EARTH SCIENCE
APPLIED SCIENCES

EARTH SCIENCE APPLICATIONS WEEK 2022

Day 2: Ecological Forecasting & Wildfires

August 10, 2022

EARTH SCIENCE APPLICATIONS WEEK 2022

WELCOME!

DAY 2 – AUGUST 10th: ECO FORECASTING & WILDFIRES

<u>Event Attendance Guidelines</u>

1. Please stay muted with cameras off
2. Post questions for speakers in the chat & they will be answered there

USGS
science for a changing world

LANDSAT'S 50TH ANNIVERSARY

LOOKING BACK & LOOKING AHEAD

TIMOTHY STRYKER

CHIEF, OUTREACH AND COLLABORATION BRANCH
NATIONAL LAND IMAGING PROGRAM
U.S. GEOLOGICAL SURVEY (USGS)
U.S. DEPARTMENT OF THE INTERIOR

NASA APPLIED SCIENCE WEEK WORKSHOP

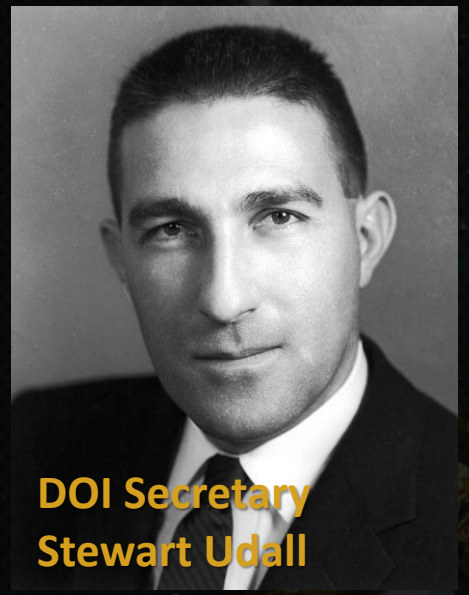
AUGUST 10, 2022

Celebrating 50 YEARS of Landsat 1972-2022

PECORA 22

OCTOBER 23-28 2022

Original DOI/USGS Risk-Takers - 1966



DOI Secretary Stewart Udall

This Photo by Unknown Author is licensed under CC BY-SA

USGS Director William Pecora

This Photo by Unknown Author is licensed under CC BY-SA

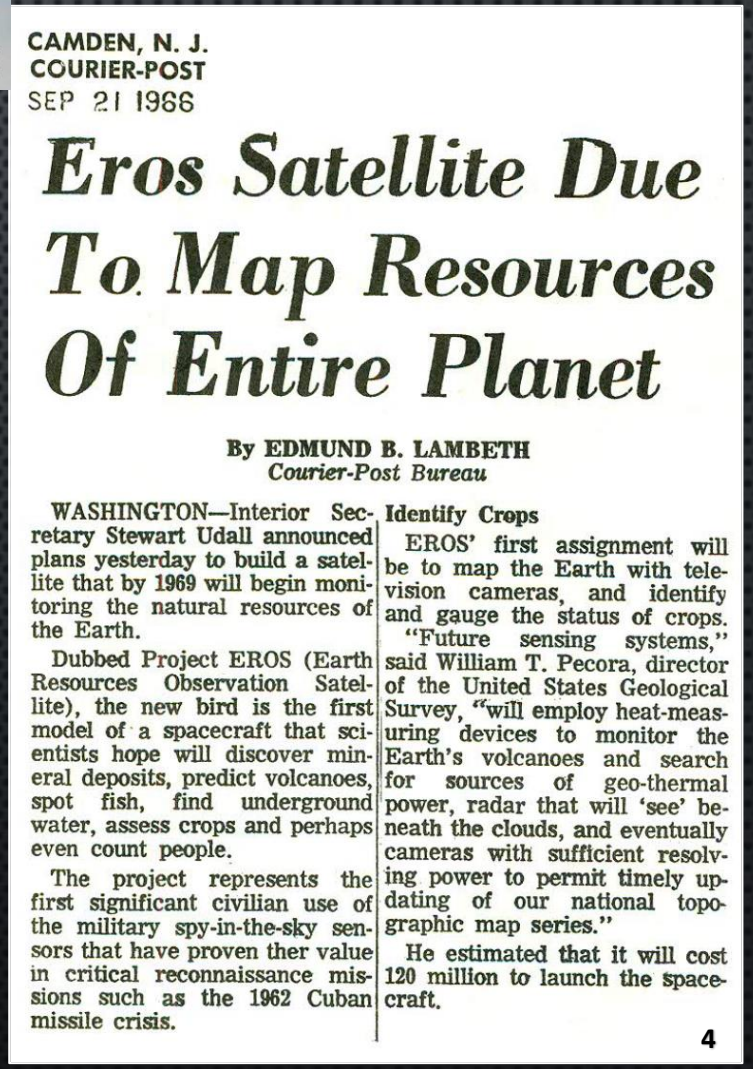
"A vision to observe Earth for the benefit of all."

Interior Secretary Stewart Udall, 1966

"The DOI's (Department of the Interior's) surprise declaration created a storm of political protest from NASA and Defense agencies…*

"…Pecora was convinced that he would be fired as a result."*

"Rumor has it that President Johnson was so angry over the stir that he never spoke with Secretary Udall again."*



CAMDEN, N. J.
COURIER-POST
SEP 21 1966

Eros Satellite Due To Map Resources Of Entire Planet

By EDMUND B. LAMBETH
Courier-Post Bureau

WASHINGTON—Interior Secretary Stewart Udall announced plans yesterday to build a satellite that by 1969 will begin monitoring the natural resources of the Earth.

Dubbed Project EROS (Earth Resources Observation Satellite), the new bird is the first model of a spacecraft that scientists hope will discover mineral deposits, predict volcanoes, spot fish, find underground water, assess crops and perhaps even count people.

The project represents the first significant civilian use of the military spy-in-the-sky sensors that have proven ther value in critical reconnaissance missions such as the 1962 Cuban missile crisis.

Identify Crops

EROS' first assignment will be to map the Earth with television cameras, and identify and gauge the status of crops.

"Future sensing systems," said William T. Pecora, director of the United States Geological Survey, "will employ heat-measuring devices to monitor the Earth's volcanoes and search for sources of geo-thermal power, radar that will 'see' beneath the clouds, and eventually cameras with sufficient resolving power to permit timely updating of our national topographic map series."

He estimated that it will cost 120 million to launch the spacecraft.

4

USGS

*Landsat Legacy Project Team, *Landsat's Enduring Legacy*, ASPRS, 2017, (page 21).

Landsat 50th Anniversary Year Events

2022 Event Timeline

Year-Long Activities

- Landsat and Social Media Products branded with 50th Anniversary Graphic
- Completion and Release of all Landsat State Fact Sheets and Landsat State Mosaics

July

- Esri User Conference: July 11–15, 2022 – San Diego, CA – Map Gallery Exhibit
- July Photogrammetric Engineering & Remote Sensing Journal Cover story on Landsat's 50th Anniversary
- 50th Anniversary articles for media and publications – July 2022
- 50th Anniversary Video and Poster – July 2022
- Landsat 50th Anniversary Events on Capitol Hill – July 21
  - Lunch and Learn (Panel Session) – House Natural Resources Committee Hearing Room
  - Evening Reception – House Science Committee Hearing Room
- Senate Resolution on the 50th Anniversary of Landsat, July 26, 2022 (Saturday 7/23/22 "Landsaturday")
- Landsat 9 Transition Turnover Event – August 10-11 – EROS-Sioux Falls, SD
  - Full two-day schedule of events including tours and special communications products
- Upcoming Smithsonian Exhibits - the National Air & Space Museum and Natural History Museum

October

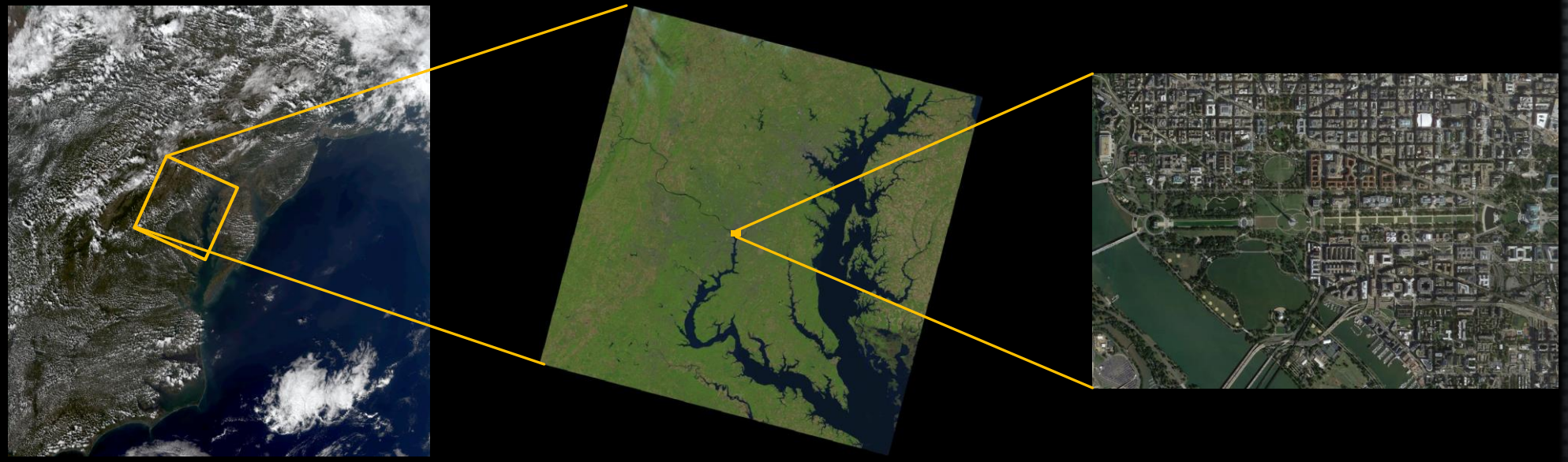
- Pecora-22: October 23 – 28, 2022 – Denver, CO *(Theme 50th Anniversary Celebration)*

USGS science for a changing world

NASA

Why is Landsat Unique?

