

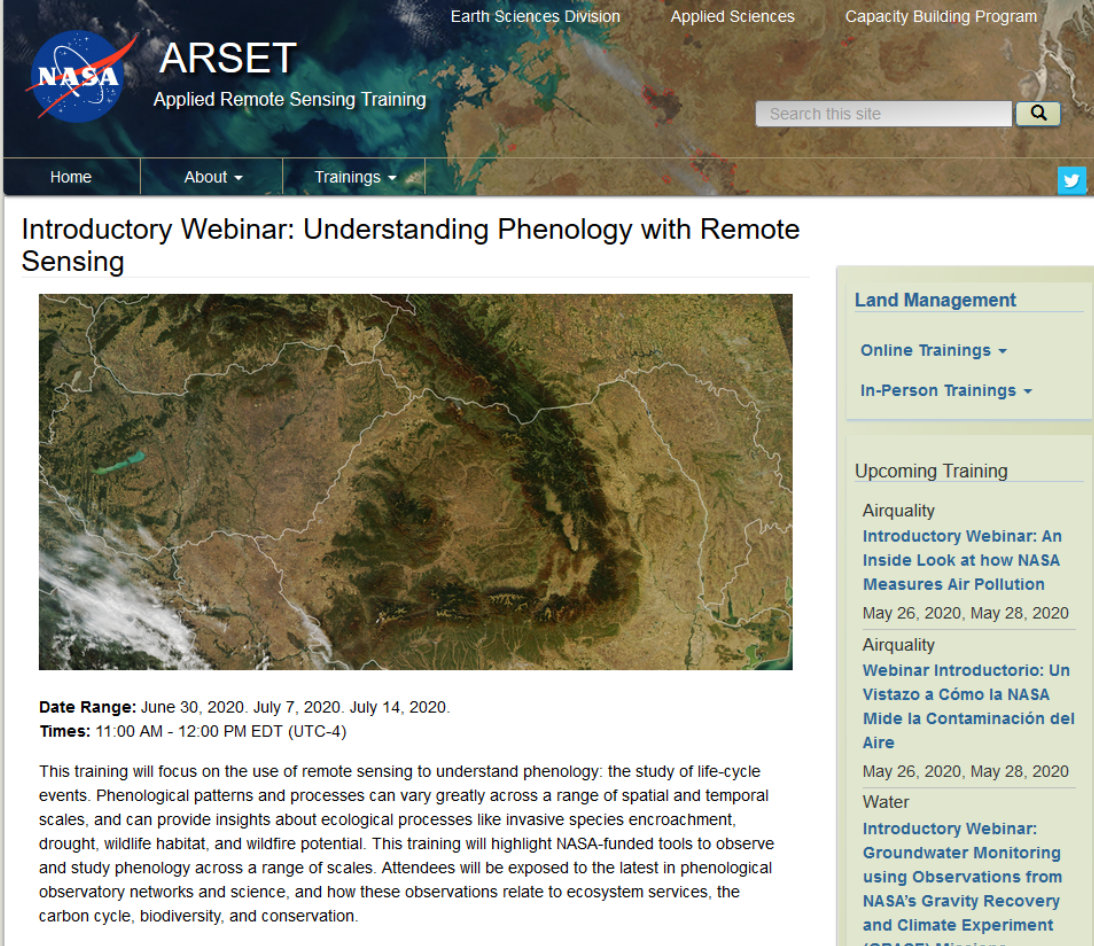
# Tracking Vegetation Phenology with Remote Sensing

Amber McCullum and Juan Torres-Pérez

July 7, 2020

# Course Structure and Materials

- Three, 1-hour sessions on **June 30, July 7, and July 14**
- Recordings, slides, and homework assignments can be found after each session at:
  - <https://arset.gsfc.nasa.gov/land/webinars/phenology>
- Prerequisites:
  - [Fundamentals of Remote Sensing](#)
- Q&A: Following each lecture and/or by email at:
  - [amberjean.mccullum@nasa.gov](mailto:amberjean.mccullum@nasa.gov)
  - [juan.l.torresperez@nasa.gov](mailto:juan.l.torresperez@nasa.gov)



The screenshot shows the ARSET (Applied Remote Sensing Training) website. The header includes the NASA logo, the text 'ARSET Applied Remote Sensing Training', and navigation links for 'Earth Sciences Division', 'Applied Sciences', and 'Capacity Building Program'. A search bar is present in the top right. Below the header, there are navigation tabs for 'Home', 'About', and 'Trainings'. The main content area features a large satellite image of a landscape with a green line indicating a path or boundary. The title of the webinar is 'Introductory Webinar: Understanding Phenology with Remote Sensing'. Below the image, the date range is listed as 'June 30, 2020, July 7, 2020, July 14, 2020' and the times as '11:00 AM - 12:00 PM EDT (UTC-4)'. A detailed description of the training follows, focusing on the use of remote sensing to understand phenology. On the right side, there is a sidebar with sections for 'Land Management', 'Online Trainings', and 'In-Person Trainings'. Under 'Upcoming Training', two air quality webinars are listed: 'Introductory Webinar: An Inside Look at how NASA Measures Air Pollution' and 'Webinar Introductorio: Un Vistazo a Cómo la NASA Mide la Contaminación del Aire', both scheduled for May 26 and May 28, 2020. A 'Water' section is also visible at the bottom of the sidebar.



# Homework and Certificates

- **Homework:**
  - One homework assignment
  - Answers must be submitted via Google Forms
- **Certificate of Completion:**
  - Attend all three live webinars
  - Complete the homework assignment by **Thursday, July 28<sup>th</sup>** (access from ARSET website)
  - You will receive certificates approximately two months after completion of the course from: [marines.martins@ssaihq.com](mailto:marines.martins@ssaihq.com)



## Homework: Understanding Phenology with Remote Sensing

This homework includes questions from the lectures from all sessions of this webinar.

To receive a certificate of completion, you must have attended all live webinar parts and complete this homework by July 28, 2020. Once you submit the homework, you will receive an email with a copy of your responses.

Once you click submit, you may click "View Your Accuracy" to see how you did.

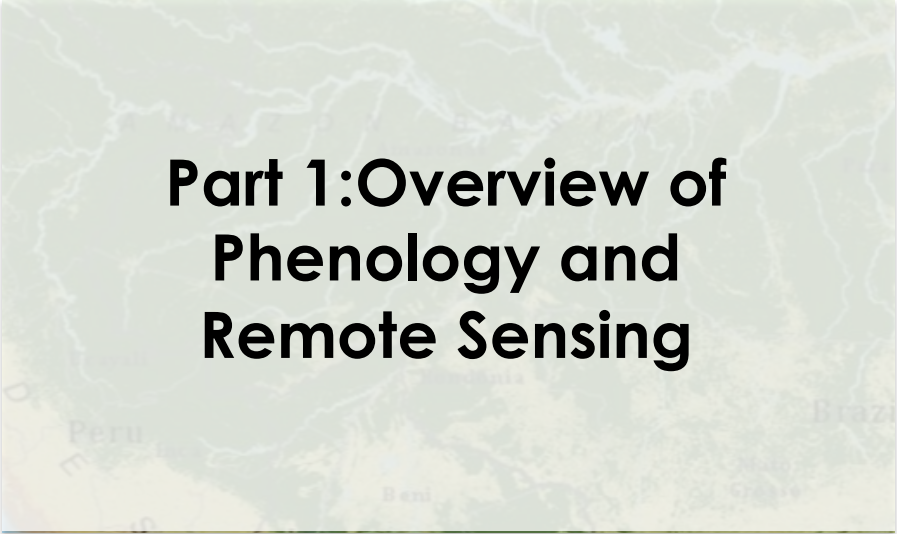
\* Required

Email address \*

Your email



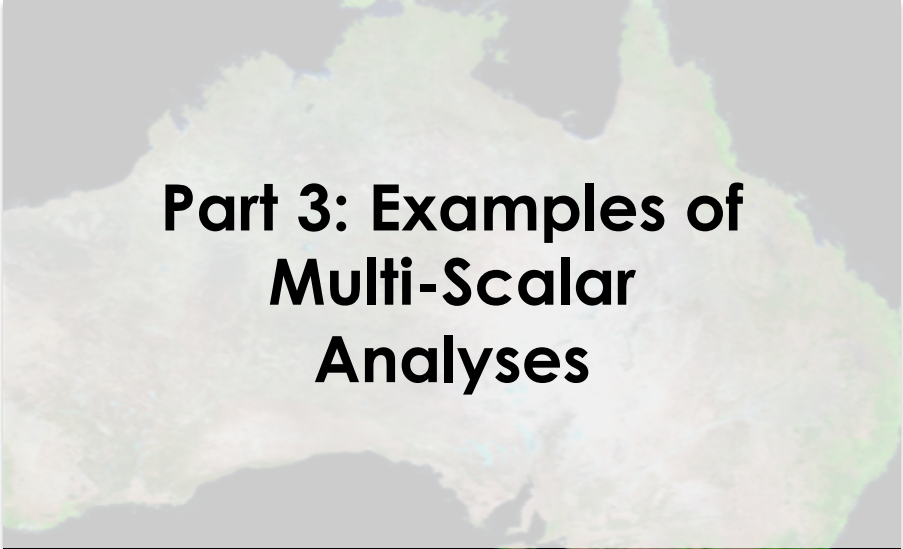
# Course Outline

A satellite-style map of South America with a semi-transparent green overlay. The text is centered on the map.

**Part 1: Overview of  
Phenology and  
Remote Sensing**

A satellite-style map of the United States with a semi-transparent green overlay. The text is centered on the map.

**Part 2: Scales of  
Phenology and  
National Networks**

A satellite-style map of Africa with a semi-transparent green overlay. The text is centered on the map.

**Part 3: Examples of  
Multi-Scalar  
Analyses**

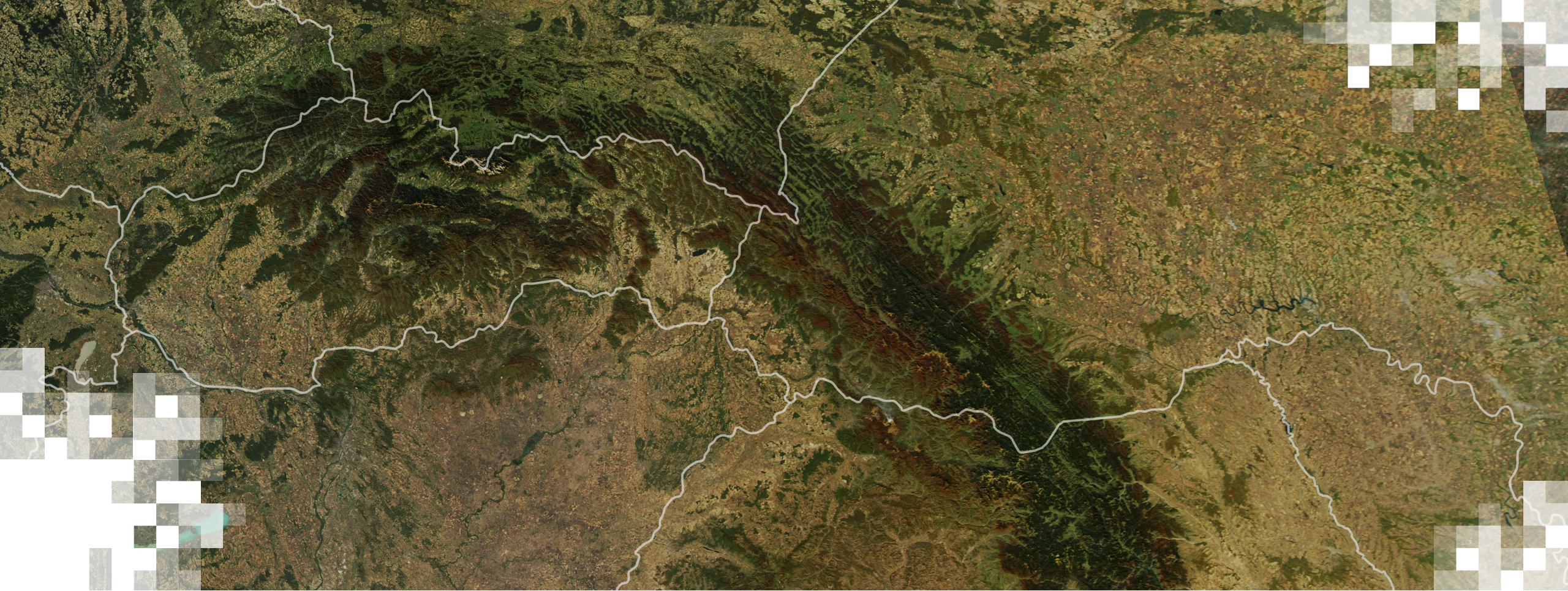


# Learning Objectives

By the end of this presentation, you will be able to:

- Recall how data can be acquired at various scales to provide a holistic understanding of phenology
- Identify the various data collecting and sharing networks such as the National Phenology Network (NPN), the National Ecological Observation Network (NEON), and the PhenoCam Network
- Access and analyze phenology data from multiple networks
- Engage in regional data collection





## Scales of Phenology

# Scales of Phenology

## Biome

A group of co-occurring plant, animal, and microbial communities that live in the same type of climate, share a well-defined geographic area, are adapted to a particular substrate and level of nutrient cycling, and exhibit a recognizable set of dominant life forms and habitats.

## Community

A group of co-occurring populations of different species, each of which interacts with some proportion of the other species.

## Population

A collection of individuals of one species inhabiting the same general area or sharing a common environment.

## Organism (Individual)

One member of a population or species that may or may not depend on other members of its population in order to survive.

*Remote sensing technologies allow for the detection of **geographically extensive** phenological patterns*

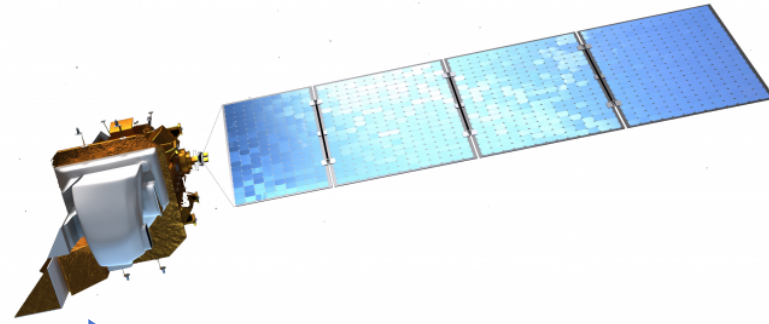
*Observational studies performed by on-the-ground phenologists provide **site intensive** documentation of phenological patterns*



Image Credit: [NPN](#)



# Connecting Land to Sky





# Connecting Land to Sky



Image Credit: [NPN](#)

## Aerial & Spaceborne Observations

- Reflectance
- Vegetation Indices
- Elevation
- Ecosystem Structure

## Ground Station Observations

- Precipitation
- Photosynthetically Active Radiation (PAR)

## Field Data Collection

- Young Needles
- Open Flowers
- Ripe Fruit
- Soil Temperature



# Connecting Land to Sky

- A multi-level validation approach that uses ground observations, dedicated web cameras, and high, medium, and coarse spatial resolution satellite data is needed to give scientists an improved level of confidence in utilizing the data.
- Many networks available for accessing and analyzing ground-based measurements.

