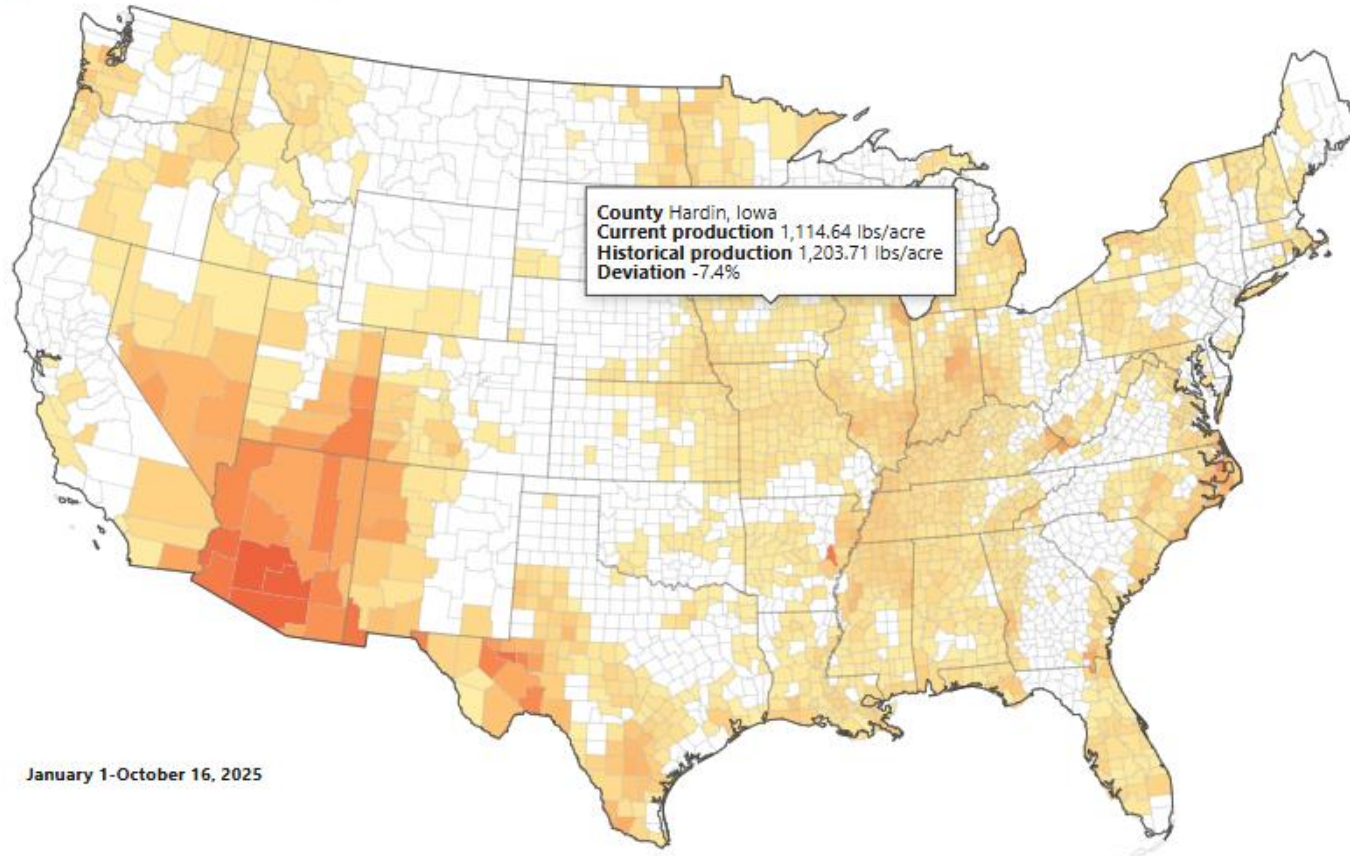
County map ⓘ 2025 ⓘ Jan 1-Oct 16 ⓘ Previous 10 years ⓘ Cumulative total ⓘ ☒ Per acre ⓘ

☒ Threshold (Deviation from historical mean) -10%

Deviation from historical mean (previous 10 years)

-100% -50% 0% +50% +100%

Hint: click on a county for a detailed report



Demo – RAP



Demo Case Study – American Prairie Reserve

- Non-profit based nature reserve in Central Montana, founded in 2001
- Part of the American Prairie Foundation
- Combination of private and public lands
- Two Crow parcel acquired in 2019
- Reserve objectives
 - Restoration of temperate grasslands and expand species diversity
 - Re-introduction of the Bison; a keystone species