- Quality of imagery and global coverage
- Cross-calibration of sensor data
- Irreplaceable 50-year record of historical change of Earth's land surfaces
- Free and open data policy
- Landscape-scale resolution
- Simultaneous observations across the spectrum from visible to shortwave to thermal infrared bands
- Supports government (civil and military), commercial, non-profit and education users across the U.S. and worldwide in a broad set of diverse applications



Weather-scale | Landsat | Commercial High-resolution

Landsat's Enduring Value *vis-a-vis* Commercial Earth Observation Satellites

Rapidly growing commercial space industry is expanding the number of available Earth observation satellite systems

- High resolution (5-meters or less) visible and near-infrared imaging Cubesats

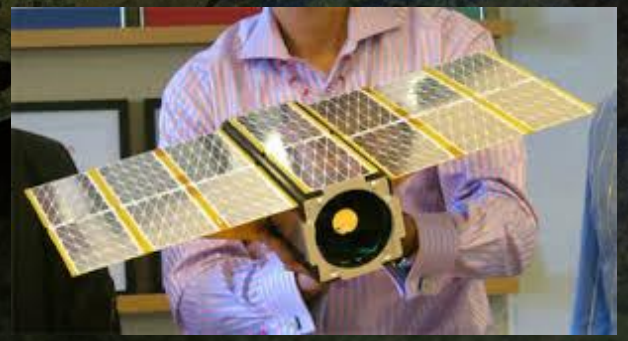
Although providing benefit in terms of higher resolution and more frequent revisit, commercial Earth observation satellites are unable to replicate full-spectrum Landsat, due to their size

- Landsat's visible-near/shortwave/thermal infrared not possible on a CubeSat
- CubeSats' 1-day revisit, 5-meter resolution not possible on Landsat
- CubeSats are essentially cameras; Landsat is an advanced scientific instrument

The Landsat full-spectrum global survey mission remains unique among U.S. federal and commercial missions

- Collects highly-calibrated science data adhering to NIST & FGDC standards
- Provides consistent global coverage, regardless of commercial value
- Serves as a trusted calibration reference for other land-imaging satellites

Commercial Earth-observing systems cannot replace Landsat, but are very complementary for environmental research and monitoring purposes

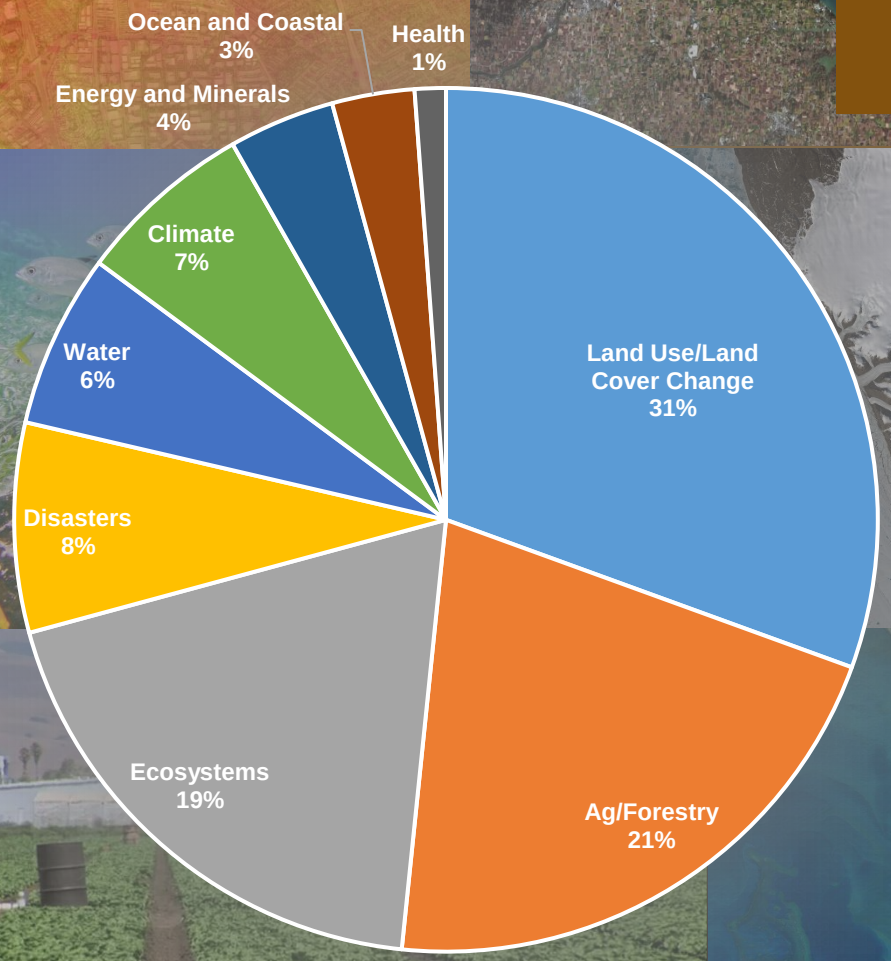


Planet Dove

Landsat 8

USGS

Landsat Applications



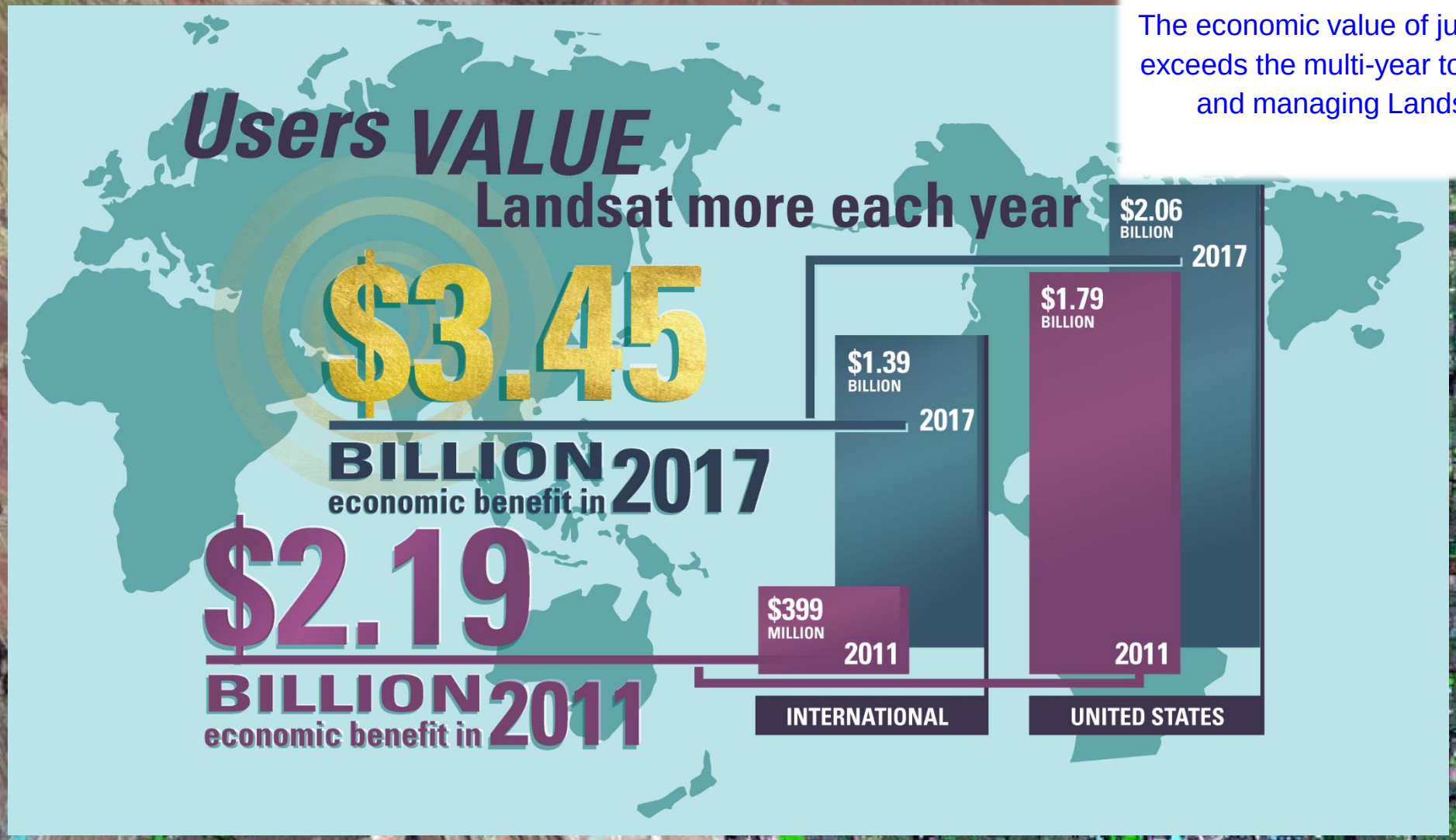
Landsat is the single most-used land imaging data set by U.S. Federal users and the 2nd highest satellite system in societal benefit impact (behind GPS)

- Federal Agencies (e.g. DOI, USDA, EPA, NASA, DOD, NOAA, State, USAID)
- State Agencies (planning, water resources, natural resources, transportation)
- University Researchers and Educators
- International Organizations (e.g., UN agencies, GEO)
- Non-Governmental Organizations (e.g., The Nature Conservancy, World Resources Institute, World Wildlife Fund, Resources for the Future)
- Commercial (e.g., Exxon-Mobil, MapBox, Descartes Labs, Esri, Gallo, L3Harris, ITT, MDA Federal, Planet)
- Foreign space agencies
- U.S. and foreign commercial satellite operators
- Cloud service providers (e.g. Amazon Web Services, Google Earth Engine, Microsoft Azure)
- General Public