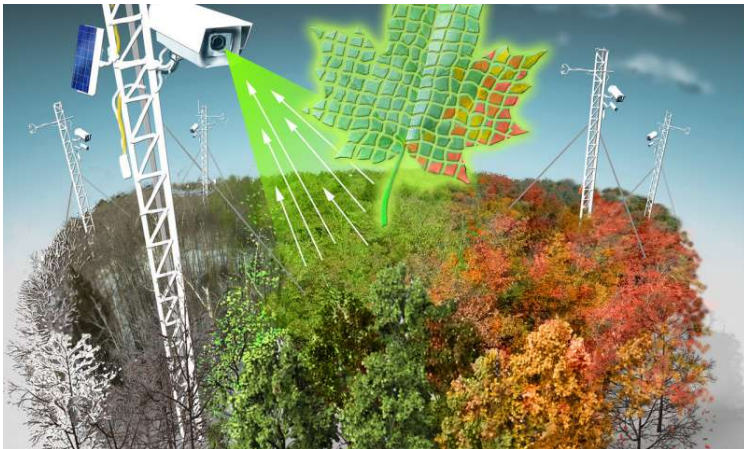


Image Credit: [Phenocam](#)

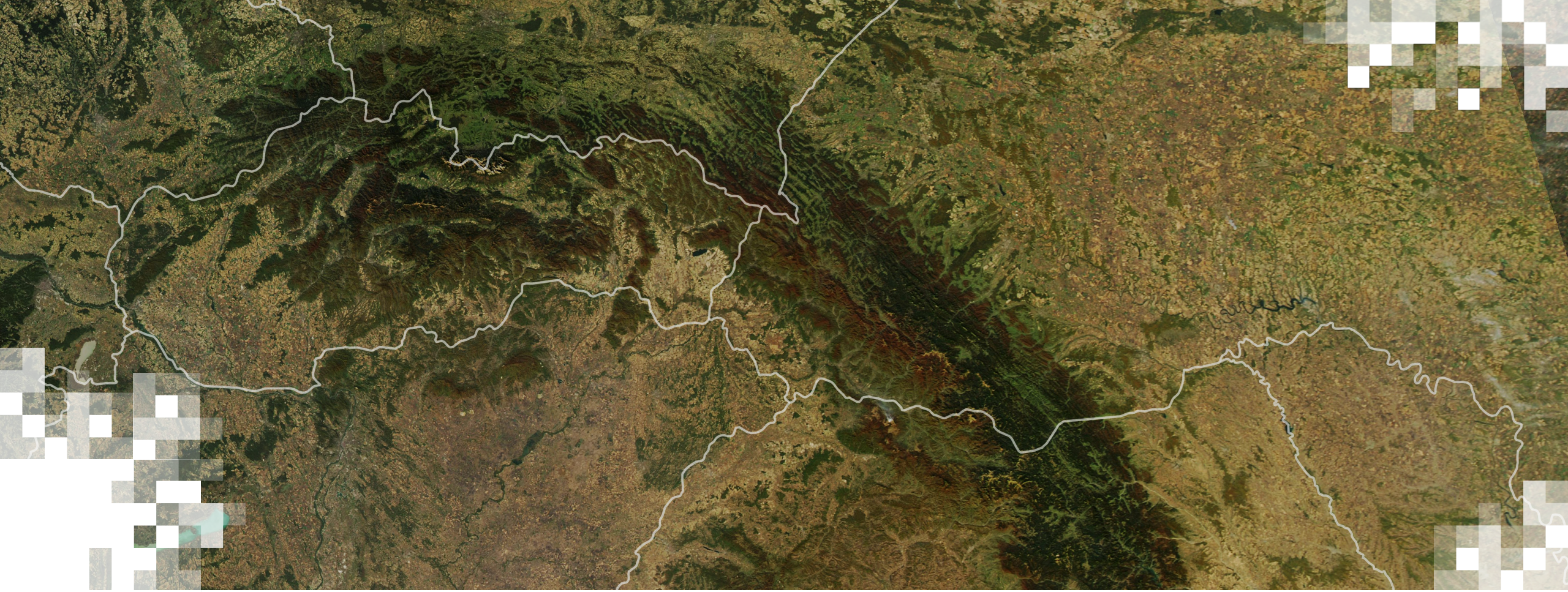


Image Credit: [NPN](#)



Image Credit: [DataNuggets](#)



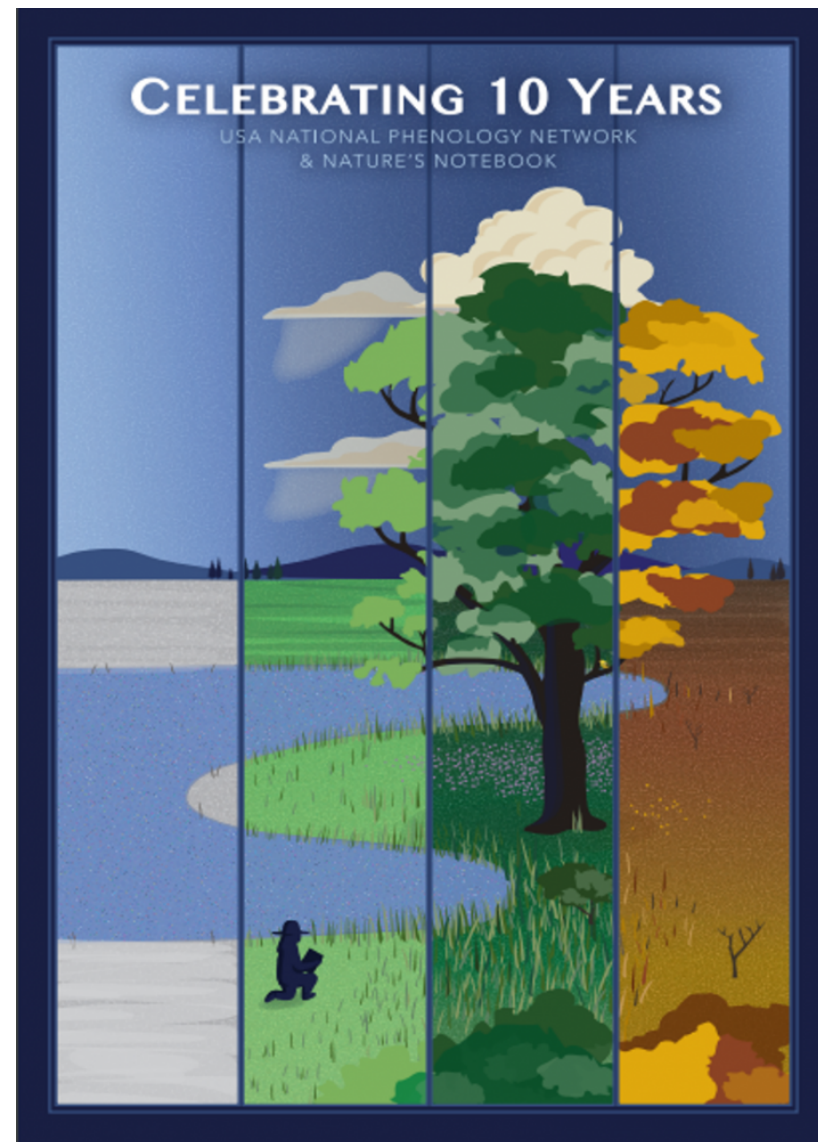


# U.S. National Phenology Network

# NPN Overview

*Collect • Store • Share  
Phenology Data and Information*

*Advance Science  
Inform Decisions  
Communicate & Connect*



# NPN Overview

## Primary Goal

- *Create a standardized dataset for use in multiple types of research.*

## Mission

- Make phenology data, models and related information available.
- Encourage people of all ages and backgrounds to observe and record phenology.

UNDERSTAND HOW SPECIES  
AND LANDSCAPES ARE  
RESPONDING TO CLIMATE  
CHANGE.

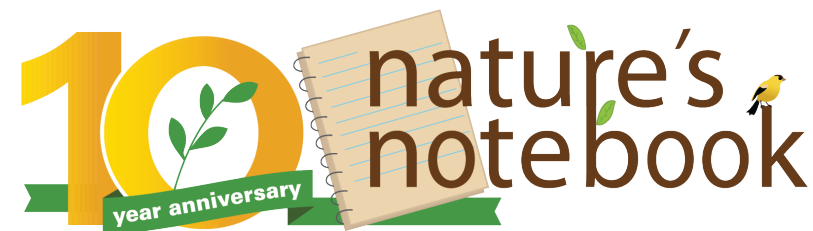


Photo Credit: C. Enquist



# Nature's Notebook

- A program designed for scientists and non-scientists to collect phenology observations for plants and animals.
- Can be used for decision making across the U.S.
- Nature's Notebook Statistics:
  - Over 13,000 active observers
  - 11,000+ active sites
  - More than 20 million records
  - Over 60 publications
  - 68 data products



TRACKING  
Seasonal **CHANGES**  
IN PLANTS AND ANIMALS

## Nature's Notebook

For scientists, naturalists,  
volunteers, land  
managers, park rangers,  
and YOU!

[nn.usanpn.org](http://nn.usanpn.org)

Nature's Notebook data locations: Image Credit: [NPN](#)



# Nature's Notebook: Phenology Records



- < 2,500
- 10,000
- 50,000
- 100,000
- 600,000

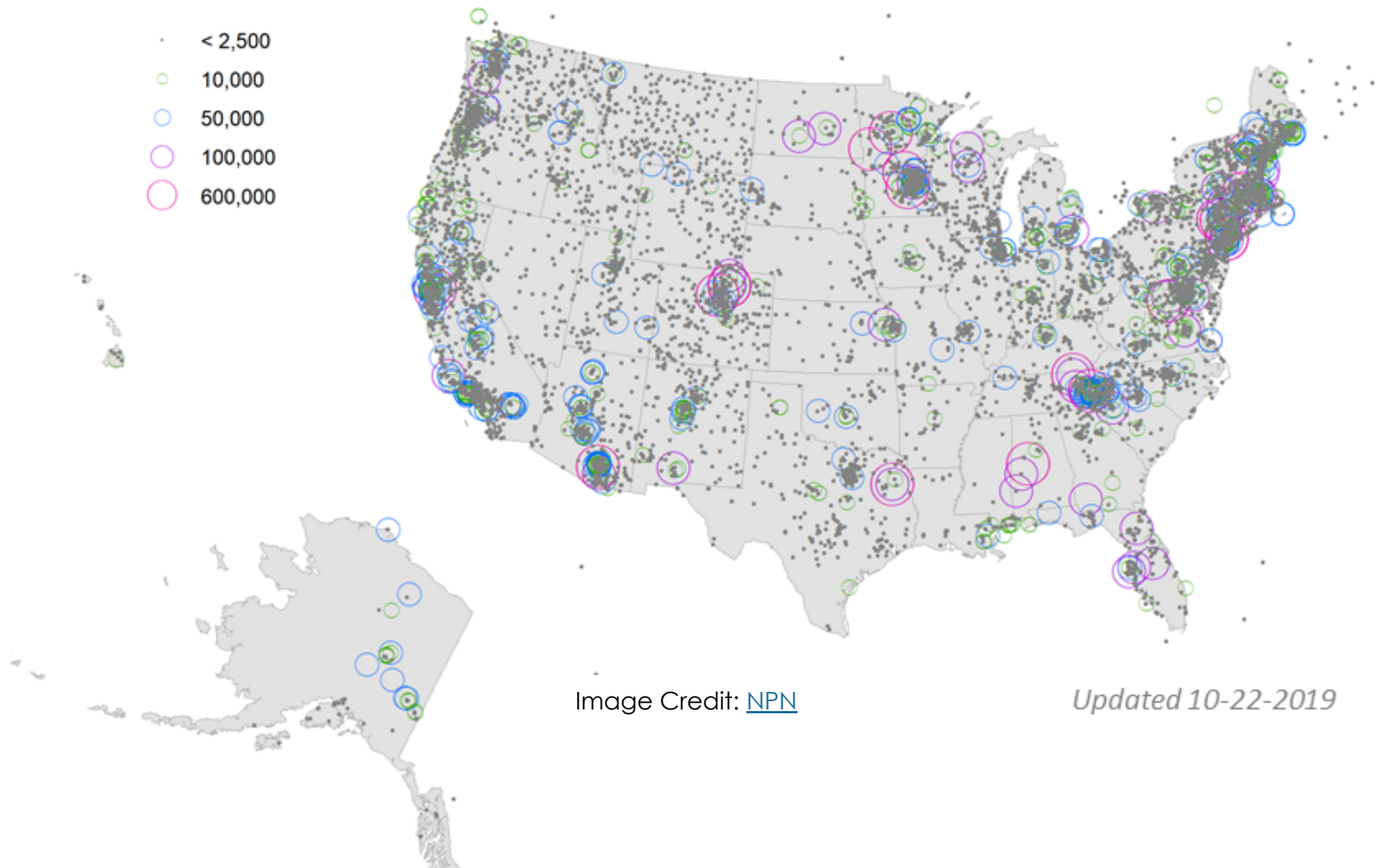


Image Credit: [NPN](#)

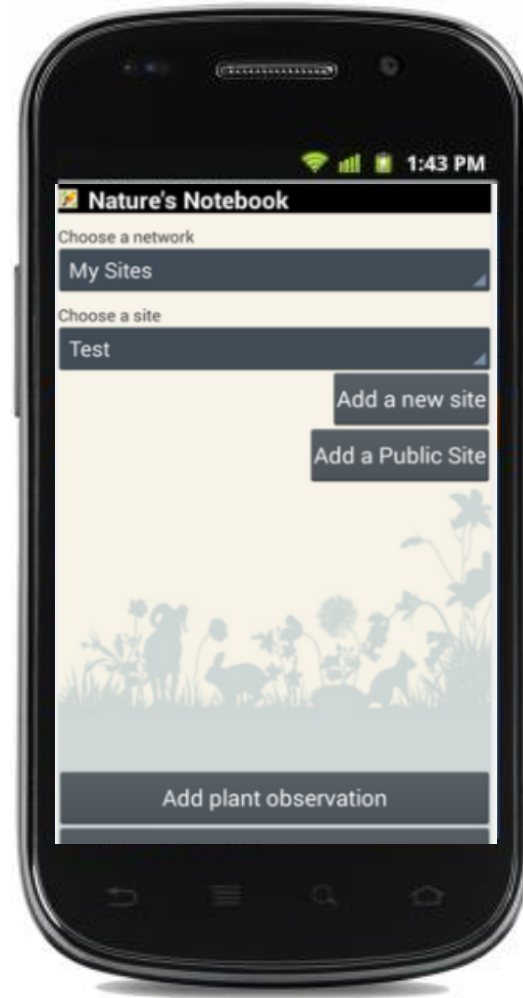
Updated 10-22-2019



# Nature's Notebook Protocols

|                                 |                           | Date:                    |
|---------------------------------|---------------------------|--------------------------|
| Do you see...                   |                           | Time:                    |
| Leaves                          | Breaking leaf buds        | y n ? _____              |
|                                 | Leaves                    | y n ? _____              |
|                                 | Increasing leaf size      | y n ? _____              |
|                                 | Colored leaves            | y n ? _____              |
|                                 | Falling leaves            | y n ? _____              |
| Flowers                         | Flowers or flower buds    | y n ? _____              |
|                                 | Open flowers              | y n ? _____              |
|                                 | Pollen release            | y n ? _____              |
| Fruits                          | Fruits                    | y n ? _____              |
|                                 | Ripe fruits               | y n ? _____              |
|                                 | Recent fruit or seed drop | y n ? _____              |
| Check when data entered online: |                           | <input type="checkbox"/> |

**Comments:**



- Long term monitoring of the same individual plants
- Importance of entering the “no” observations
- At least weekly observations - Catch the first “yes”
- If uncertain, use the “?”