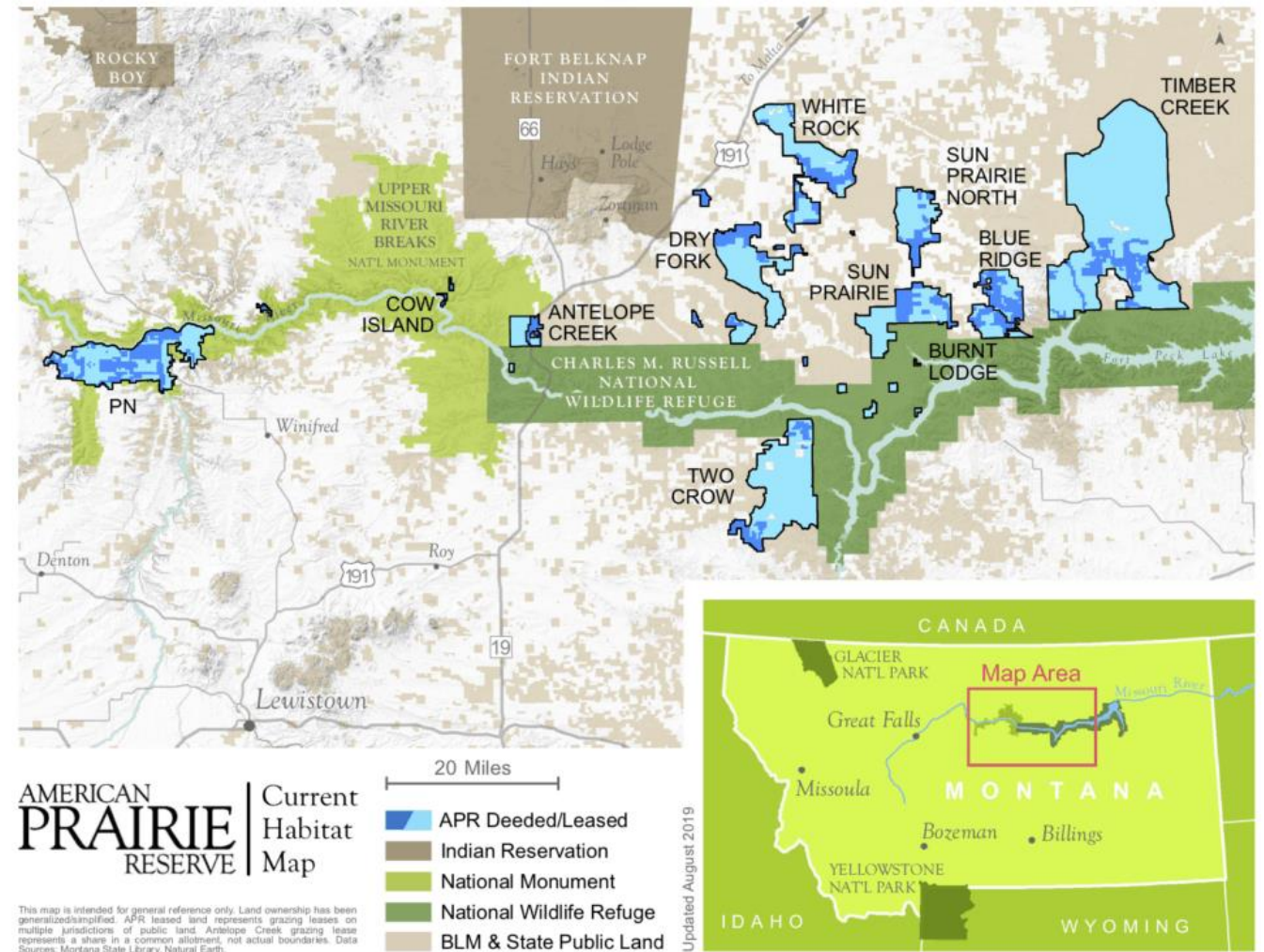


Image Credit: [Forest Policy Hub](#)

Hands on Exercise Time

Ask a trainer for assistance!

We will reconvene at 2:30pm



RAP Tools to Explore

Step 1. In small groups or individually select a rangeland ecosystem of interest explore

Large ranching areas in the U.S.: Doughboy, NE, Falfurrias, TX, Scoville, ID, or Anselmo, NE

National Grasslands: Pawnee National Grassland near Greeley, CO; Curlew National Grassland near Pocatello Idaho; or Cimarron National Grassland near Elkhart, KS

Step 2. Navigate to <https://rangelands.app/>

Step 3. Explore features and tools such as:

- RAP Web map (vegetation covers, different resolution products, export csv files)
- Production Explorer
 - Time series of herbaceous vegetation production (explore different reports, plot different years, download plot as a PNG)
 - Explore historical production and Calculate stocking rates
- Herbaceous Production Report
 - County level assessments, printing reports
 - Deviation from historical average

RAP Hands on Exercise Discussion

- Q & A
- Reflection questions:
 - What location did you choose to explore?
 - Which tool(s) did you use and why?
 - Did you find any difficulties with the tools or data?
 - Did you see anything interesting or confusing?
 - How might this apply to your work/how might you use these resources in the future?

Rangeland Analysis Platform Summary

- Free web-based support tool
- No registration required
- Rangeland productivity
 - 10 m (Sentinel-2): vegetation trends 2018-present
 - 30 m (Landsat): vegetation trends 1986-present
- Landsat and Sentinel-2 data with USDA, NRCS, BLM, and NPS vegetation data surveys
- Production models based on specific EPA Eco Region characteristics
- Production report uses NDVI and EPA Eco regions for biomass estimates
- Herbaceous production report for county level compared against historical averages

Want to learn more? Check out ARSET's [Spectral Indices for Land and Aquatic Applications](#) training!