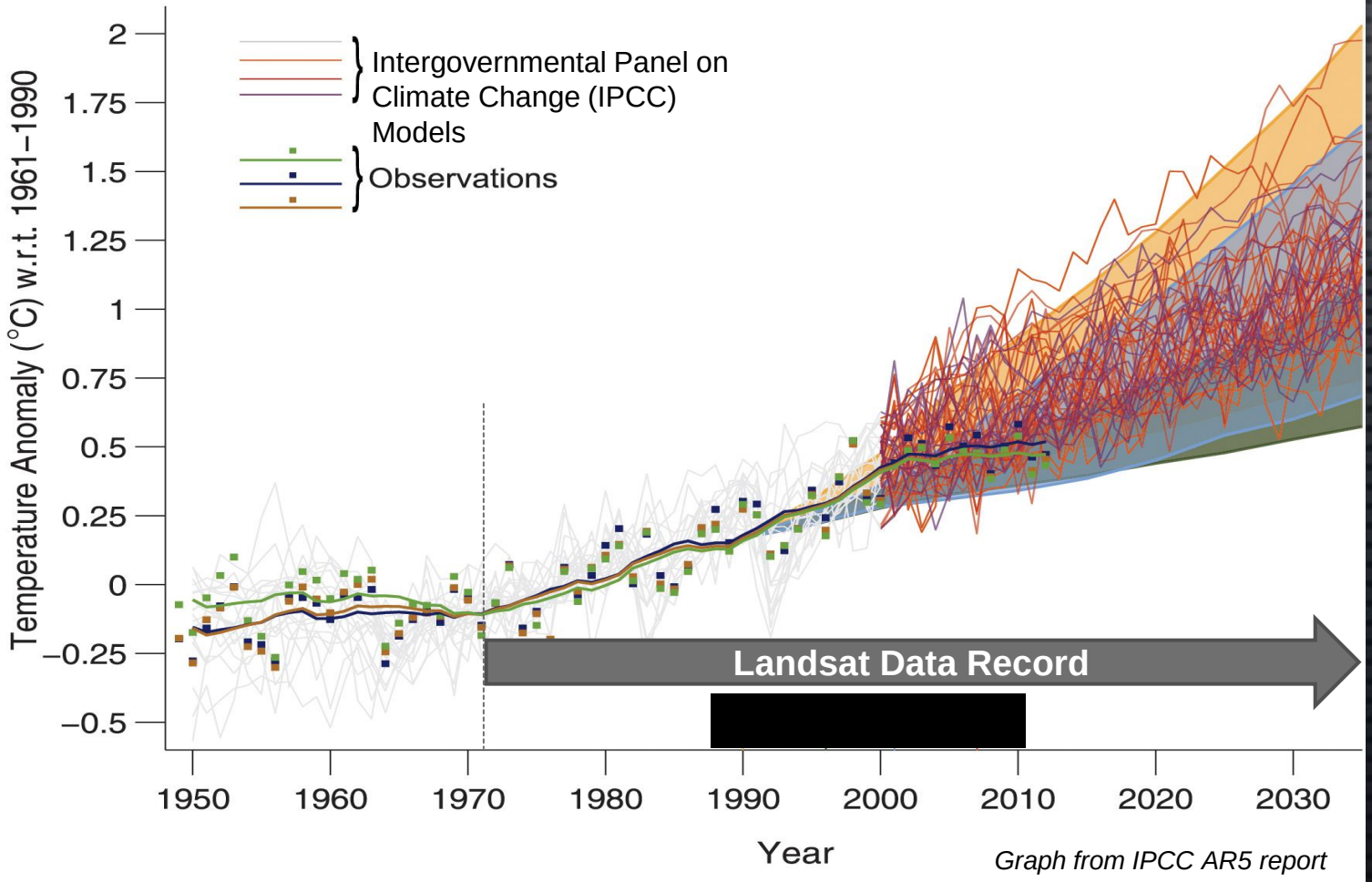
Supports Federal, state, local, tribal, academic, commercial, non-profit, and international use

Landsat's Economic Benefits

The economic value of just one year of Landsat data far exceeds the multi-year total cost of building, launching, and managing Landsat satellites and sensors



Landsat & Climate Change



Graph from IPCC AR5 report

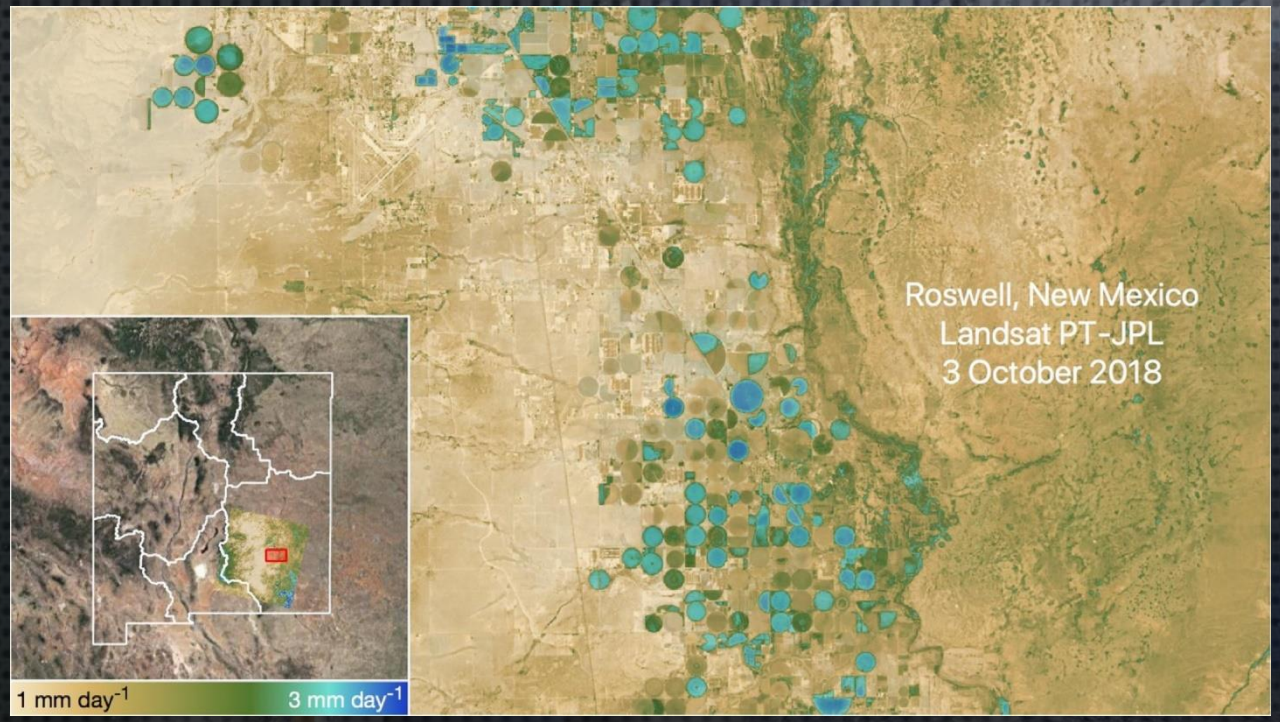
"As the longest-running continuous satellite image dataset for land processes, Landsat data provide unparalleled witness to the enormous changes occurring on Earth since 1972."
(Kennedy, et al., Environmental Research Letters, 2014)

"The US Global Change Research Program identified Landsat as a critical observatory for climate and environmental change research due to the unbroken length of the Landsat record and its ability to monitor remote regions with surface features such as glaciers, rainforests, permafrost, and coral reefs."
(CRS Report on Landsat 9 and the Future of the Sustainable Land Imaging Program)

Landsat Data Record coincides with dramatic global temperature changes; sustaining it will ensure tracking of future global changes

Landsat and Water Monitoring

Every Western State uses Landsat's unique thermal capability for managing consumptive water use and facilitating water rights transfers and agreements



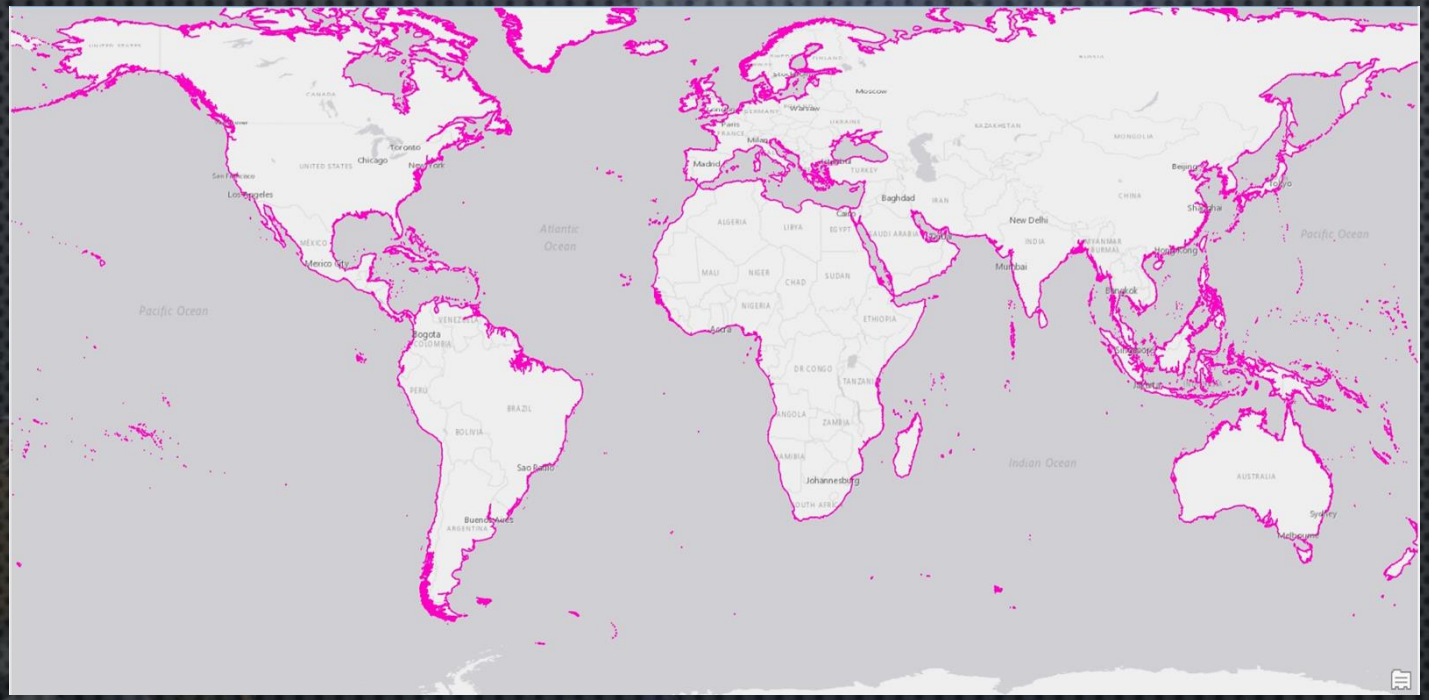
Landsat-derived map of water use by center pivot irrigation fields in Roswell, New Mexico in October 3, 2018. Image credit: Fisher et al. NASA, AGU19