# Nature's Notebook: Duration and Habitat Details

Breaking Leaf Buds

Leaves

Increasing leaf size

Colored leaves

Flowers or Flower Buds

Open Flowers



Fruits

Ripe Fruits

Recent Fruit or Seed Drop

DURATION & HABITAT DETAILS

Animal Phenophases

Deciduous Plant Phenophases



Pollinators



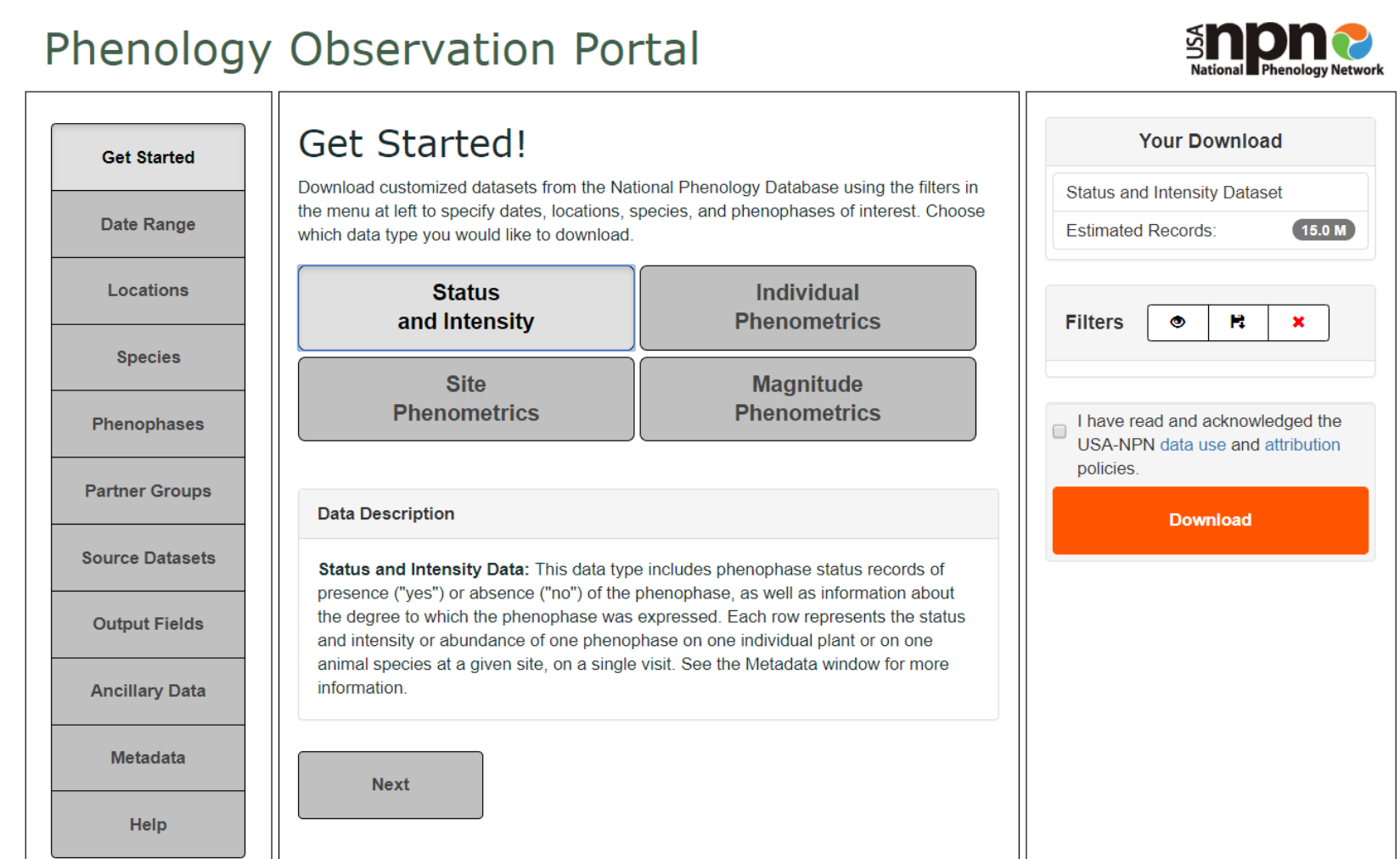
Flowers for Bats



Greenwave



# NPN Phenology Observation Portal



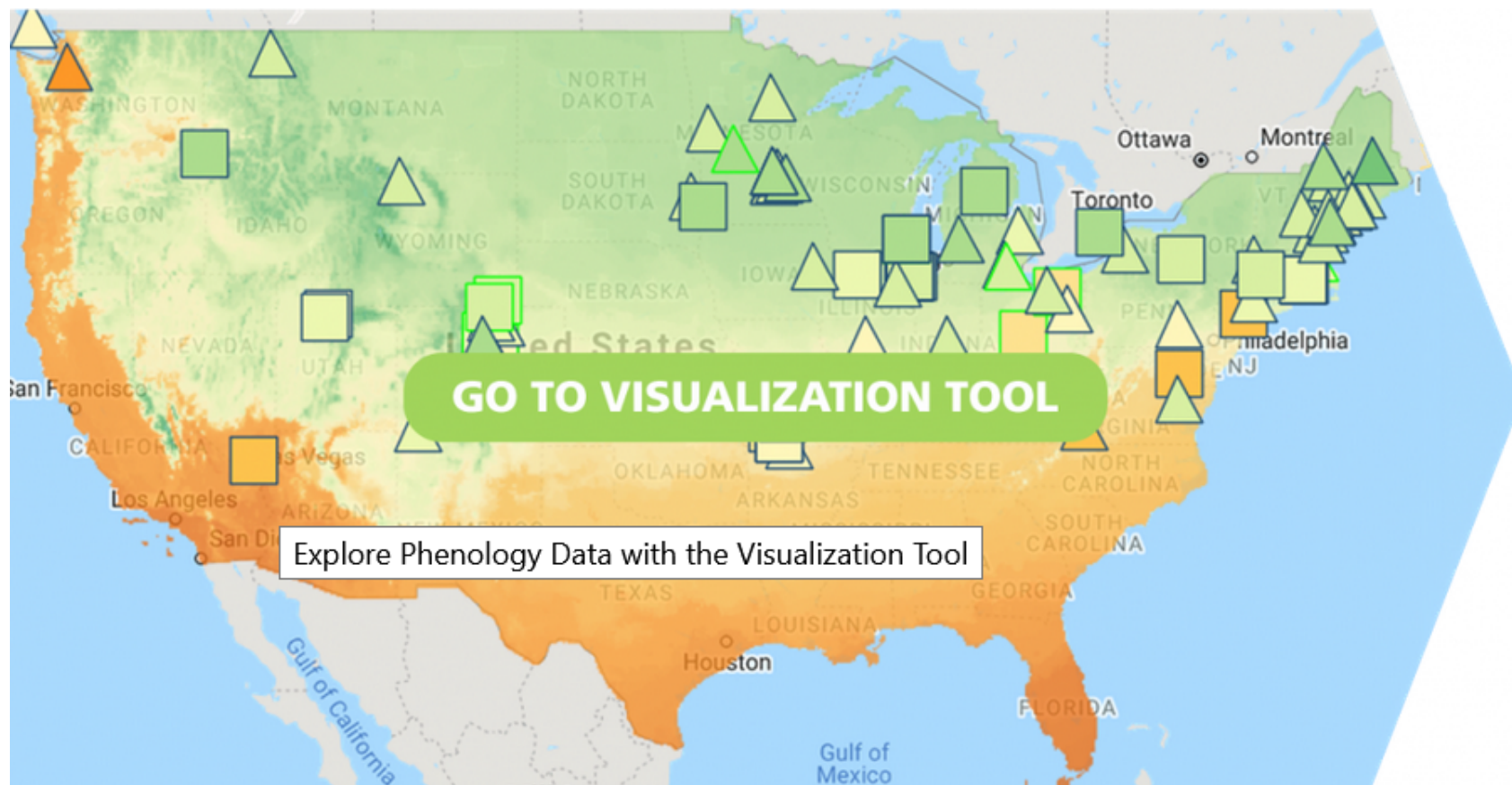
The screenshot displays the NPN Phenology Observation Portal interface. On the left is a vertical navigation menu with options: Get Started, Date Range, Locations, Species, Phenophases, Partner Groups, Source Datasets, Output Fields, Ancillary Data, Metadata, and Help. The main content area is titled "Get Started!" and includes a paragraph explaining that users can download customized datasets from the National Phenology Database using filters. Below this are four buttons for data types: Status and Intensity (highlighted with a blue border), Individual Phenometrics, Site Phenometrics, and Magnitude Phenometrics. A "Data Description" section provides details for "Status and Intensity Data". At the bottom of the main area is a "Next" button. On the right, the "Your Download" section shows the selected dataset "Status and Intensity Dataset" with an estimated record count of 15.0 M. It includes a "Filters" section with icons for visibility, refresh, and close. Below that is a checkbox for acknowledging the USA-NPN data use and attribution policies, followed by a prominent orange "Download" button. The USA NPN National Phenology Network logo is in the top right corner.

[www.usanpn.org/data/observational](http://www.usanpn.org/data/observational)



# NPN Visualization Tool

- Map
- Scatter plot
- Activity curve
- Calendar
- AGDD Time Series



<https://www.usanpn.org/data/visualizations>



# NPN Visualization Tool

**USA npn**  
National Phenology Network

## Visualization Tool

**Seasonal Stories**  
Quick access to curated visualizations

**Data Explorer**  
Select data & create visualizations

**Settings**  
Update application level settings

**How fast is it warming up this year where I live?**  
This graph shows the heat accumulated across the year at a single location, and how that compares to previous years.  
[Please provide your zip co...](#) [See visualization](#)

**Where did spring arrive early this year?**  
This map shows where spring leaf out arrived earlier or later compared to the long-term average.  
[See visualization](#)

**Are milkweed flowers available when monarchs need them?**  
This Activity Curve shows the overlap between open flowers in common milkweed plants and activity of monarch butterflies in the Midwest this year.  
[See visualization](#)

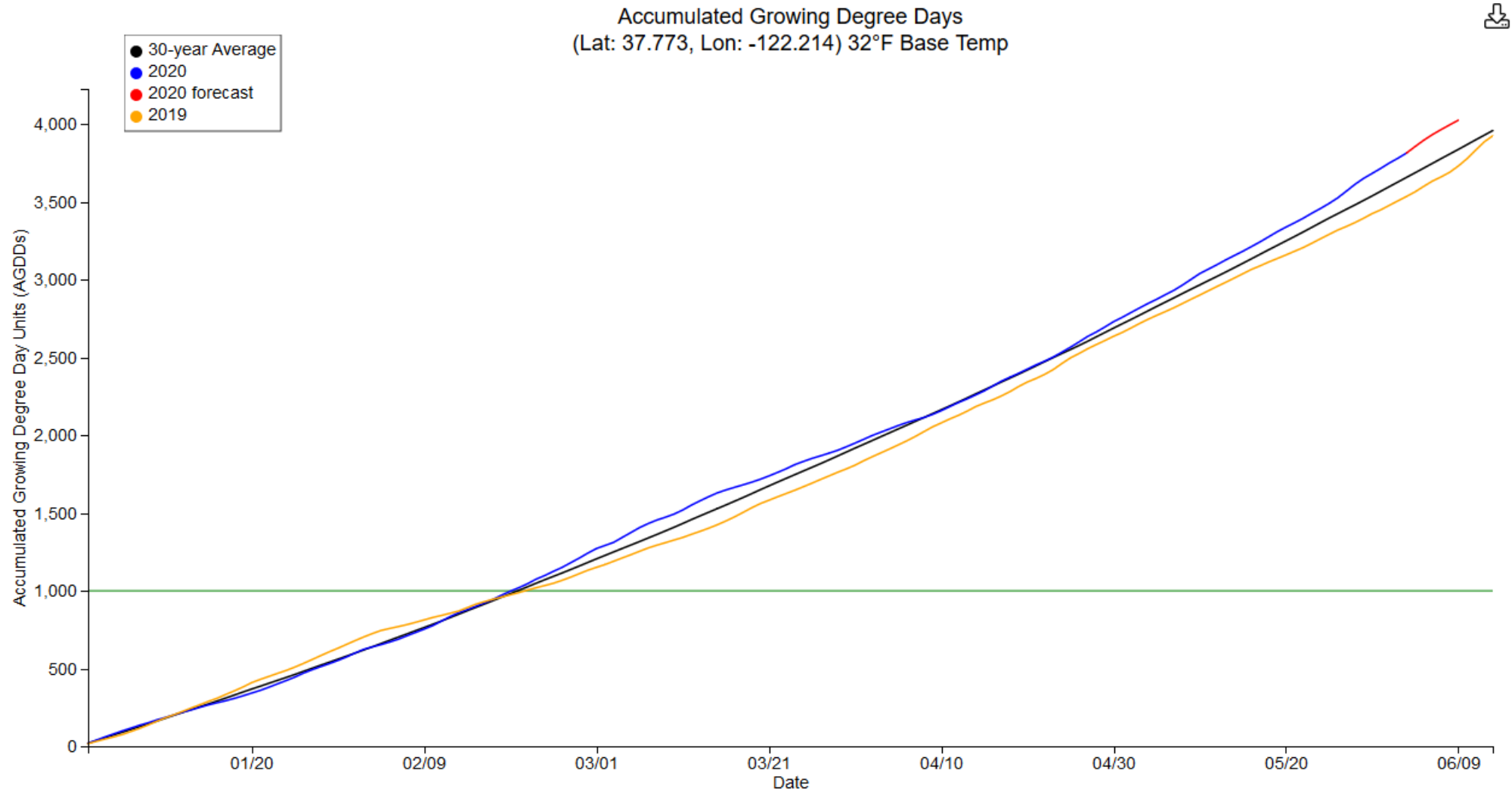
**When will flowers be available for pollinators?**  
This Phenology Calendar shows reports of open flowers from the past two years.  
[See visualization](#)

**How does winter temperature relate to leafing in the Soapberry family?**  
This scatterplot graph shows how minimum winter temperatures relate to the onset of spring leafing in the Soapberry family, which includes maples and chestnuts.  
[See visualization](#)

**Where did eastern tent caterpillars first emerge in southern states in 2019?**  
This Pheno Forecast shows when enough heat had accumulated to trigger emergence of eastern tent caterpillars.  
[See visualization](#)



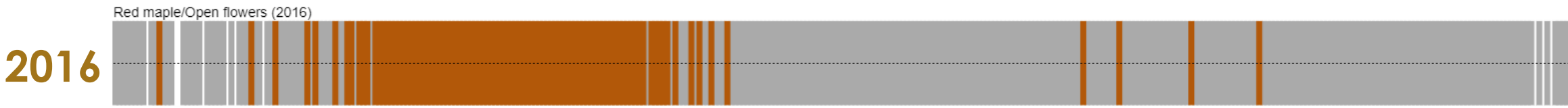
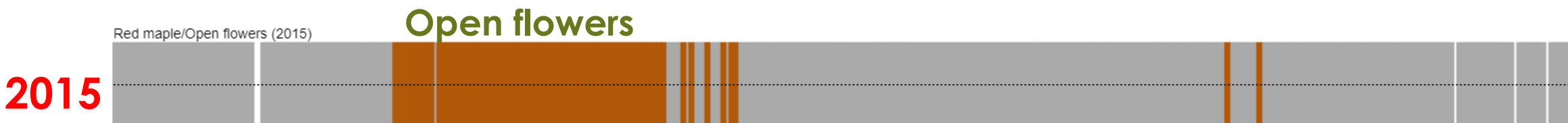
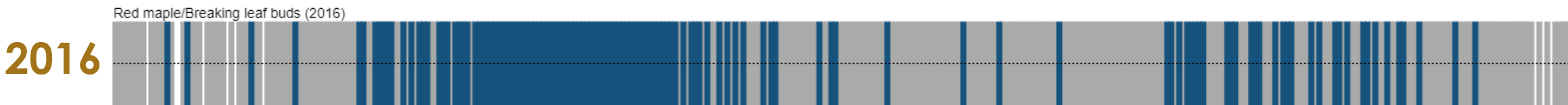
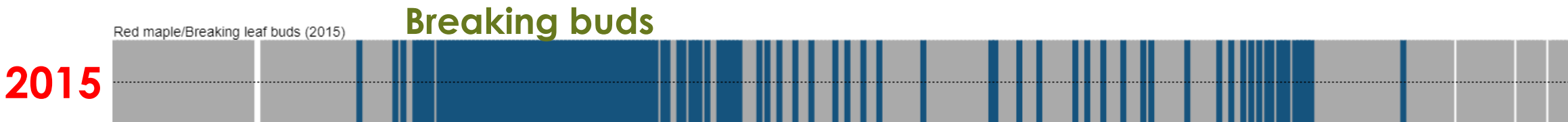
# NPN Visualization Tool: Time Series



USA National Phenology Network, [www.usanpn.org](http://www.usanpn.org)



# NPN Visualization Tool: Calendar

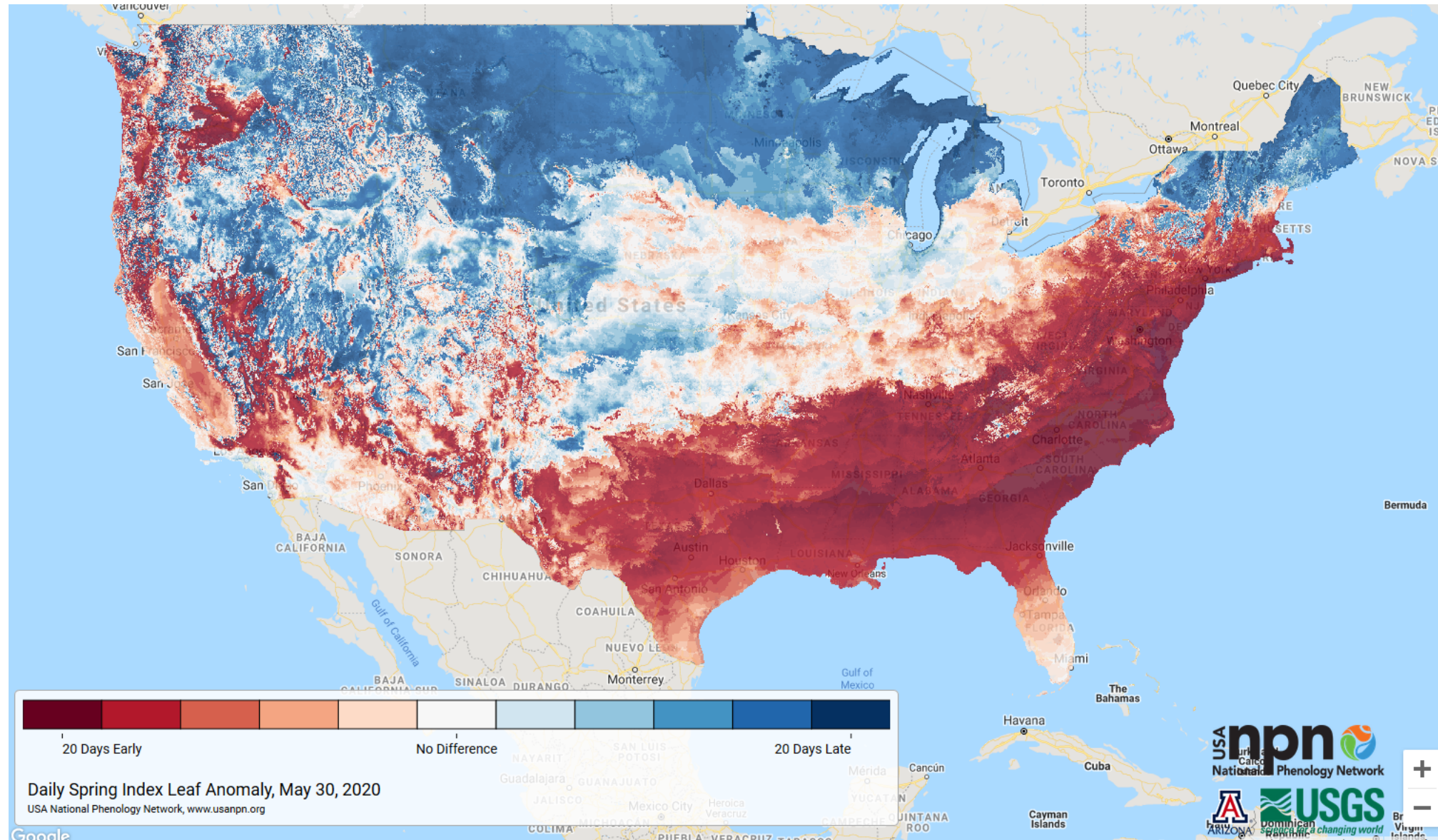


January February March April May June July August September October November December