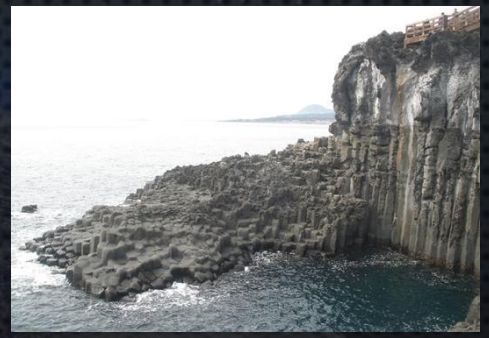
Landsat is used to detect and address harmful algal blooms in lakes and coastal waters

A hazardous algal bloom containing the toxin *microcystis* covered large portions of western Lake Erie in September 2017. Swirls of algae can be seen south of the Detroit River's mouth in this natural-color Landsat 8 image. Credit: USGS EROS

Idaho's Mapping Evapotranspiration application is a former winner of the Harvard University John F. Kennedy School of Government's Innovations in American Government Award

Global Landsat Data Enables Global Coastline Depictions



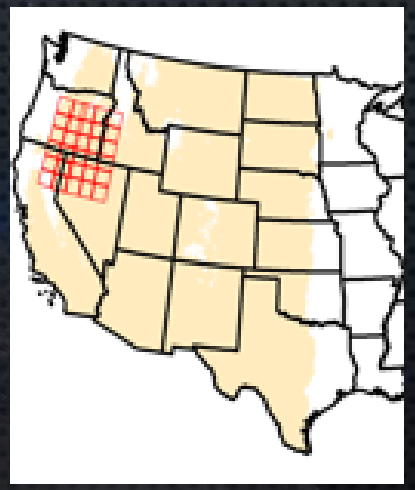


Global Coastline Explorer Tool - https://rmgsc.cr.usgs.gov/gce/

Invasive Species Mapping

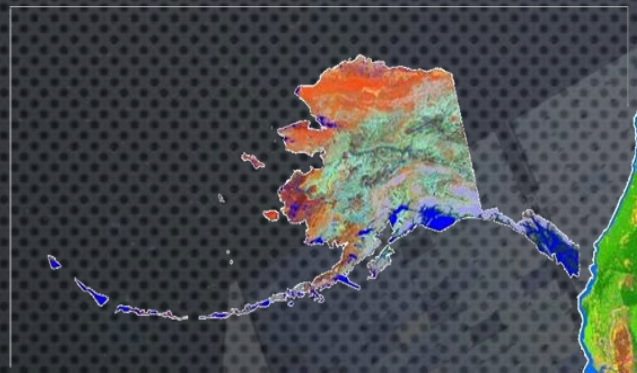
- INVASIVE GRASSES SUCH AS CHEATGRASS CONTRIBUTE TO ECOSYSTEM DEGRADATION AND INCREASED FIRE INTENSITY IN THE WESTERN UNITED STATES.
- LANDSAT DATA, COMBINED WITH EUROPE'S SENTINEL-2 DATA CAN PROVIDE 3X/WEEK OBSERVATION FREQUENCY FOR WESTERN STATE LAND MANAGERS' EARLY DETECTION AND RAPID RESPONSE.
- CONTRIBUTES TO BLM SAGEBRUSH ECOSYSTEM CONSERVATION AND THE INTEGRATED RANGELAND FIRE MANAGEMENT STRATEGY ACTIONABLE SCIENCE PLAN.

Mapping invasive grass cover using Harmonized Landsat and Sentinel-2 data



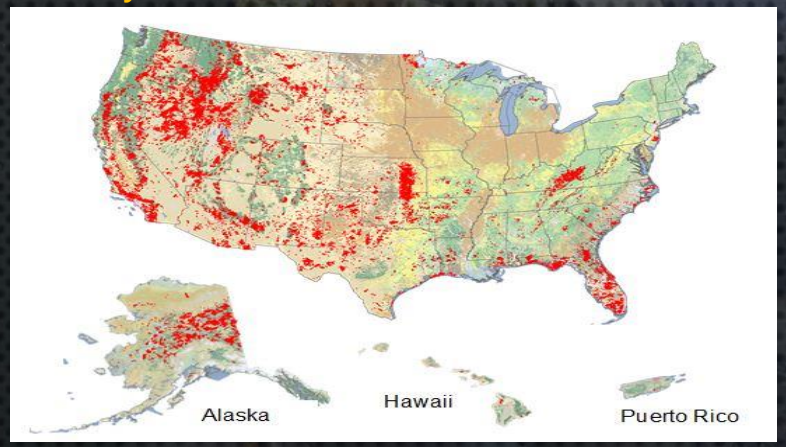
Expanding mapping effort to all Western U.S. using the USGS Denali Tallgrass High Performance Computing capability and the Landsat archive

Landsat and Vegetation and Fire-Fuels Mapping (DOI/USDA)

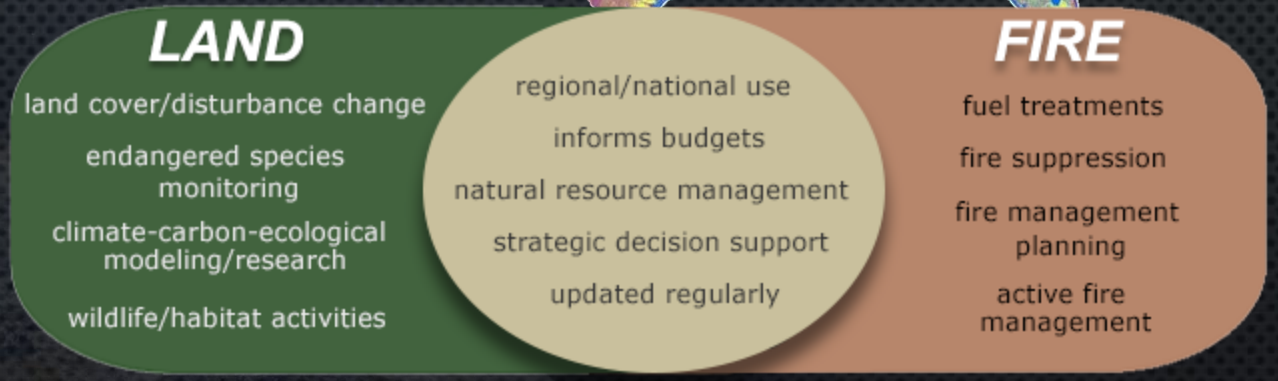


LANDFIRE team gathering field data in a remap prototype area of central Idaho

The Monitoring Trends in Burn Severity program uses Landsat to map burn severity, extent, and trends



The Burned Area Emergency Response program equips ground teams with Landsat-based burn severity maps immediately following fires to aid in remediation efforts



LANDFIRE uses Landsat to provide a common "all-lands" set of vegetation and wildland fire/fuels information, for strategic fire and resource management planning and analysis via 20+ national geospatial layers, databases, and eco-models

USGS

Understanding Amazon Deforestation Patterns with Landsat

Landsat Gallery
https://landsat.visibleearth.nasa.gov/

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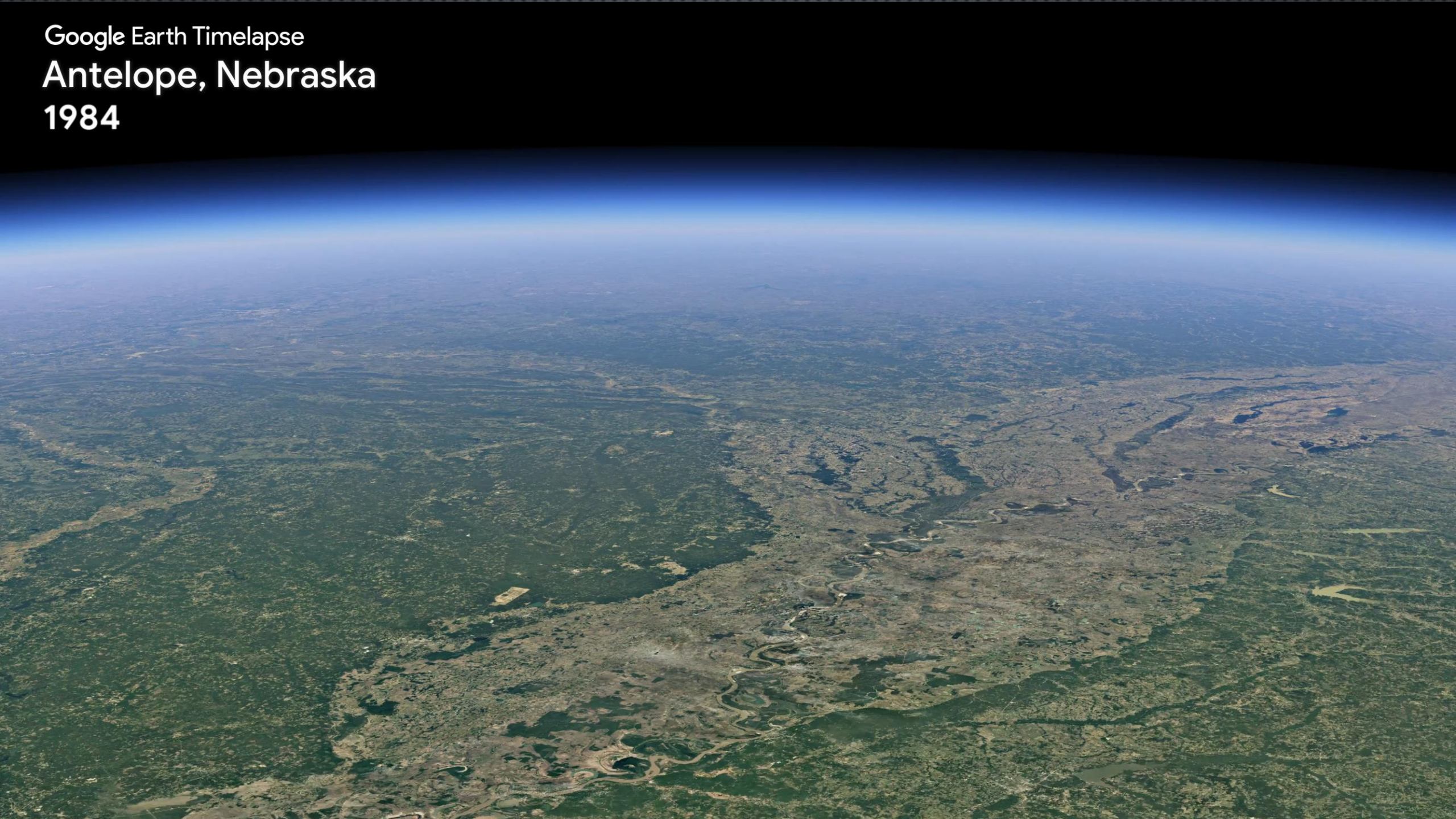
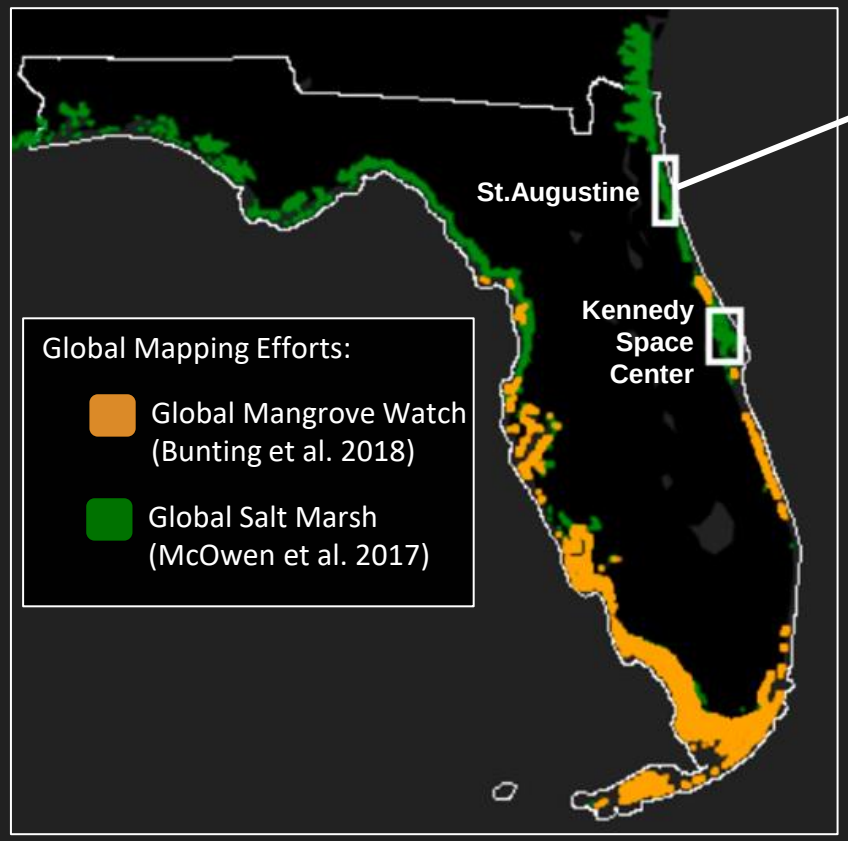
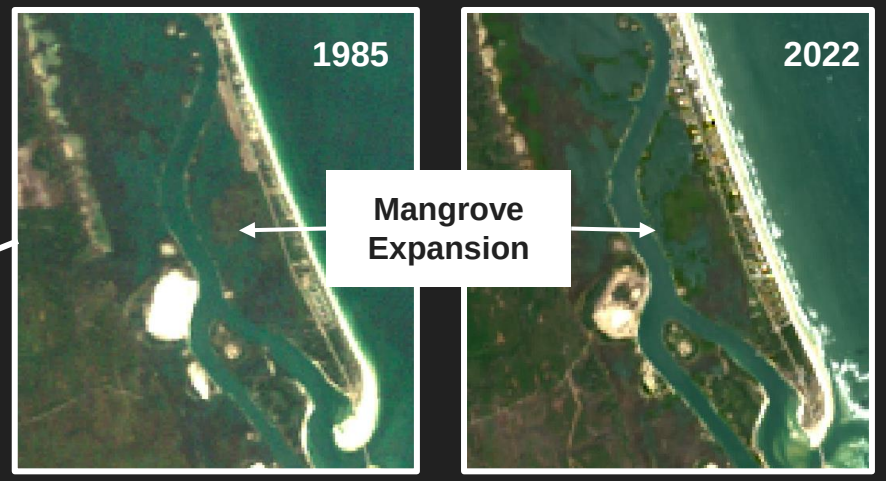
State of Para, Brazil
acquired June 4, 2000 - June 19, 2019
Landsat.visibleearth.nasa.gov


Google Earth Timelapse
Antelope, Nebraska
1984

Landsat and Coastal Wetlands Mapping / Monitoring

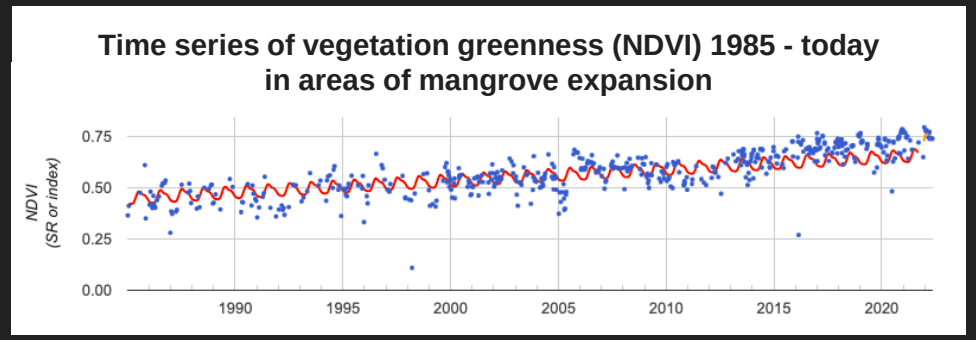
1. Mangroves and saltmarshes in Florida are changing in response to warming temperatures and rising seas due to climate change





Landsat 5 & 8 imagery of coastal wetlands near St. Augustine, FL.

2. Landsat's long archive reveals how wetland habitats have changed in recent decades

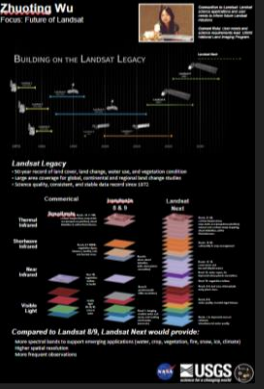


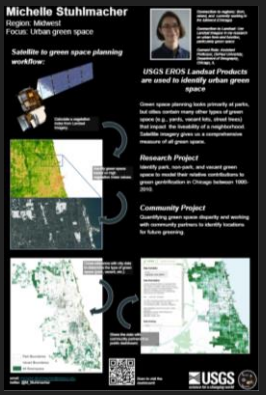
3. Future monitoring relies on the continuation of Landsat in order to predict coastal change impacts to coastal populations, economies, and adaptation to climate change

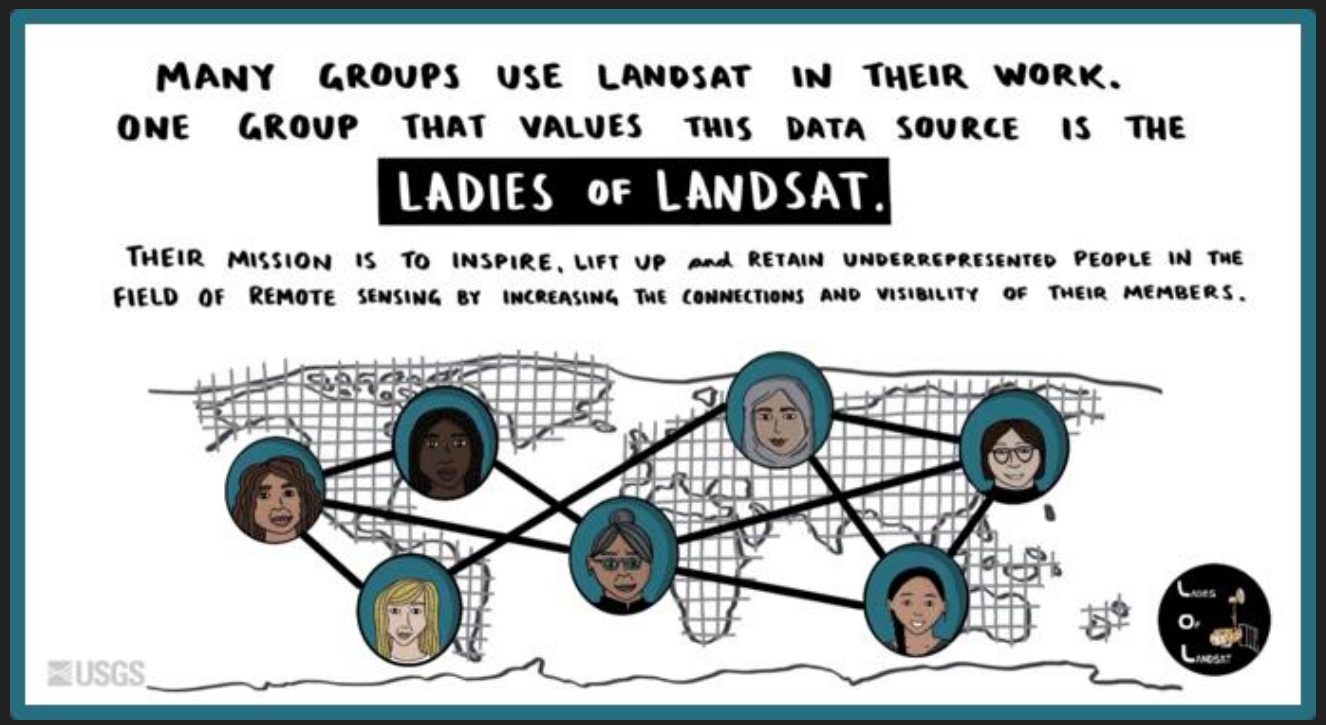
NASA Postdoctoral Program

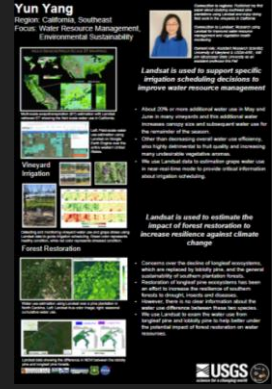
Courtesy of Cheryl Doughty
NASA Postdoctoral Program Fellow