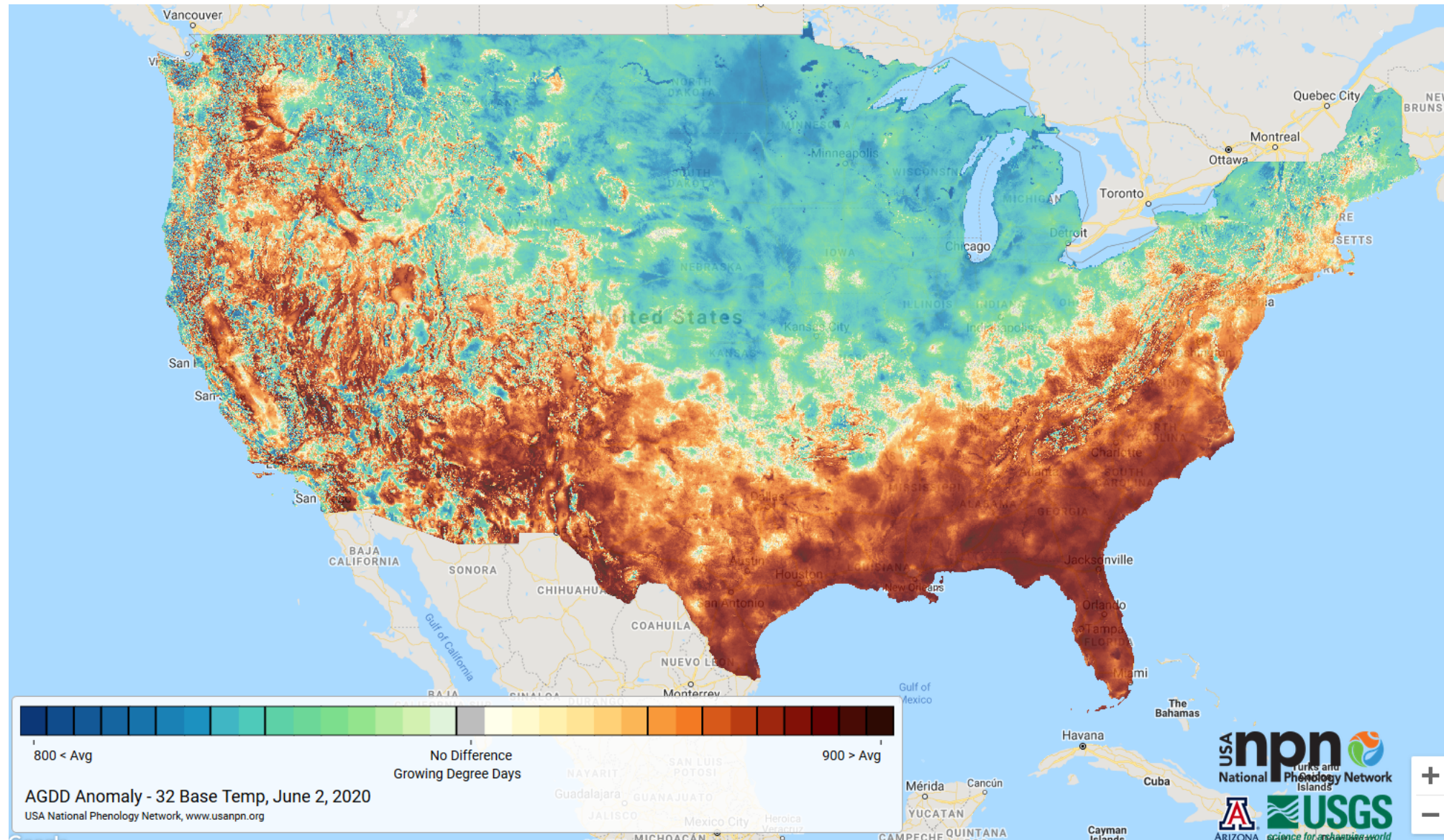
USA National Phenology Network, [www.usanpn.org](http://www.usanpn.org)



# NPN Visualization Tool: Spring Indices

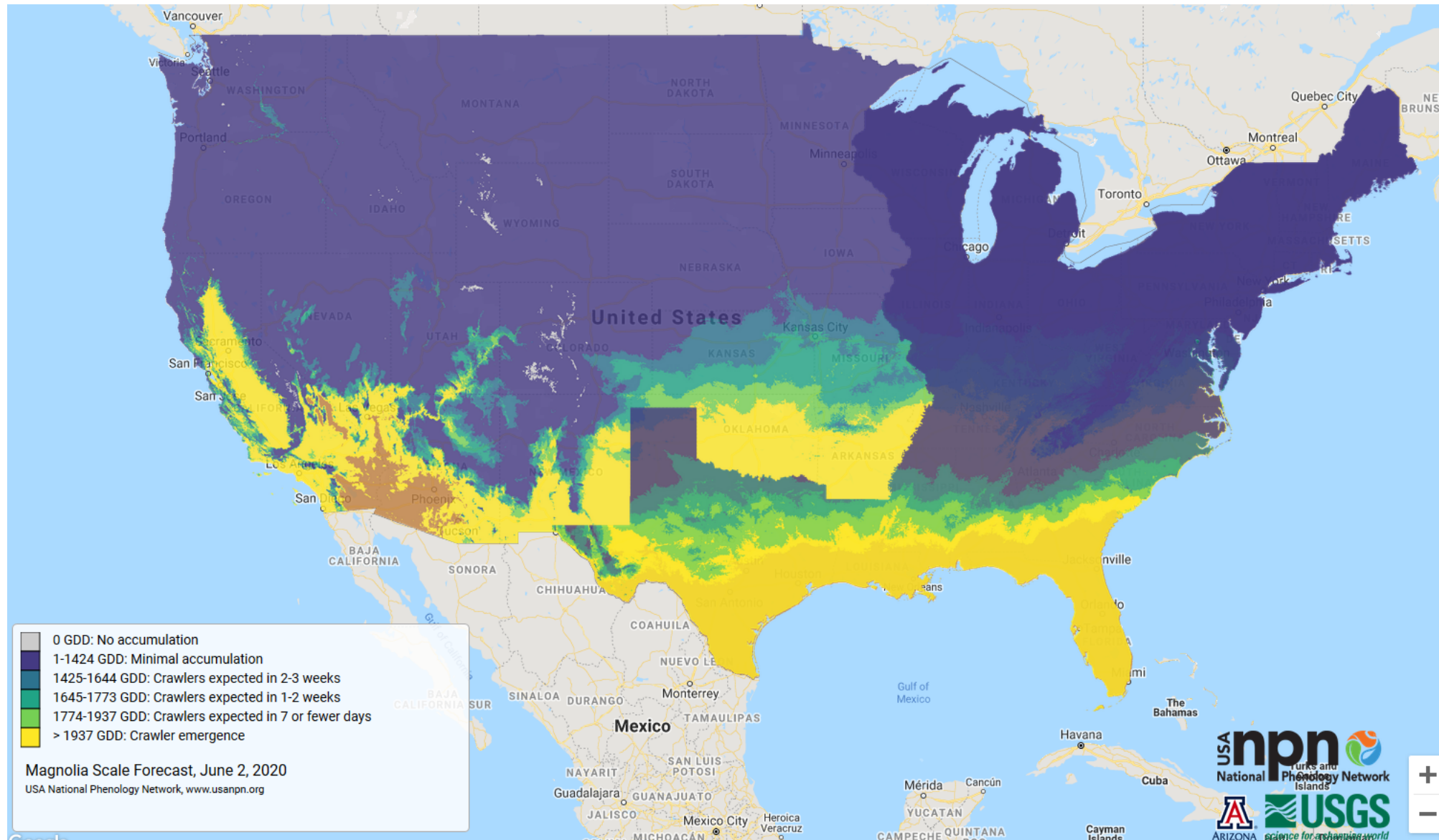


# NPN Visualization Tool: Accumulated Growing Degree Days Anomalies





# NPN Visualization Tool: Pheno Forecasts



# NPN Connections and Resources

[Viz Tool](#)  
[Webinar](#)  
[Recording](#)  
[Demonstration](#)

## Connect with USA-NPN...

- Sign up for a phenology e-newsletter
- Become an **observer**
- Discover **new tools and resources**



[www.facebook.com/USANPN](http://www.facebook.com/USANPN)

[www.pinterest.com/USANPN](http://www.pinterest.com/USANPN)



[www.twitter.com/@loriannebarnett](http://www.twitter.com/@loriannebarnett)  
[www.twitter.com/@theresacrimmins](http://www.twitter.com/@theresacrimmins)

***Nature's Notebook***  
**Support**

[support@usanpn.org](mailto:support@usanpn.org)



# Indigenous Phenology Network

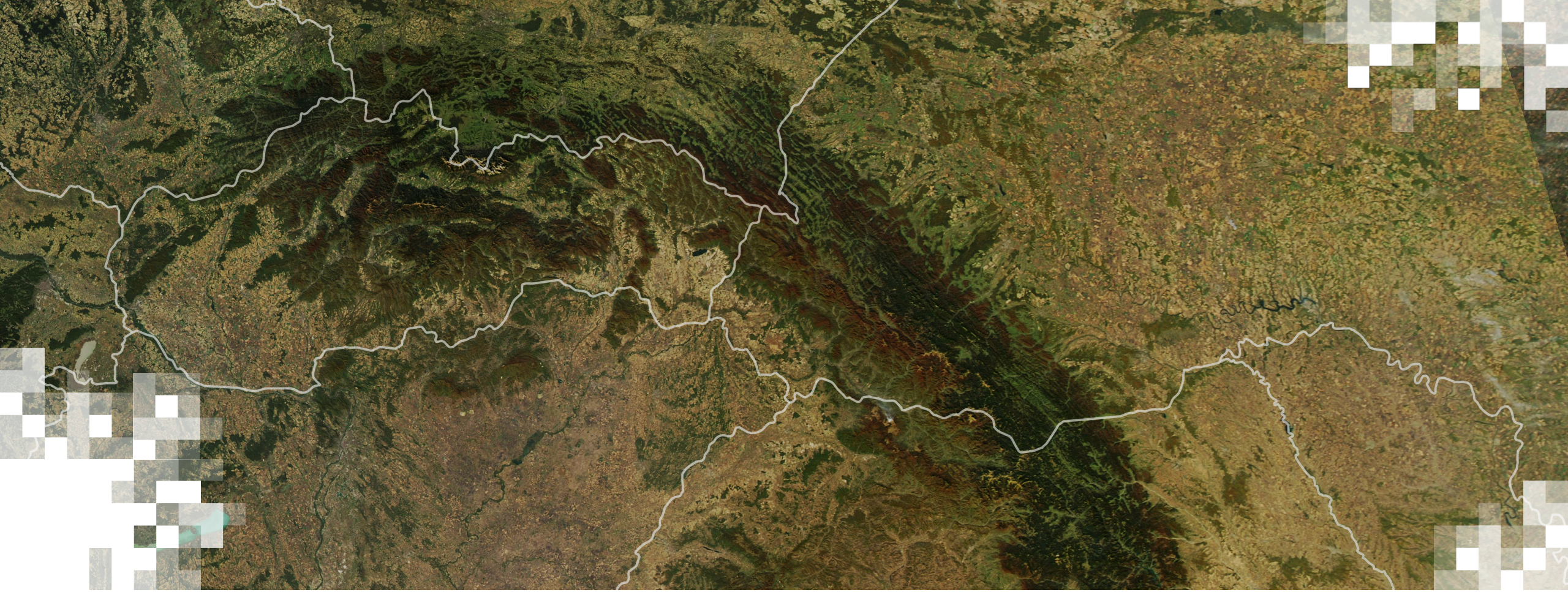
- Grassroots organization whose participants are interested in understanding phenology on lands and species of importance to native people.
- Relational Doctrine (a few points)
  - Everything in the natural world is family, with inherent rights.
  - Our ancestors teach compassion, humility, and give-more-than-take in relationship with nature.
  - Connection to the natural world is essential to individual and social well being.
  - Learning about the natural world takes place both through individual and intergenerational experience.

**Get connected!  
To join contact  
Brian Miller:  
[bwmiller@usgs.org](mailto:bwmiller@usgs.org)**



Image  
Credit:  
[IPN](#)





# National Ecological Observatory Network (NEON)

# National Ecological Observatory Network (NEON)

- A continental-scale observation facility operated by Battelle and designed to collect long-term open access ecological data to better understand how U.S. ecosystems are changing.
- NEON collects environmental data and archival samples that characterize plant, animals, soil, nutrients, freshwater, and atmosphere from [81 field sites](#), strategically located in [terrestrial](#) and [freshwater](#) ecosystems across the U.S.



A tower studded with sensors keeps watch at a NEON core terrestrial site near Front Royal, Virginia. Image Credit [Science/Trevor Frost](#)



# NEON Data Collection

- Collection methods are standardized across field sites to provide high quality datasets from [in situ automated instrument measurements](#), [observational sampling](#), and [airborne remote sensing surveys](#).
- Over 175 open-access data products are available on the [NEON data portal](#).
- NEON also provides a variety of open-access [data tutorials](#), [code packages](#), and other resources to enable the use of NEON data.
- NEON also archives over 100,000 biological, genomic, and geological samples each year, which are available upon request from the [NEON Biorepository](#).



Various data collection sites. Image Credit: [NEON](#)



# NEON Sites

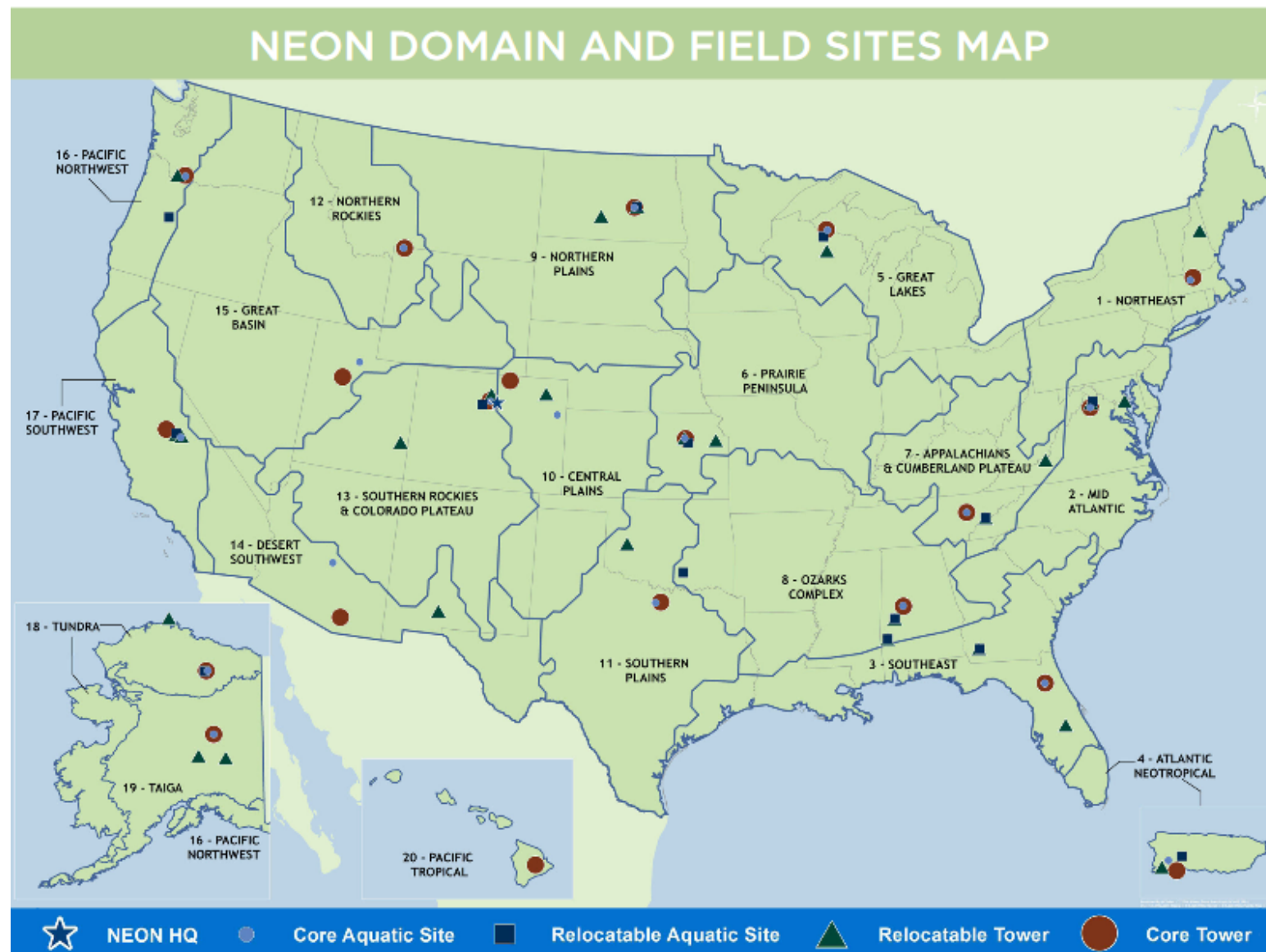


Image Credit: [NEON](#)



# NEON Data

- Digital Data:
  - Sensor Data
  - Organismal Sampling
  - Remote Sensing
  - Acquisition and Sampling Protocols
- Physical and Biological Specimens
  - Soils Currently Available
  - Other biological specimens in the future pertaining to: Atmosphere, Biogeochemistry, Ecohydrology, etc.



NEON provides large amounts of freely available resources for research, including data and specimens.  
Credit: [Sandra Chung, NEON, Inc.](#)



Soil samples taken for the Clean Air Status and Trends Network (CASTNET).  
Credit: [Josh Roberti, NEON, Inc.](#)





# NEON Data Types: Automated

- Automated Instruments
- Continuous collection of:
  - Meteorological: Fluxes of Carbon, Water, Energy
  - Soil: Physical Properties, Soil Heat Flux
  - Phenological: Phenocam
  - Surface Water: Precipitation
  - Ground Water Data



Examples of automated instruments in the NEON Network:  
Image Credit: [NEON](#)



# NEON Data Types: Observational

- Collection of terrestrial and aquatic data where possible
- Focus on sentinel taxa: sensitive organisms that indicate the health of an ecosystem
- Phenology:
  - Phenology observations
  - Plant presence and cover
  - Woody plant vegetation structure
  - Aquatic plants and microalgae, etc.