Community Interest and Support









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Public Research & Engagement

"The opening of the Landsat archive to free, web-based access is like giving a library card for the world's best library of Earth conditions to everyone in the world."

Adam Gerrand, Food & Agriculture Organization of the United Nations

[Landsat Benefits, State By State | U.S. Geological Survey (usgs.gov](#)

USGS

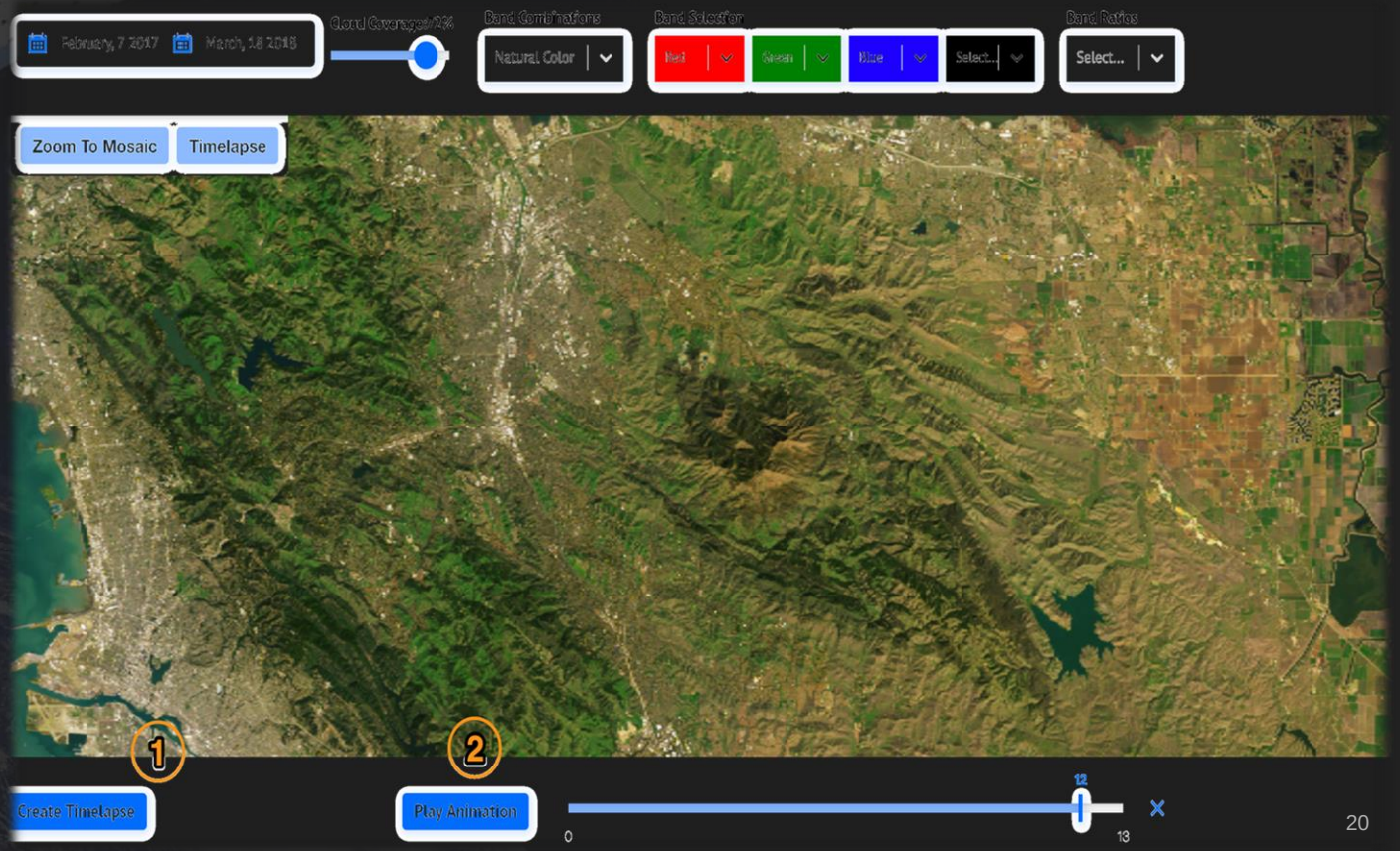
NP-2018-08-261-GSFC - https://landsat.gsfc.nasa.gov/how_landsat_helps/case-studies-2/

Landsat Collection 2
Released in the Commercial Cloud – May 2021

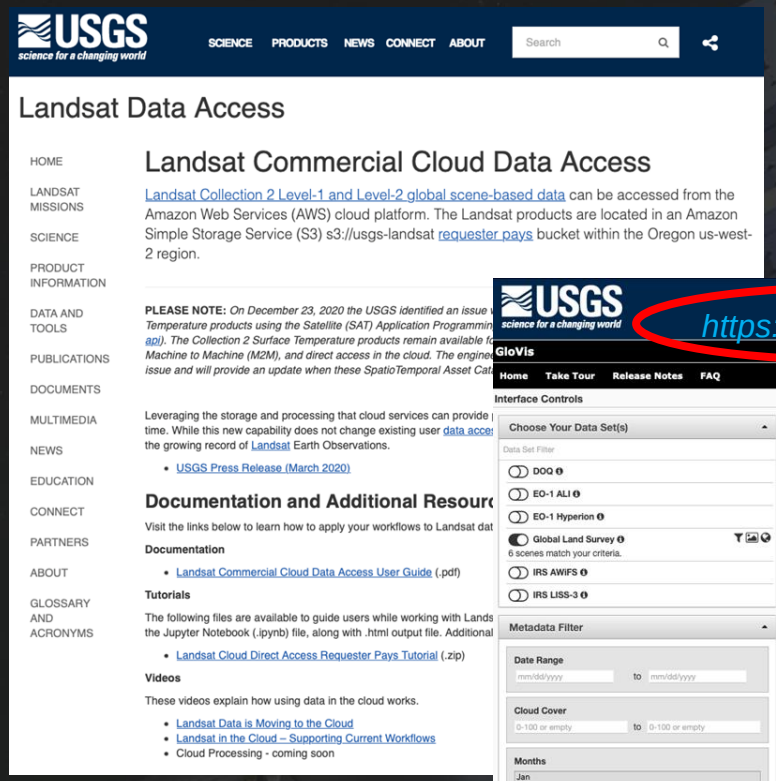
- Improved radiometry, geometry, metadata and access
- New tools for search and discovery
- Direct access to U.S. Analysis-Ready Data tiles
- **Continued growth in Landsat data access via more efficient processes**