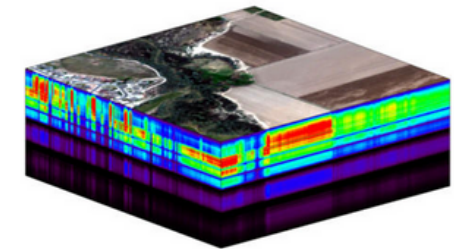
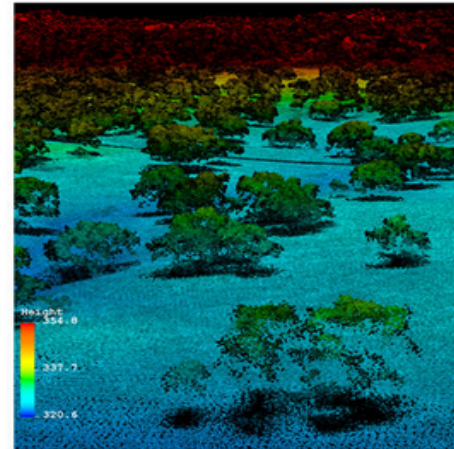


Examples of observational data types in the NEON network: Image  
Credit: [NEON](#)



# NEON Airborne Remote Sensing

- Conducted over NEON field sites during peak greenness to collect quantitative information of each field site on land cover and changes to ecological structure and chemistry, including the presence and effects of invasive species across landscapes.
- Lidar Data and Hyperspectral Data



From Left to Right: Airborne Observation Platform (AOP), landscape for data collection, point cloud from the lidar system, Hyperspectral cube from the spectrometer. Image Credit: [NEON](#)



# NEON Data Portal

NEON SCIENCE DATA PORTAL BIOREPOSITORY

NSF | neon Operated by Battelle

ABOUT DOWNLOAD DATA RESOURCES CONTACT US

SIGN IN

## Welcome to the NEON Data Portal

Get Started... Search data products by keywords, locations, states, years, etc...

The National Ecological Observatory Network provides **open data** to understand changing ecosystems.

### Explore Data Products

Search and filter the catalog of all available and pending data.

EXPLORE

### Data Quality

NEON takes pride in delivering high-quality data and documentation.

LEARN MORE

### Working with NEON Data

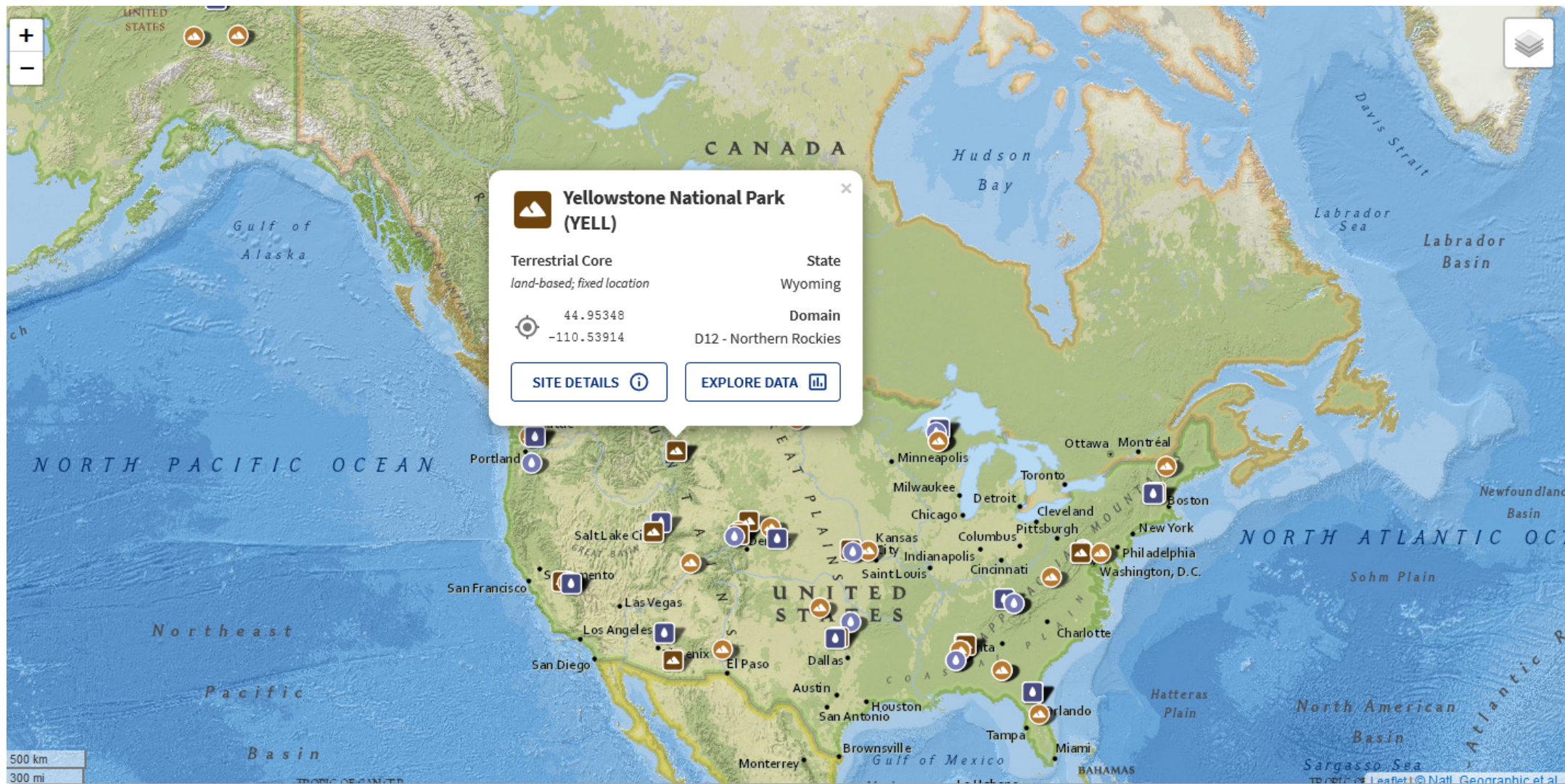
NEON provides open source utilities and tutorials to expedite analysis.

GET STARTED

<https://data.neonscience.org/>



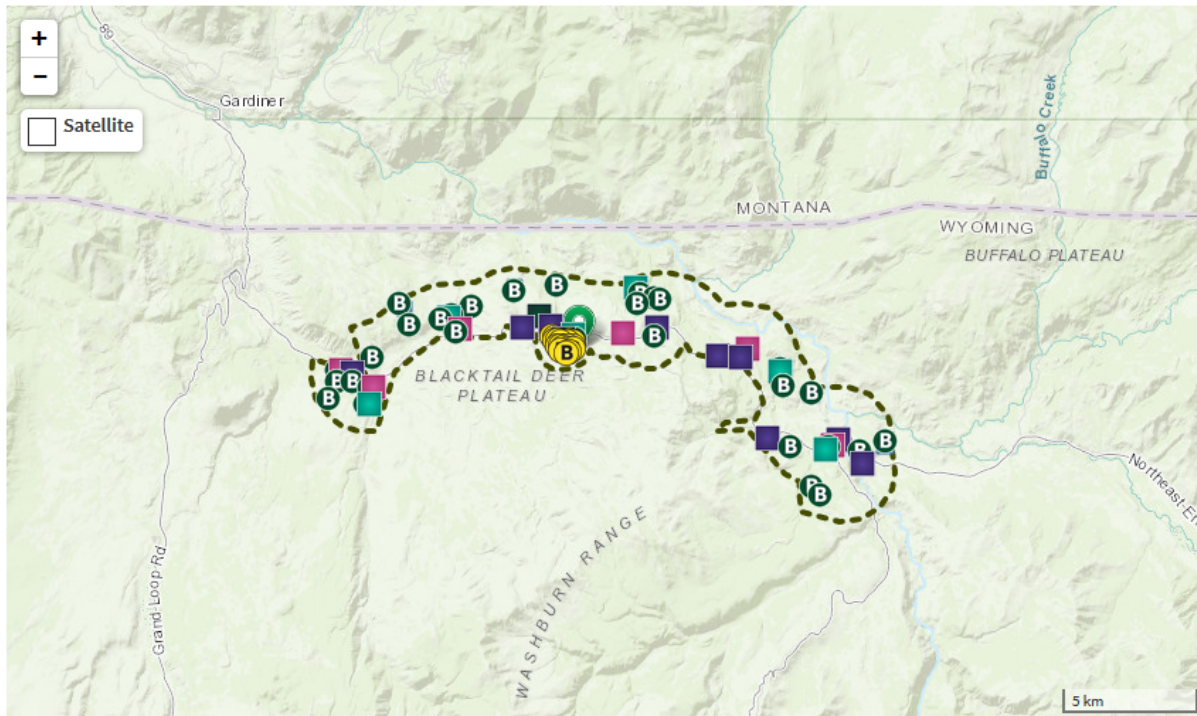
# NEON Data Portal



# NEON Data Portal

## Yellowstone Northern Range (Frog Rock) - YELL

Core Terrestrial | Wyoming | D12: Northern Rockies



Leaflet | Tiles © Esri World Topo Map— Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, ...

NEON Site Details. Image Credit: [NEON](#)

### Site Characteristics

|   |  |
|---|--|
| Latitude/Longitude:<br>44.95348, -110.53914 | <b>Dominant NLCD Classes:</b><br>Evergreen Forest<br>Grassland/Herbaceous<br>Shrub/Scrub |
| Elevation: 2116 m                           |  |
| Mean Annual Temperature: 0C/32F             |  |
| Mean Annual Precipitation: 509 mm           |  |

### Map Legend

Click the check boxes to filter results on

- NEON Sampling Boundary
- Tower Airshed Boundary
- Tower Location

### Distributed Plot Types

- Distributed Base Plot
- Distributed Bird Grid
- Distributed Mammal Grid
- Distributed Mosquito Plot
- Distributed Tick Plot

### Tower Plot Types

- Tower Base Plot
- Tower Phenology Plot

[BROWSE DATA](#)

Research Conducted under Yellowstone Research Permit-YELL-2018-SCI-5870



# NEON Data Portal

## Explore Data Products

### All Products

☰ 181 products from 81 sites 📅 Data available Jan 2000 – Jun 2020

📄 DOWNLOAD FULL CATALOG CSV JSON PDF

### Filtered Products

☰ 37 products from 57 sites 📅 Data available Jun 2012 – Jun 2020

📄 DOWNLOAD FILTERED CATALOG CSV JSON PDF

#### Filter

✕ RESET ALL FILTERS

#### Search

Utah, "snow depth", 2019, etc...

Use several terms to match products having *any* term (*term OR term*). Quote terms to match phrases (e.g. "wind speed"). [Browse keywords](#) for ideas.

#### Available Dates

✕ RESET

Show products that have any data available between two dates.



#### Sort

by Product Name ▾



"Available" data products will always show above "Coming Soon" data products, except when sorting by search relevance.

Showing first 10 of 37 filtered products

#### Albedo - spectrometer - flightline

DOWNLOAD DATA 📄

PRODUCT DETAILS ⓘ

Total amount of solar radiation in the 0.4 to 2.5 micron band reflected by the Earth surface into an upward hemisphere divided by the total amount incident from this hemisphere; data are provided by flightline

Product ID  
DP2.30011.001

Available Dates  
2013-06 through 2019-09

Data Themes



Key: ■ Available ■ No data

View By: SUMMARY SITE STATE DOMAIN



# NEON Data Portal

## fPAR - spectrometer - mosaic

The fraction of incident photosynthetically active radiation (400-700 nm) absorbed by the green elements of a vegetation canopy; mosaiced from the fPAR level 2 product onto a spatially uniform grid at 1 m spatial resolution and provided as 1 km by 1 km tiles.

DOWNLOAD DATA 

PRODUCT DETAILS 

Product ID



DP3.30014.001

Available Dates

2013-06 through 2019-09

Data Themes



Key:  Available  No data

View By:

SUMMARY

SITE

STATE

DOMAIN



Image Credit: [NEON](#)





# NEON Data Portal

## Phenology images

RGB and IR images of the plant canopy taken from an automated camera on the tower top. Images are collected every 15 minutes and closely follow protocols of the Phenocam Network.

DOWNLOAD DATA 

PRODUCT DETAILS 

Product ID



DP1.00033.001

Available Dates

2016-01 through 2020-06

Data Themes



Key:  Available  No data

View By:

SUMMARY

SITE

STATE

DOMAIN



Image Credit: [NEON](#)



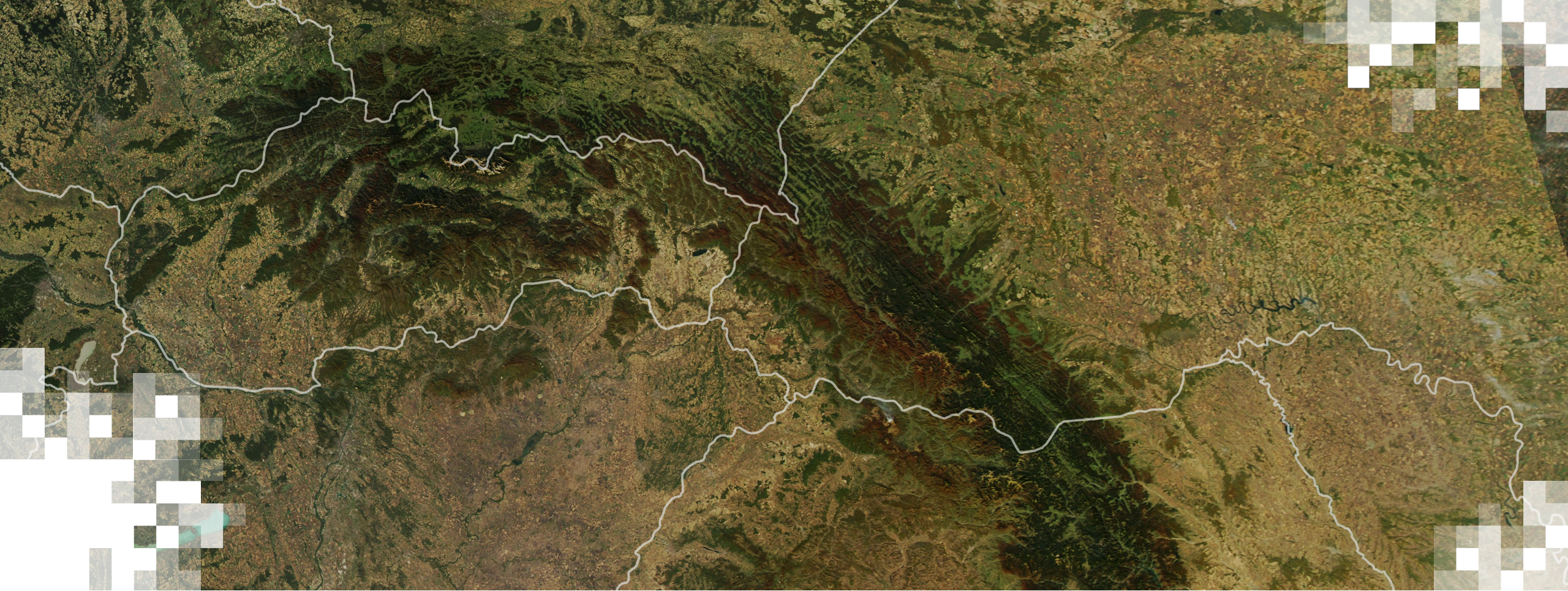
# NEON Resources

- Data Tutorials:
  - Self-paced tutorials are designed for you to use as:
    - Standalone help on a single topic
    - As a series to learn new techniques (R and Python code for analysis)
- Teaching Modules
- Workshops
- Science Videos
- Researcher information
- Communication resources



<https://www.neonscience.org/resources>





PhenoCam

# PhenoCam

- A cooperative, continental-scale, phenological observatory that uses imagery from networked digital cameras to track vegetation phenology in a diverse range of ecosystems across North America and around the World.
- Near surface remote sensing



<https://phenocam.sr.unh.edu/webcam/>



Cornell University.



# The PhenoCam Network

## Important Science Questions:

- How do photoperiod, temperature, and precipitation govern phenological transitions in different vegetation types?
- How will phenology respond to climate change, and what are the associated uncertainties?
- How will these phenological shifts impact ecosystem processes and climate system feedbacks in relation to carbon and water?



# PhenoCam: How It Works

- A bridge between satellite remote sensing data and direct field measurements
- Automated imagery via consumer-grade camera overlooking vegetation of interest
- Time lapse of images to identify patterns and shifts in vegetation
  - Most daily repeat times
- Generally RGB; some with near infrared data too

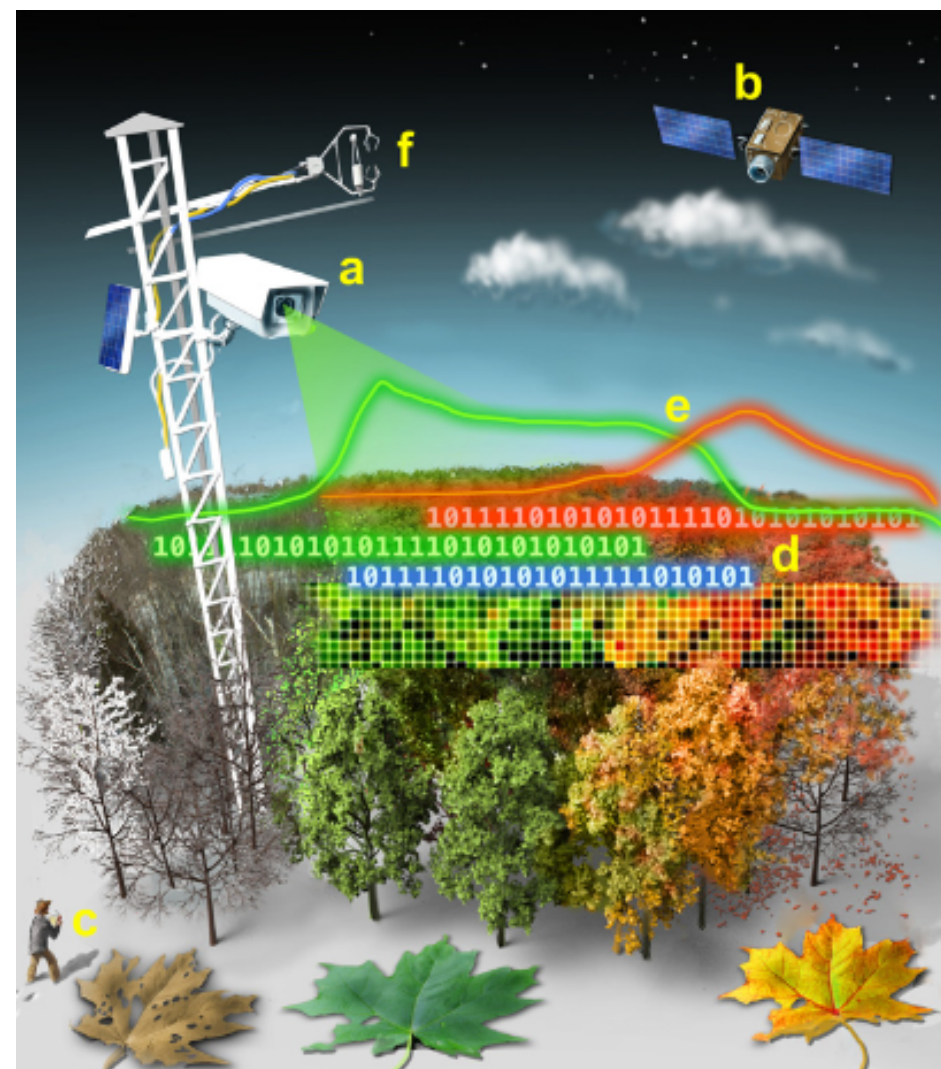


Image Elements: (a) Tower-mounted PhenoCam; (b) satellite sensor; (c) human observer; (d) RGB data; (e) seasonal variation in vegetation indices; (f) eddy covariance instrument. Image Credit: [Richardson, 2018](#)



# PhenoCam Data Access: Search

- Free to sign up: <https://phenocam.sr.unh.edu/webcam/>
- Registration required
- Search data via map or using site filters

Site name:  Site Type:  Primary Vegetation Type:  Dominant Species:  Currently Active:  Flux Data:

Group:

Selected Camera Sites : (49)



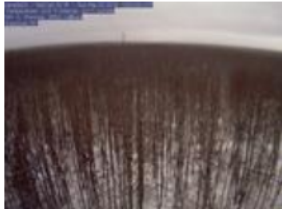



|  |  |   |  |   |  |
|--|--|---|--|---|--|
| <br>alligatorriver<br>IR   X   EC   I | <br>bartlettir<br>IR   X   EC   I | <br>canadaOA<br>IR   X   EC   I | <br>dukehw<br>IR   X   EC   I | <br>freemanwood<br>IR   X   EC   I | <br>harvard<br>X   EC   I |
|--|--|---|--|---|--|

Image Credit: [PhenoCam](https://phenocam.sr.unh.edu/)



# PhenoCam Data Access: Map

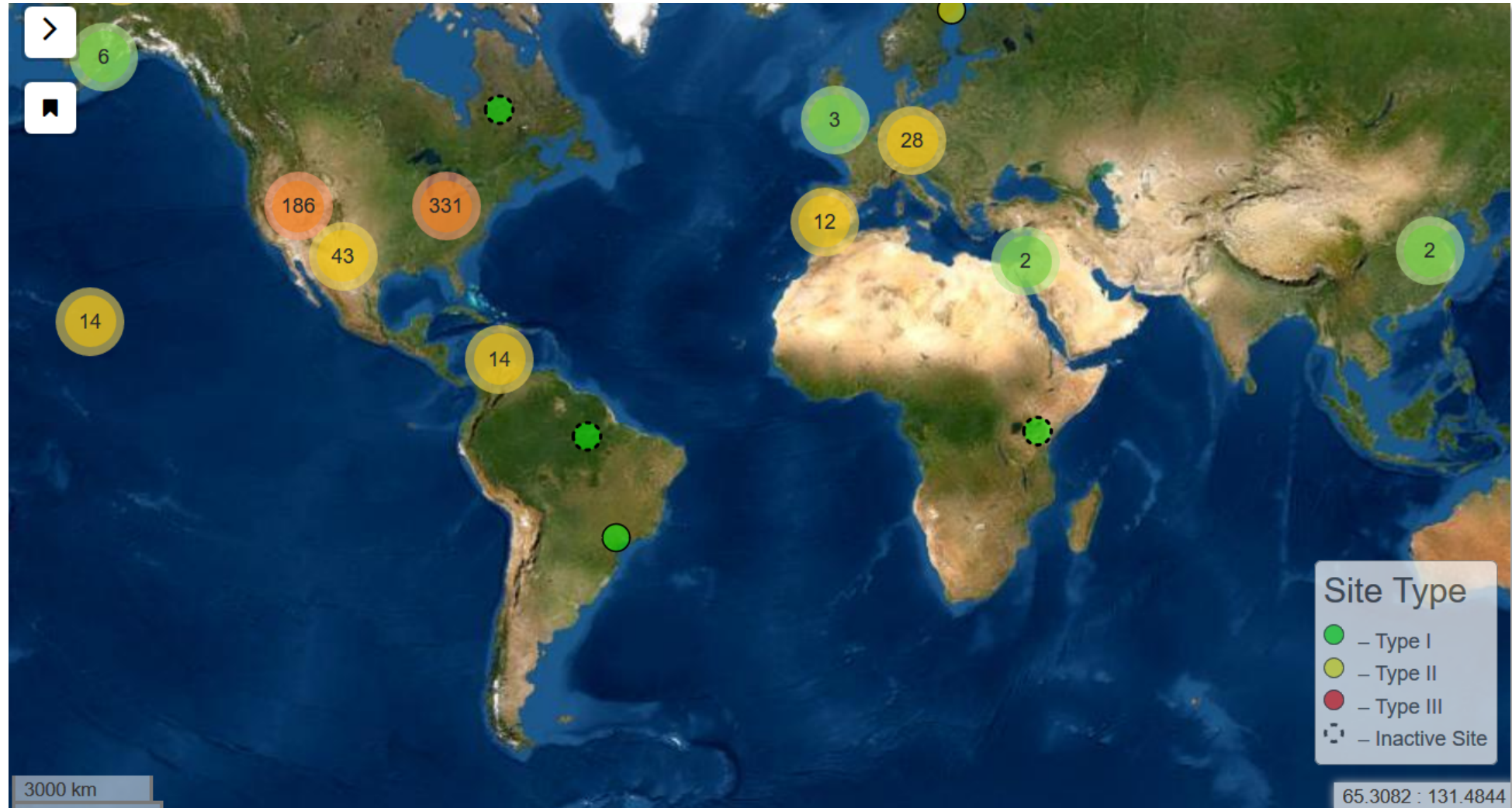


Image Credit: [PhenoCam](https://phenocam.com)





# PhenoCam Data Access: Map

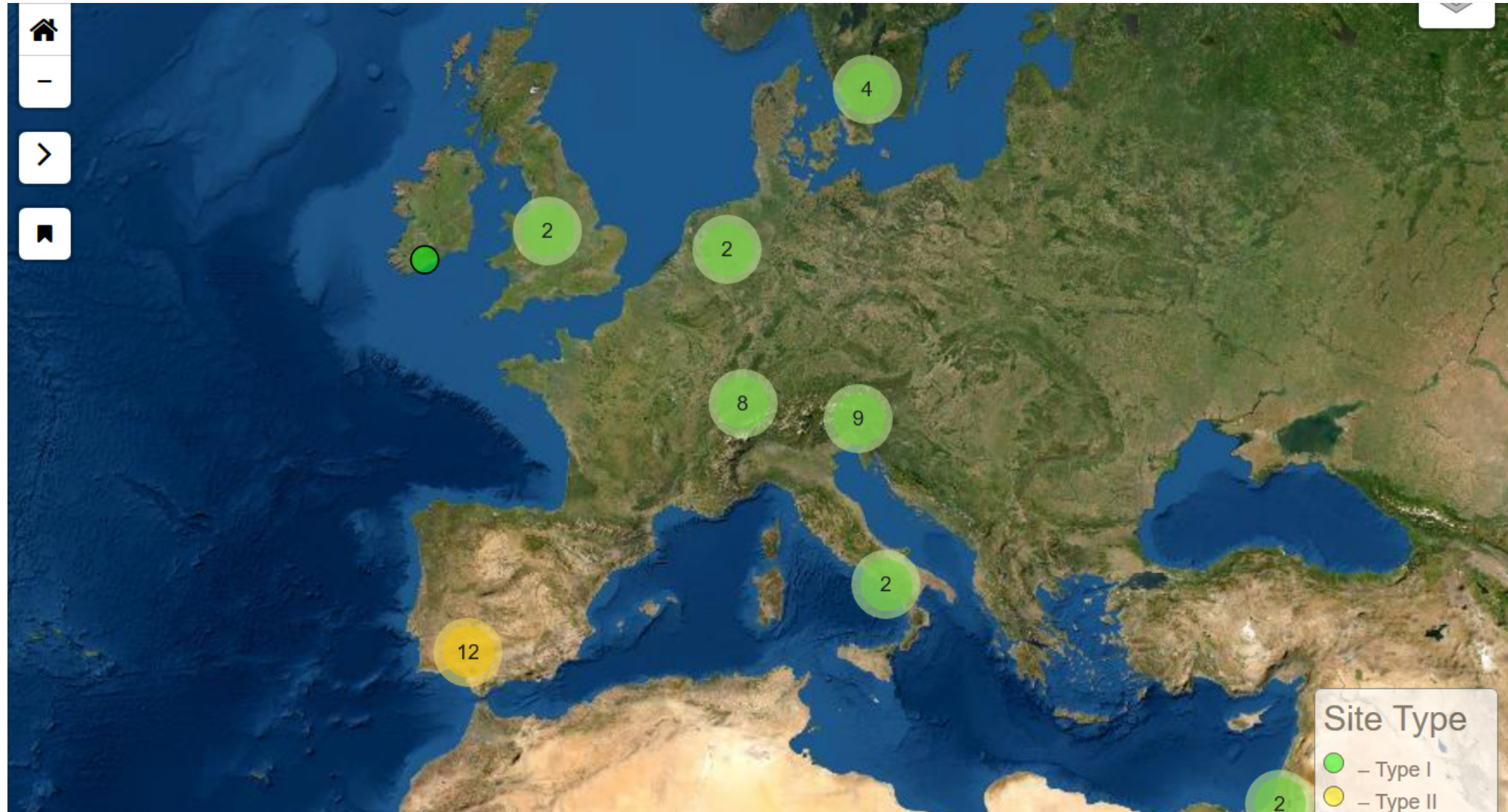


Image Credit: [PhenoCam](#)



# PhenoCam Data Access: Map

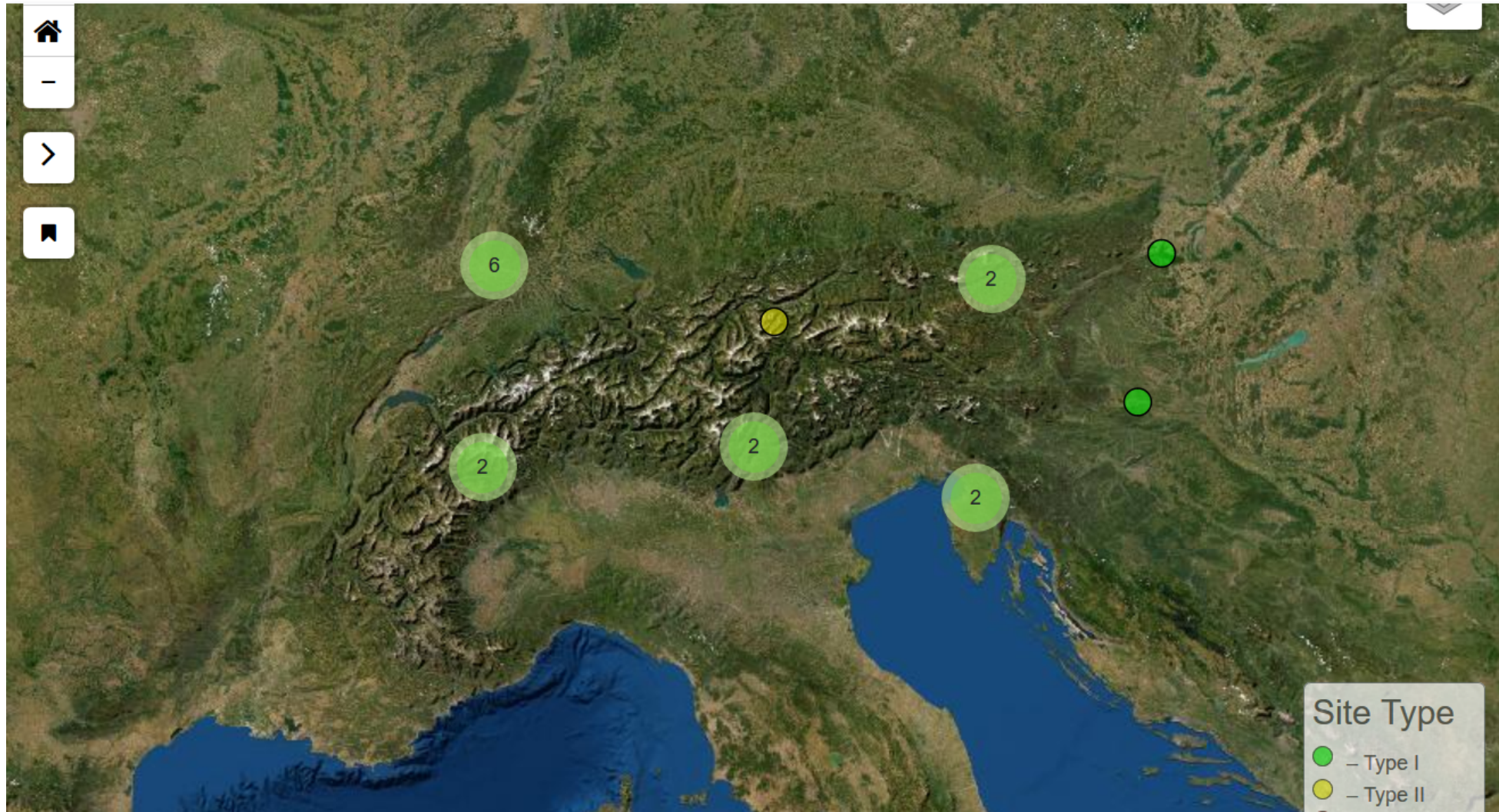



Image Credit: [PhenoCam](#)



# PhenoCam Data Access: Map

The screenshot displays a satellite map interface. On the left side, there is a vertical toolbar with icons for home, zoom out, navigation, and bookmark. A central popup window provides details for a specific site:

- montebondonegrass**
- Monte Bondone grassland FLUXNET site, Monte Bondone, Italy
- 
- Lat: 46.0147
- Lon: 11.0458
- Elev: 1550
- Start Date: 2015-04-30
- End Date: 2020-05-31
- Status: active
- Images: 66371

In the bottom right corner, a legend titled "Site Type" shows a green circle for "Type I" and a yellow circle for "Type II". A green pin is visible on the map, corresponding to the site location.