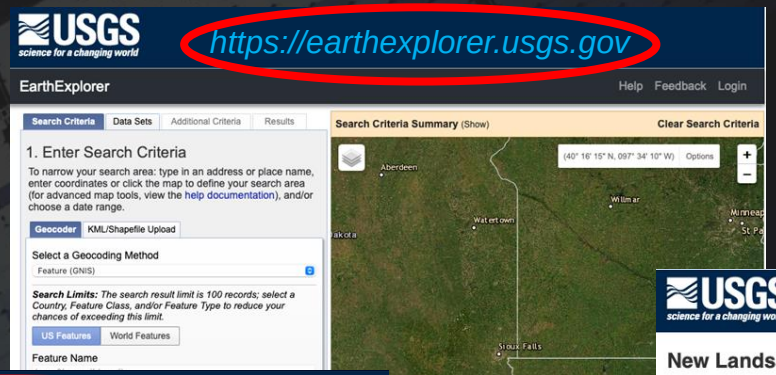
COG
Cloud Optimized Geotiff

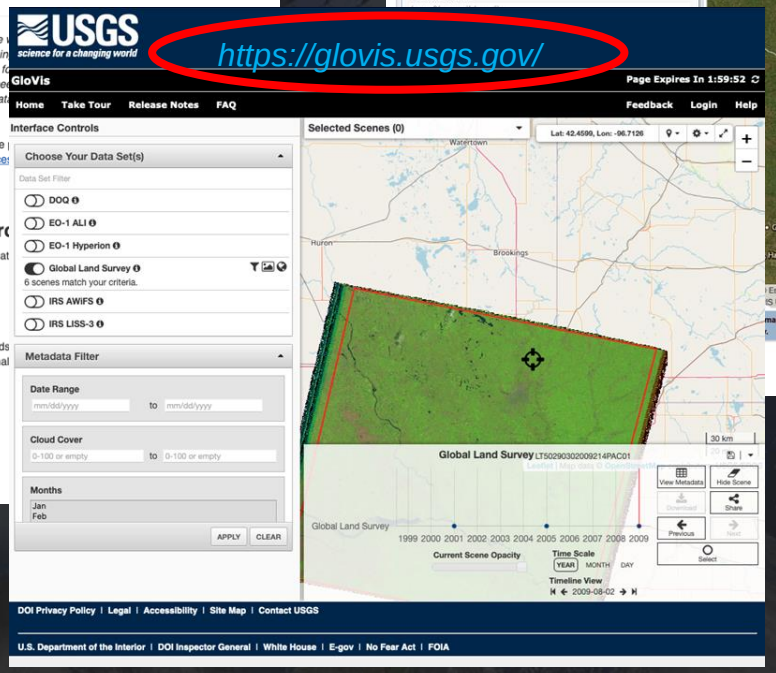
STAC
SpatioTemporal Asset Catalog

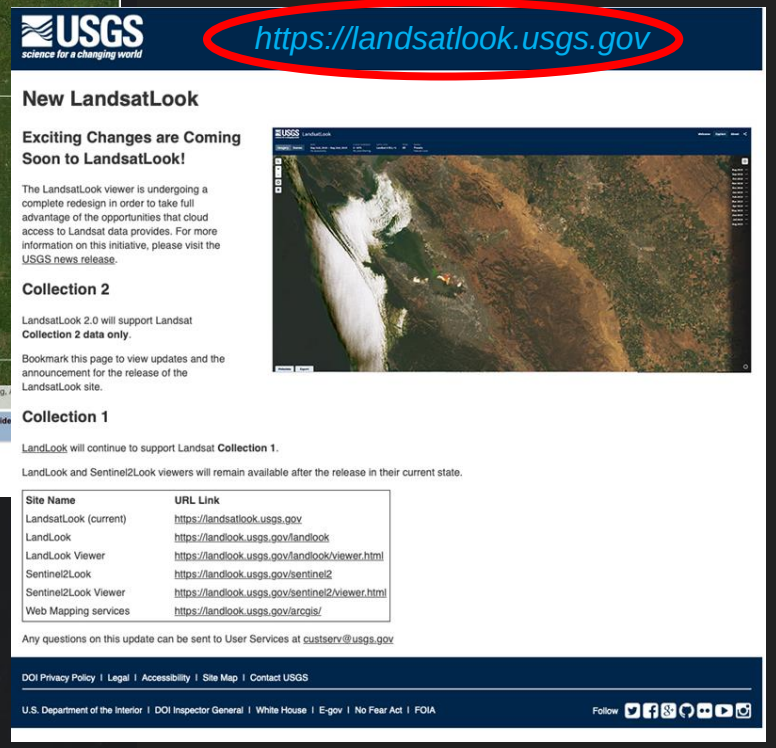


Free and Open Data Access: USGS Web Tools

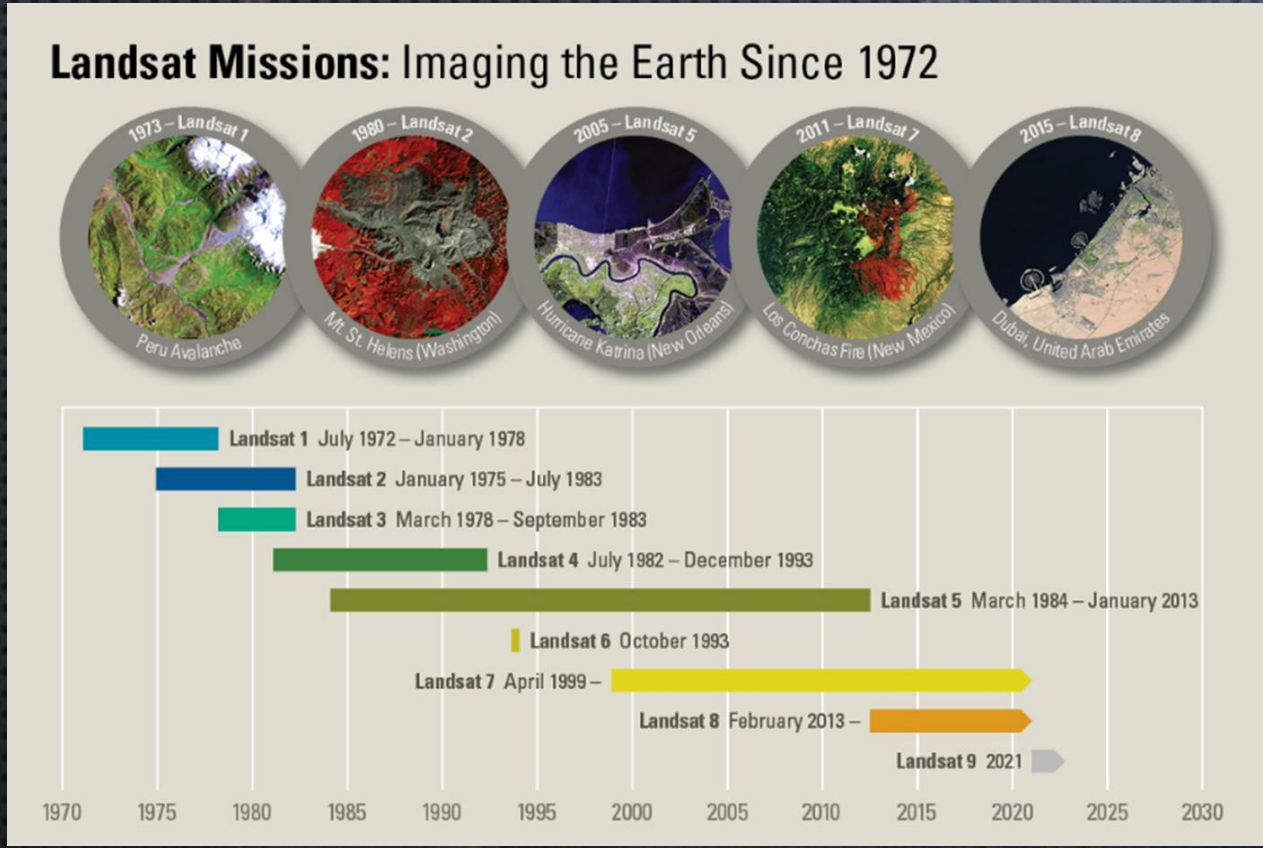






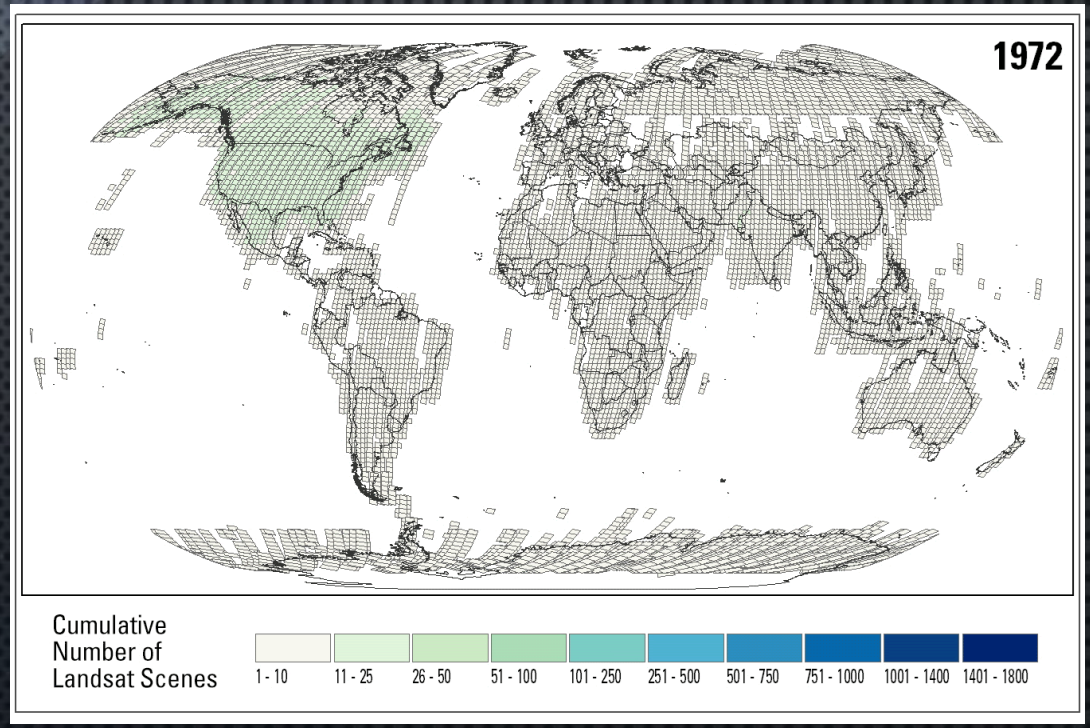


NASA – USGS Partnership



- ~5 Decades of land cover, land use, and vegetation information
- Large area coverage for global, continental and regional studies
- The most cited land-imaging satellite in peer-reviewed scientific literature, and the citation rate is increasing

NASA Satellite Development & Launch
USGS Ground System Development, Satellite Operations & Data Access