Image Credit: [PhenoCam](#)



# PhenoCam Site Data

Lat: 46.0147 Lon: 11.0458 Elev(m): 1550

Image Count: 66371 Start Date: 2015-04-30 Last Date: 2020-05-31

Data Releases: [Data Release v2.0](#)

Ancillary Data: [ORNL MODIS/VIIRS Subset Tool](#)

## Site Metadata

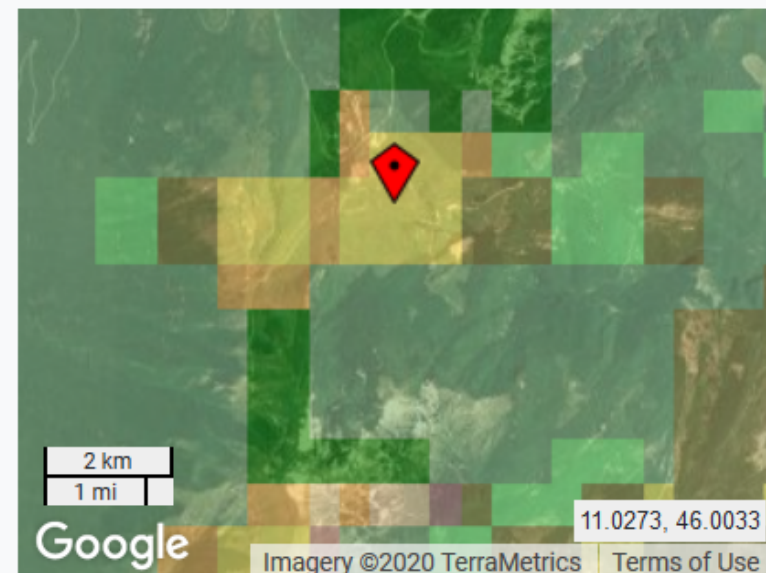
[Monte Bondone - Grassland] - NetCam SC IR - Sun May 31 2020 12:01:02 CET

Temperature: 38.0 °C internal

Exposure: 44



Image Credit: [PhenoCam](#)



Google Imagery ©2020 TerraMetrics Terms of Use

## Base Layer

- Google Satellite
- Google Hybrid
- Google Physical

## Overlays

- MCD12Q1 2016

- 0 - Water Bodies
- 1 - Evergreen Needleleaf Forests
- 2 - Evergreen Broadleaf Forests
- 3 - Deciduous Needleleaf Forests
- 4 - Deciduous Broadleaf Forests
- 5 - Mixed Forests
- 6 - Closed Shrublands
- 7 - Open Shrublands
- 8 - Woody Savannas
- 9 - Savannas
- 10 - Grasslands
- 11 - Permanent Wetlands
- 12 - Croplands
- 13 - Urban and Built-Up
- 14 - Cropland-Natural Vegetation Mosaics
- 15 - Snow and Ice
- 16 - Barren or Sparsely Vegetated



# PhenoCam Site Data

ROI Name: GR\_1000 (entire FOV of grassland)

gcc (green chromatic coordinate) timeseries plot

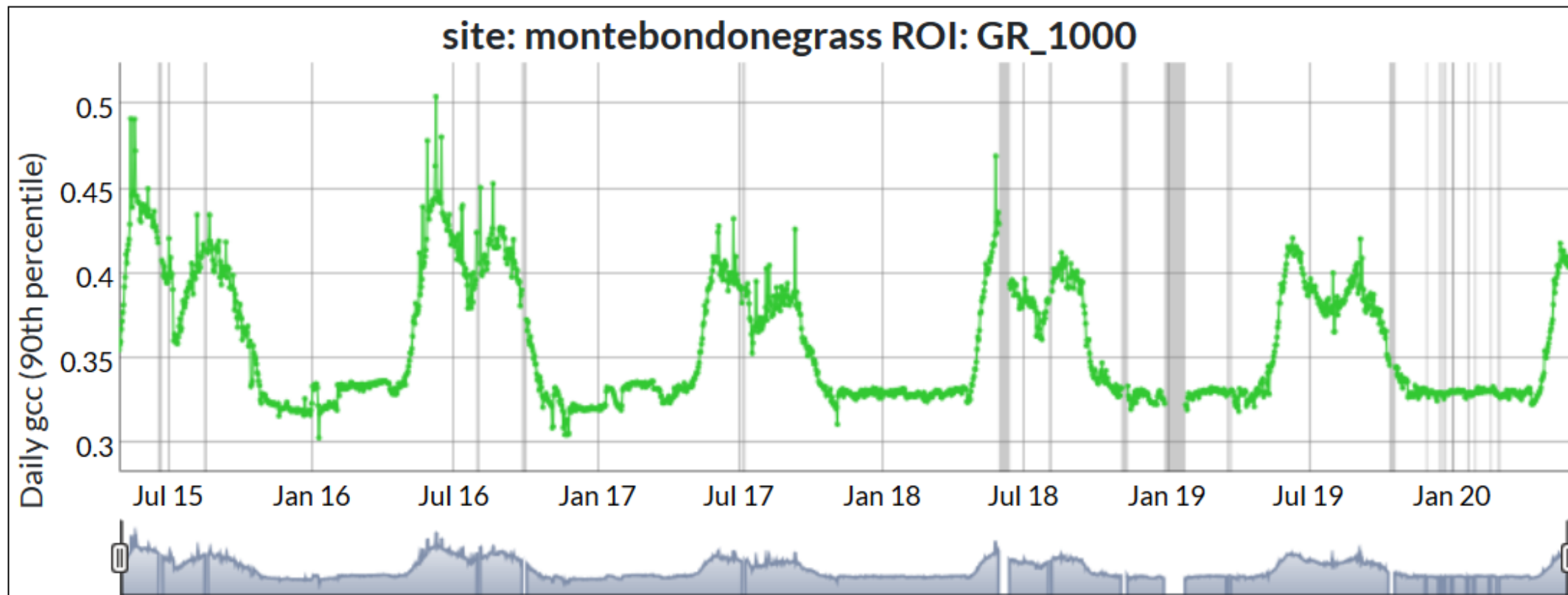


Image Credit: [PhenoCam](#)













# PhenoCam Site Data: MODIS/VIIRS Subsets

The screenshot shows the NASA EarthData website interface. At the top, there is a navigation bar with the NASA logo, 'EARTHDATA', 'Other DAACs', 'Feedback', and a help icon. Below this is a banner for 'MODIS/VIIRS Subsets' with the text 'Moderate Resolution Imaging Spectroradiometer / Visible Infrared Imaging Radiometer Suite Land Products Subsets' and the 'ORNL DAAC' logo. A secondary navigation bar contains links for 'Home', 'Get Data', 'Documentation', 'Resources', 'Publications', 'Citation', and 'Sign in'. The main content area shows a breadcrumb trail: 'Home > Get Data > Fixed Sites Subsets Tool > Trentino Alto Adige Monte Bondone'. The title of the page is 'Fixed Sites Subsets Tool : Trentino Alto Adige Monte Bondone'. Below the title is a search bar labeled 'Search Sites...' and a 'List' button. The main content is a map of the Trentino region in Italy, with a green pin marking the 'Trentino Alto Adige Monte Bondone' site. To the right of the map is a sidebar with a 'Country' dropdown set to 'Italy', a green button for 'Subset Data & Visualizations', and a 'Network Information' section. The network information section contains a table with the following data:

| Network        | Link              |
|----------------|-------------------|
| FLUXNET        | IT-MBo            |
| EUROPEANFLUXES | IT-MBo            |
| PHENOCAM       | montebondonegrass |



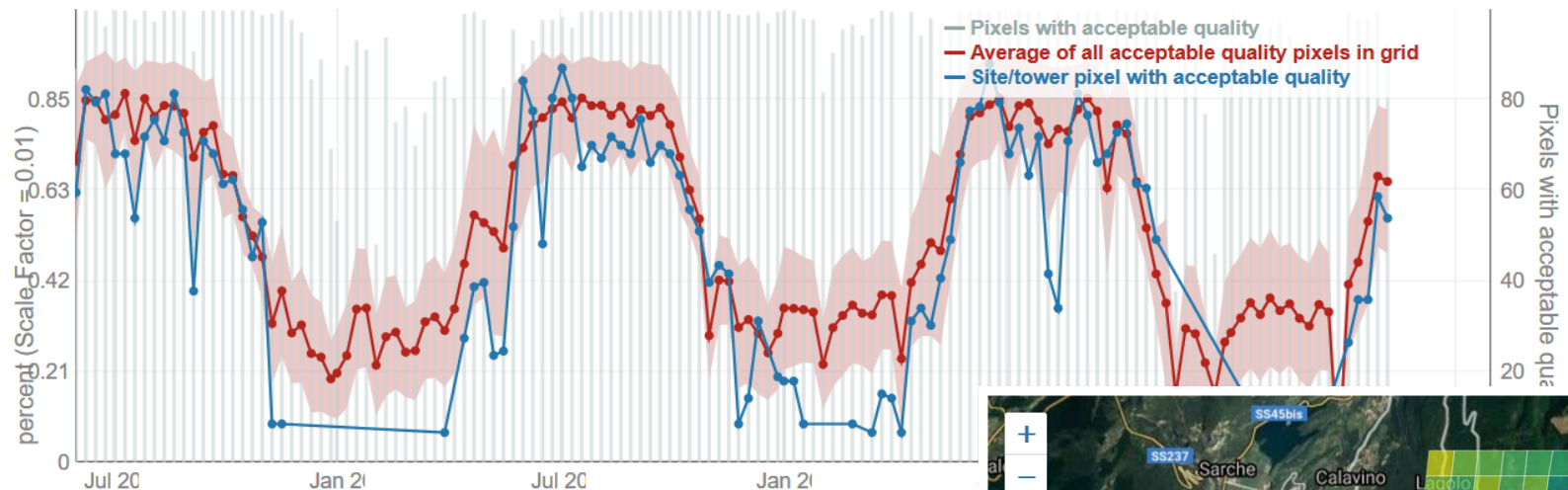
# PhenoCam Site Data: MODIS/VIIRS Subsets

| Product  | Product Name  | Frequency | Resolution (m) | Start Date | End Date   |
|--|---|-----------|----------------|------------|------------|
| <b>MODIS Collection 6</b>  |   |           |                |            |            |
|  MCD15A2H   | MODIS/Terra+Aqua Leaf Area Index/FPAR (LAI/FPAR)          | 8-Day     | 500            | 2002-07-04 | 2020-05-08 |
|  MCD15A3H   | MODIS/Terra+Aqua Leaf Area Index/FPAR (LAI/FPAR)          | 4-Day     | 500            | 2002-07-04 | 2020-05-16 |
|  MCD64A1    | MODIS/Terra+Aqua Burned Area (Burned Area)                | Monthly   | 500            | 2000-11-01 | 2020-03-01 |
|  MOD09A1    | MODIS/Terra Surface Reflectance (SREF)                    | 8-Day     | 500            | 2000-02-18 | 2020-05-08 |
|  MOD11A2    | MODIS/Terra Land Surface Temperature and Emissivity (LST) | 8-Day     | 1000           | 2000-02-18 | 2020-05-08 |
|  MOD13Q1    | MODIS/Terra Vegetation Indices (NDVI/EVI)                 | 16-Day    | 250            | 2000-02-18 | 2020-04-22 |
|  MOD15A2H   | MODIS/Terra Leaf Area Index/FPAR (LAI/FPAR)               | 8-Day     | 500            | 2000-02-18 | 2020-05-08 |
|  MOD16A2  | MODIS/Terra Net Evapotranspiration (ET)                   | 8-Day     | 500            | 2001-01-01 | 2020-04-30 |
|  MOD17A2H | MODIS/Terra Gross Primary Productivity (GPP)              | 8-Day     | 500            | 2000-02-18 | 2020-05-08 |
|  MOD17A3H | MODIS/Terra Net Primary Production (NPP)                  | Yearly    | 500            | 2000-01-01 | 2014-01-01 |



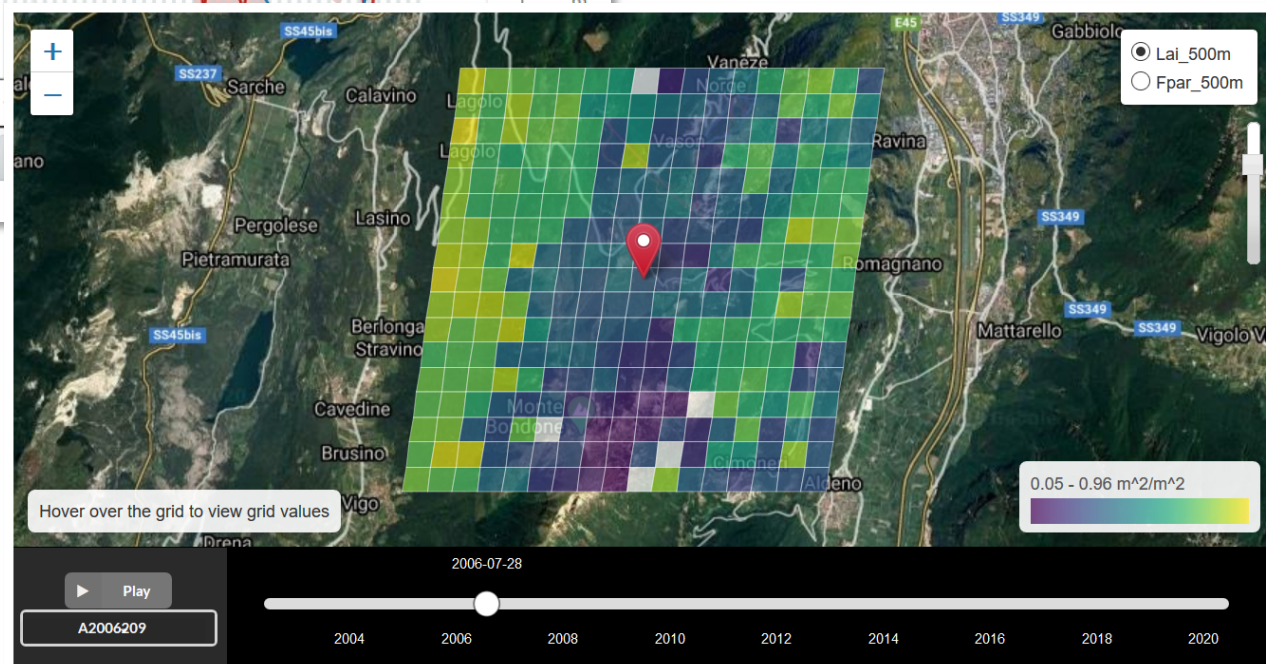
# PhenoCam Site Data: MODIS/VIIRS Subsets

MCD15A2H / Fpar\_500m (All acceptable pixels)



Includes all pixels that have acceptable

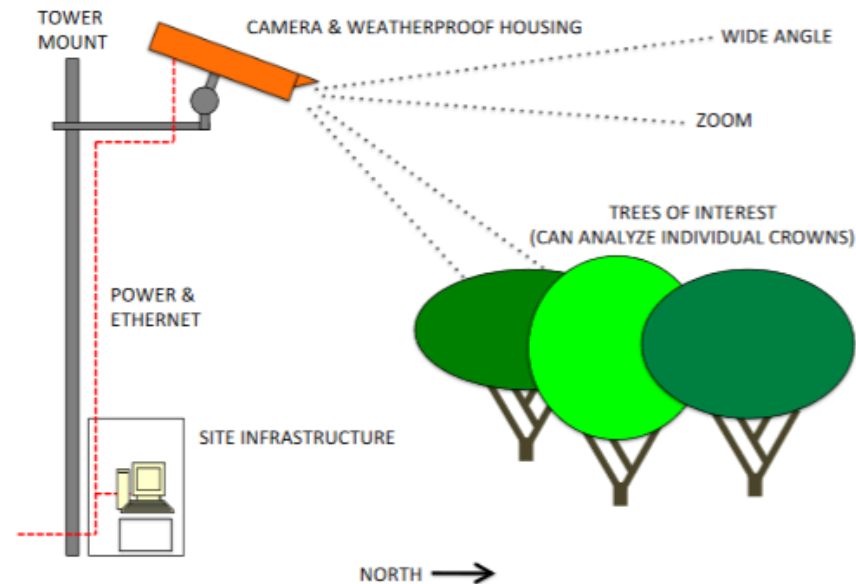
Time series of MODIS FPAR (top) and gridded data image (right). Image Credit: [ORNL DAAC](https://ornl-daac.github.io/)





# PhenoCam Resources

- Camera Setup and Installation:
  - Installation Tool Documents
  - Configuration and Deployment
- Standard Data Products
- Image Analysis Tools:
  - R, Python, and MATLAB Packages
  - Available on GitHub
- Phenology Modelling:
  - R Package: phenor
- Educational Resources:
  - Links to NEON, NPN Resources, etc.

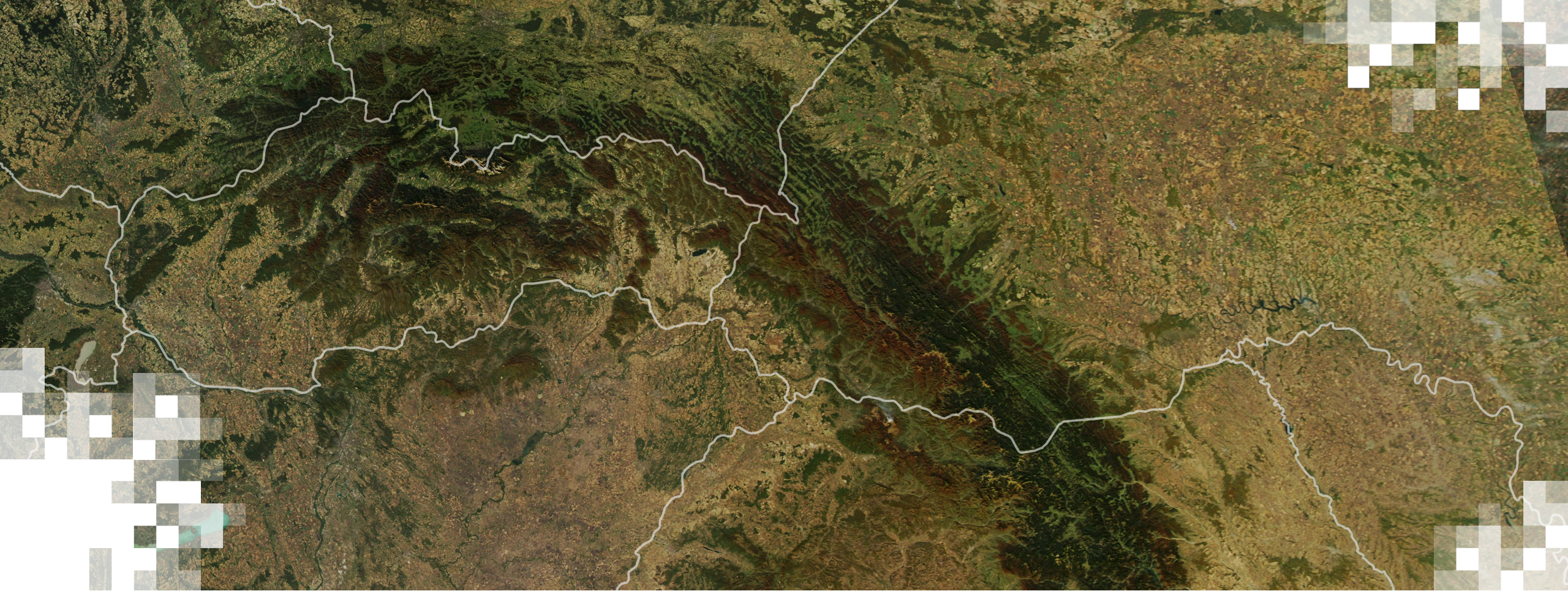


Deployment schematic from installation document. Image Credit: [PhenoCam](#)



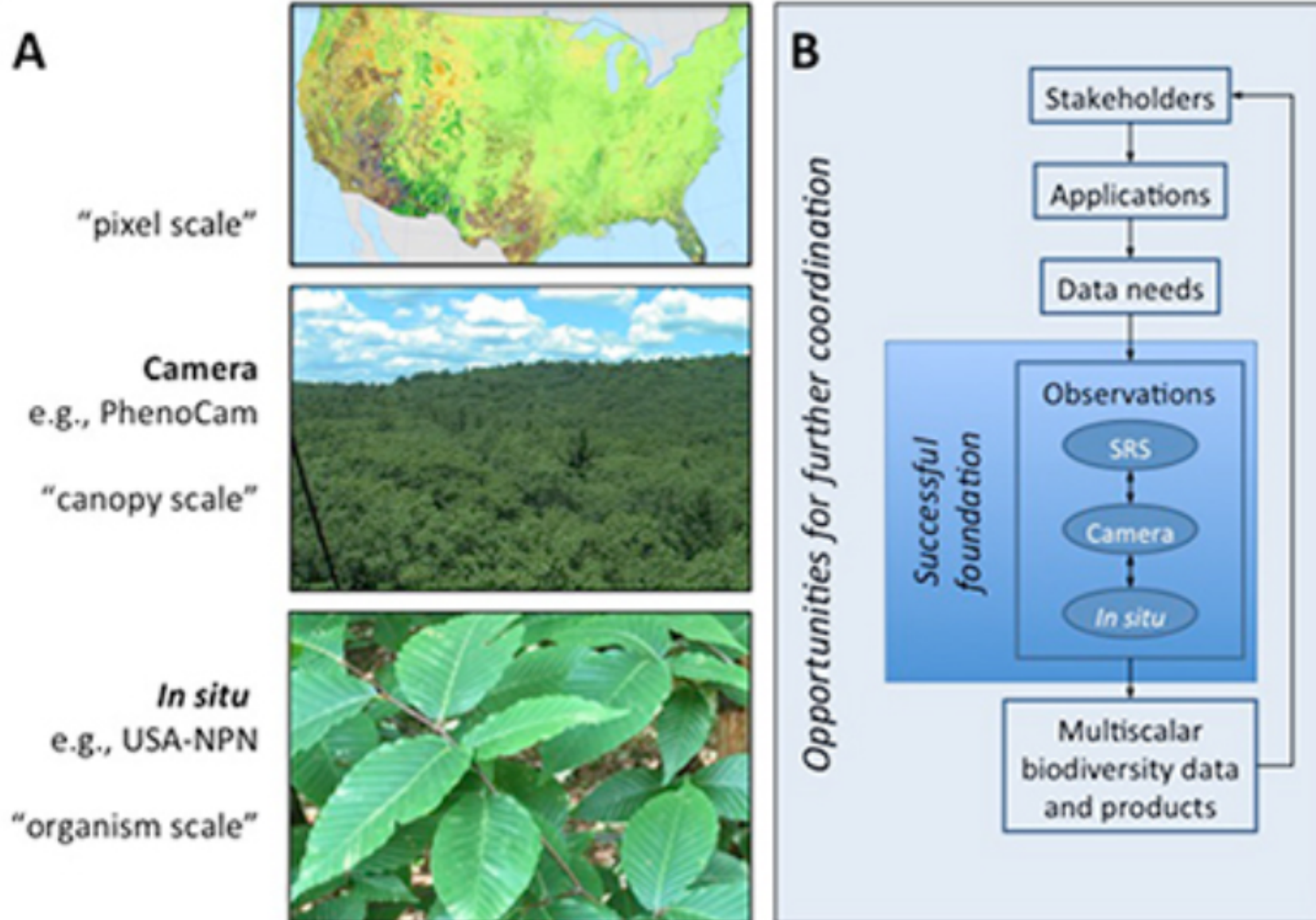
<https://phenocam.sr.unh.edu/webcam/tools/>





Connecting the Dots

# Advanced Phenology Information System (APIS)



(A) Capturing phenology at multiple scales and (B) the multiple components involved in potential and promising coordination. (USA-NPN is the USA National Phenology Network, and SRS is Satellite Remote Sensing.) Credit: [USGS \(satellite data\)](#), [Andrew Richardson \(photos\)](#)



# Advanced Phenology Information System (APIS)

- Building an advanced pheno-climatic information system for NASA and the Earth science community
- Provides access to **integrated** field, tower-based, airborne, and multi-scale satellite time series data and observations
- Tracked over the various scales, from individual species to ecosystems to entire continents
- NASA-funded project from 2017 – 2020
- Brings together many of the data and tools we have presented here

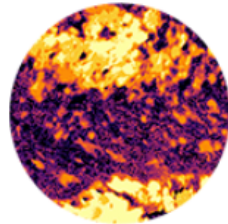


# Conservation Science Partners (CSP)



- A nonprofit collective established to meet the analytical and research needs of diverse stakeholders in conservation projects
- Connect with universities, nonprofits, and other national partners to create products and trainings focused on ecology and conservation

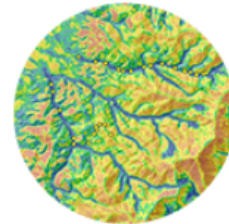
## CAPABILITIES & SERVICES



*Advanced  
geospatial  
and remote  
sensing  
analysis*



*Ecosystem  
and  
population  
modeling*



*Ecological  
and spatial  
statistics*



*Multi-scale  
conservation  
planning and  
design*

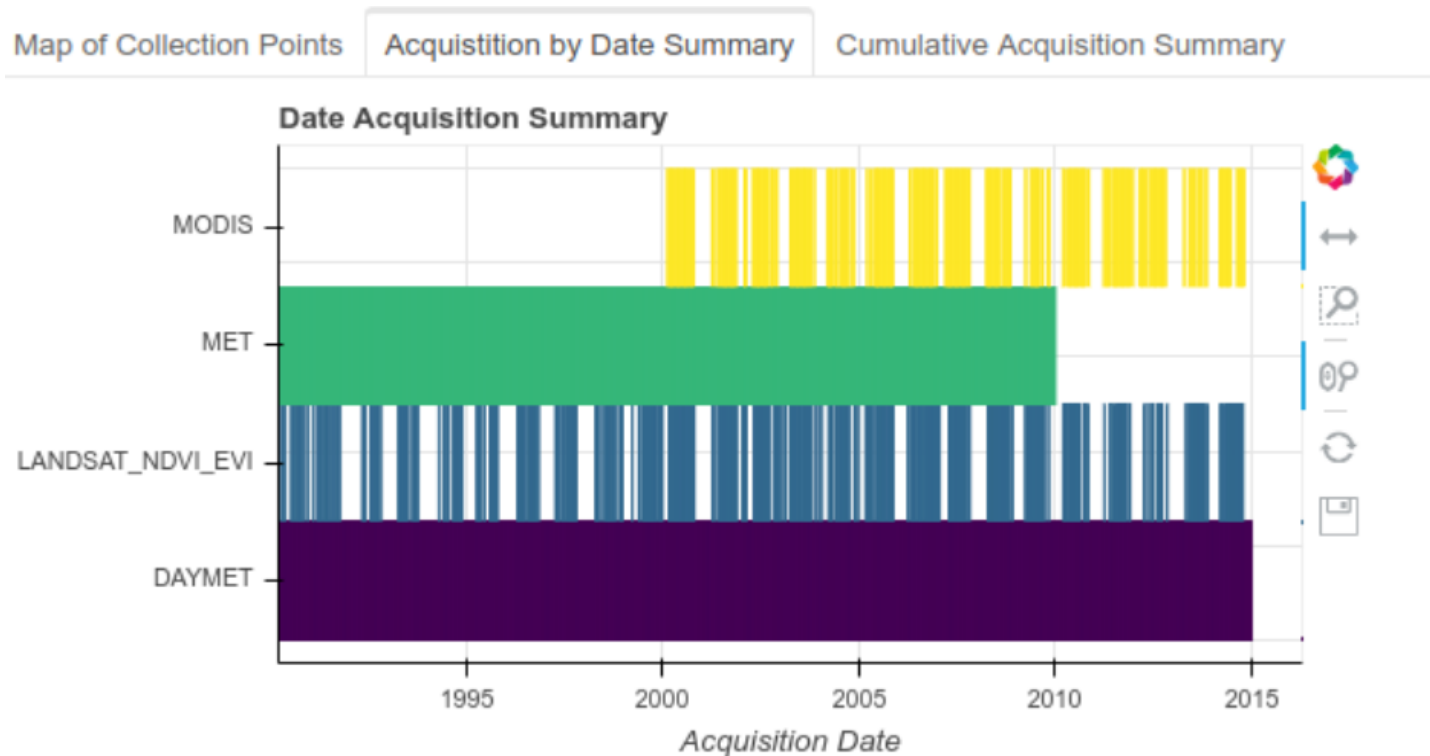


*Advanced  
training and  
education*



# Data ACQuisitions and REtrieval (dacqre)

- A toolset for extracting geospatial data, such as those used as covariates from phenological modeling, from Google Earth Engine (GEE), given a set of point locations and optional parameters.

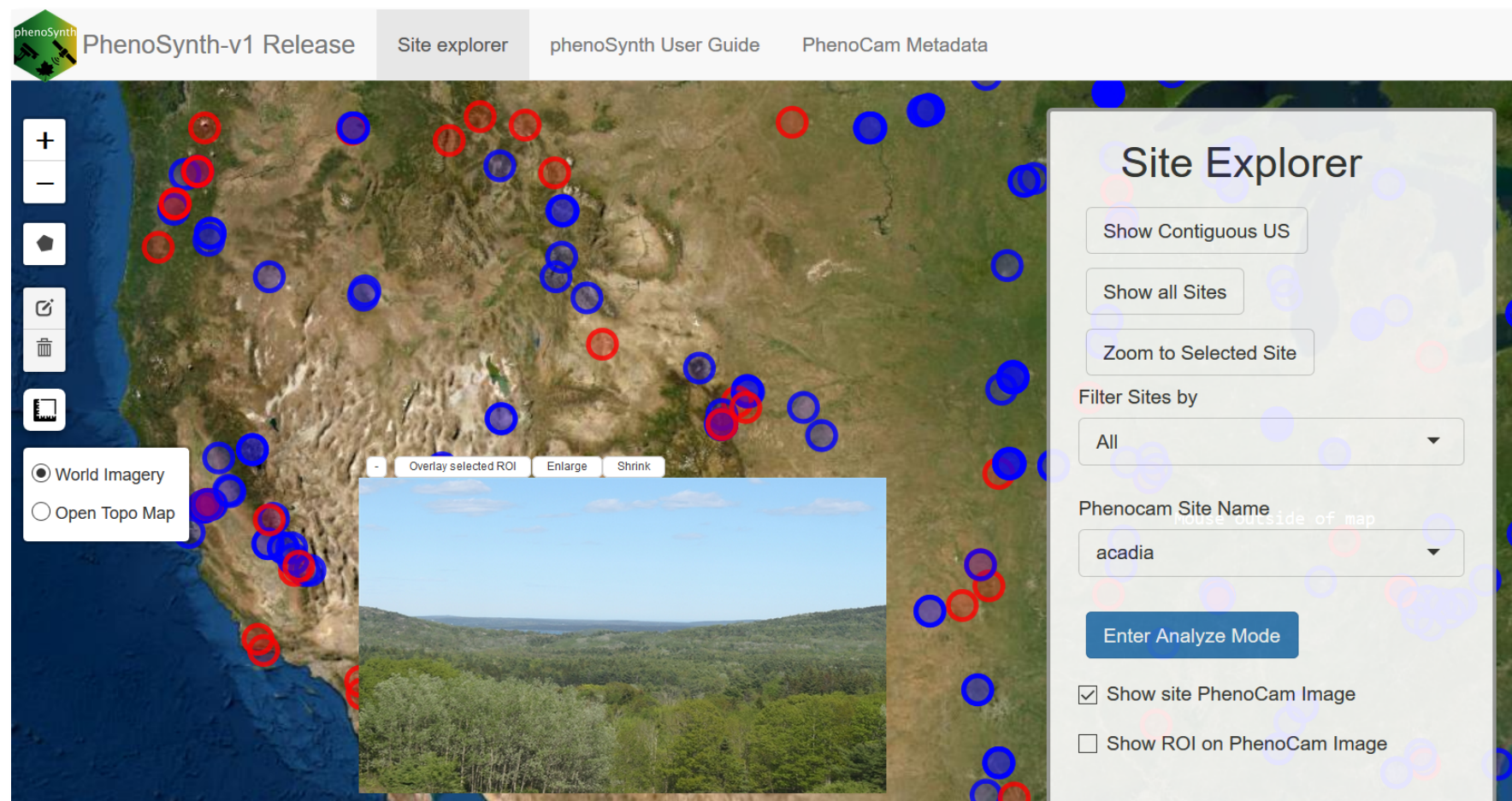


<https://gitlab.com/apis-staging/dacqre/-/wikis/0.-Home>



# PhenoSynth

- R code and R Shiny platform to access PhenoCam and NEON data
  - For the Contiguous U.S.
- Filter by site type or name
- Visualize and Analyze



<http://phenocam.nau.edu/phenosynth/>



# Summary

- Phenology: Analyzed on many scales, from field data to near-surface cameras and flux towers, to airborne data and satellites.
- Many networks collecting and sharing data:
  - NPN
  - NEON
  - PhenoCam
  - APIS
- These existing initiatives represent an opportunity for improved understanding of ecological patterns and processes.
- Real-time phenological monitoring, coupled with cross-scale data integration and modeling, can contribute to improved management of ecological systems in the face of increasing climate variability and change.

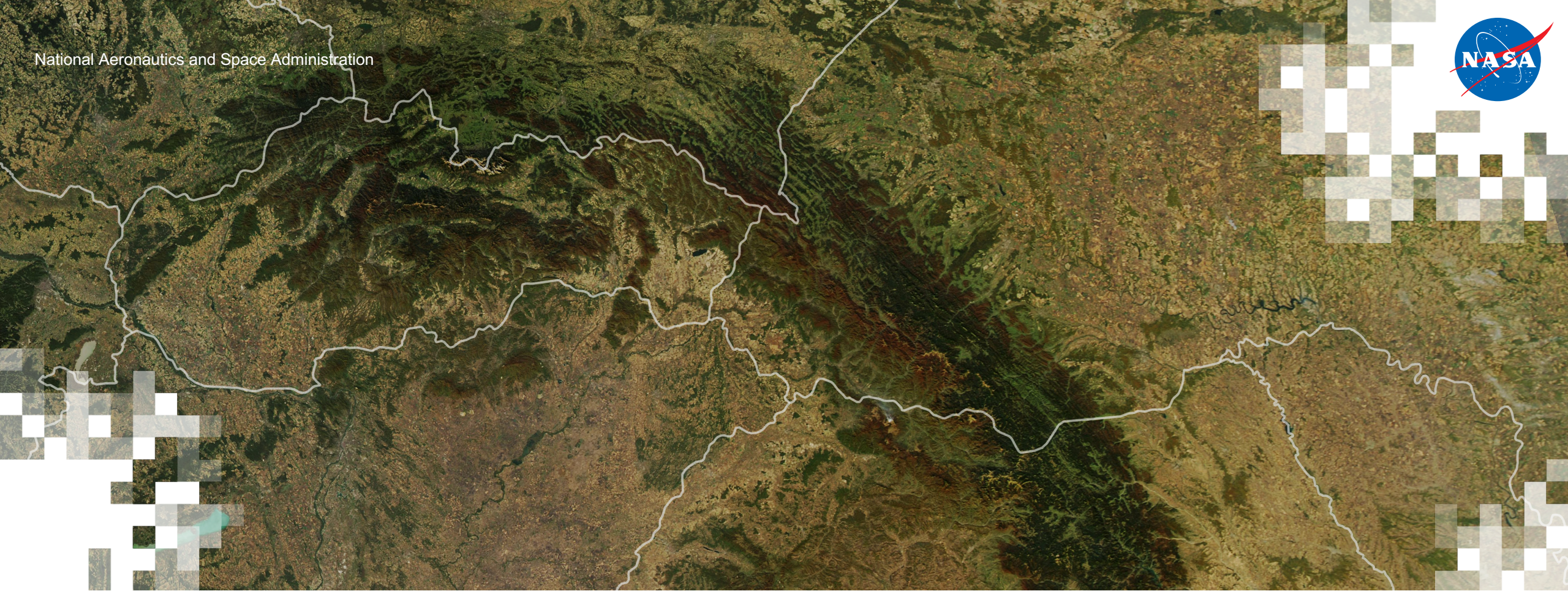




# Contacts

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- ARSET Website:
  - <http://arset.gsfc.nasa.gov>





# Next Session: Utility and Advantage of Multi-Scale Analysis

July 14, 2020

# Questions

- Please enter your questions into the Q&A box.
- We will post the questions and answers to the training website following the conclusion of the course.





**Thank You!**