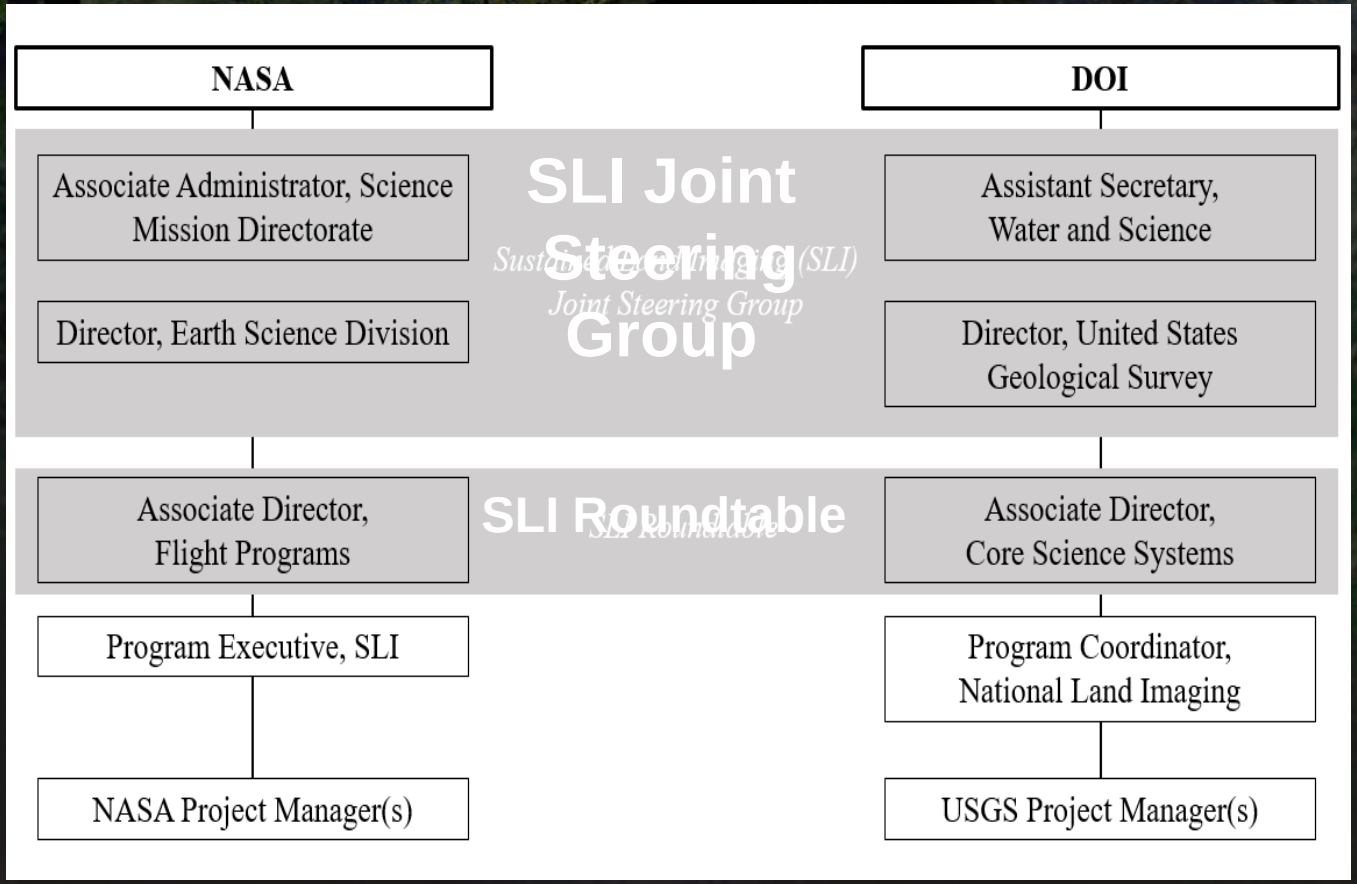


- Data archive contains 300 billion km^2
- Adds 50 million km^2 per day

USGS

Sustainable Land Imaging (SLI) Governance

- SLI: Joint program by which NASA and DOI/USGS ensure the continuation of the multi-decadal Landsat series of missions
- New ten-year agreement signed in December 2021
- Joint Steering Group: Top-level steering board to integrate SLI program efforts
- Roundtable: Mid-level executive review team to coordinate SLI activities



NASA/DOI Interagency Agreement for Collaboration on SLI Projects (2021)

Landsat Programmatics

Federal Landsat activities are funded from two Congressional committees:

- Commerce, Justice, Science and Related Agencies for all NASA Landsat funding
- Interior, Environment, and Related Agencies for all DOI/USGS Landsat funding

NASA Landsat funding is managed within the Sustainable Land Imaging program of the NASA Earth Science Division

- Development of the space and launch segments
- Technology development

DOI/USGS Landsat funding is managed within the National Land Imaging Program of the USGS Core Science Systems Mission Area

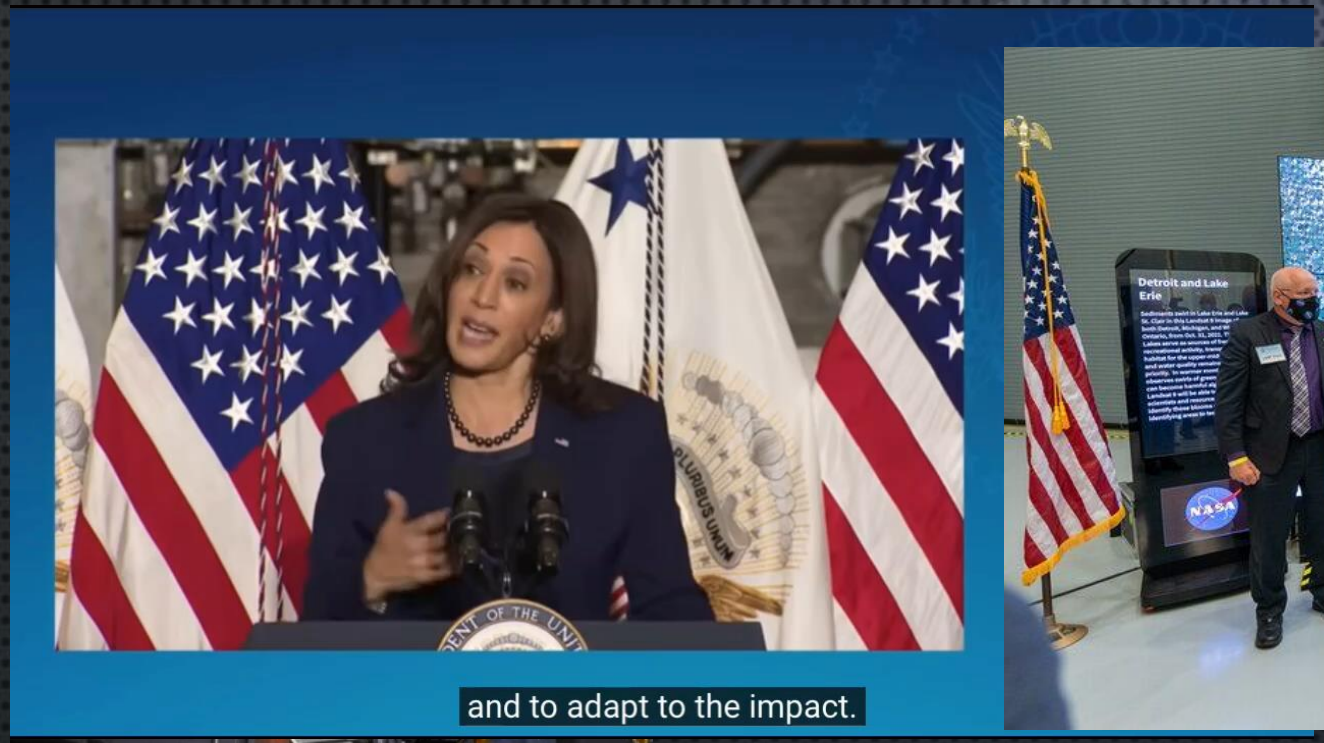
- Development & operation of the ground systems and flight operations
- Development and enhancement of Landsat products
- Collection and analysis of user requirements and capabilities

Landsat 9 – The First SLI Mission

Launched from Vandenberg SFB on September 27, 2021

Landsat 9 “First Light” image of an area of Florida near Eglin Air Force Base

Vice President Harris visit to NASA Goddard - 11/5/2021



VP Harris with USGS Director Applegate Viewing OSAM-1 demonstration with Landsat 7 mockup

NASA Goddard Director Andruczyk discussing first Landsat 9 images with VP Harris (view of SE Michigan, NW Ohio, W Lake Erie, and S Lake St Clair

Landsat Operations Status

Landsat 9 (2021 -)

Collecting up to 730 new scenes per day; full mission transition to USGS this summer

Landsat 8 (2013 -)

Collecting up to 730 new scenes per day; night and off-nadir imaging of volcano and fire imaging.

Landsat 7 (1999 - 2022)

Recently lowered into storage orbit; awaiting NASA satellite rendezvous and refueling

Earth Resources Observation and Science Center (EROS) - Sioux Falls, SD

Landsat Archive Operations

10 million unique Landsat scenes available in the near 50-year archive, with well over 100 million downloads since Landsat data become freely available in 2008.

Reprocessed “Collection 2” available on the Amazon Cloud.

Status of Landsat 8

- Landsat 8 is fully operational 9 years after its launch (2013)
  - Risk Class ‘B’ mission with a 5-year design life (TIRS instrument is Risk Class C, with a 3-year design)
- Landsat 8 has experienced issues with its Thermal Infrared Sensor (TIRS)
  - Stray light design issue and two failures of the scene select mirror encoder system; operational workarounds in place
- Landsat 8 Solar Array Drive Assembly (SADA) longevity is in question
  - Joint Polar Satellite System SADA life-test unit failed catastrophically at equivalent of 12 years of operation
  - Same unit as used on both Landsat 8 and pre-launch Landsat 9
  - Landsat 9 SADA then replaced with a known good unit; pulled SADA had the same issue as JPSS SADA
  - Landsat 8 SADA will reach 12 years of operation in 2025
- The Aerospace Corporation survey found that, on average, Class B missions survive approximately 12-15 years, and Class C missions 7-9 years
  - Landsat 8 will reach 15 years in 2028; TIRS already at 9 years
- Loss of Landsat 8 would reduce revisit to 16 days; significant impact to many user applications
  - Evapotranspiration, critical for water management; Climate change and Cryospheric science, Fire monitoring
  - Sentinel-2 can mitigate, but lack of concurrent thermal imagery hampers continuity of observations

USGS

LANDSAT NEXT launch date needs to minimize chance of gap in weekly Landsat data

Sustainable Land Imaging into the Future (NASA-DOI/USGS)

Celebrating 50 YEARS of Landsat 1972-2022

Landsat 7

1999 - present

Landsat 8

2013 - present

Landsat 9

2021 -

Landsat Next

Late-2020s

+

Commercial/Interagency/ International Partnerships

OSAM-1 (On-orbit Servicing, Assembly, and Manufacturing)

Mid-2020s

Sustainable Land Imaging

USGS

NASA

Landsat Next Requirements Meet Emerging Needs

Multi-spectral → Super-spectral

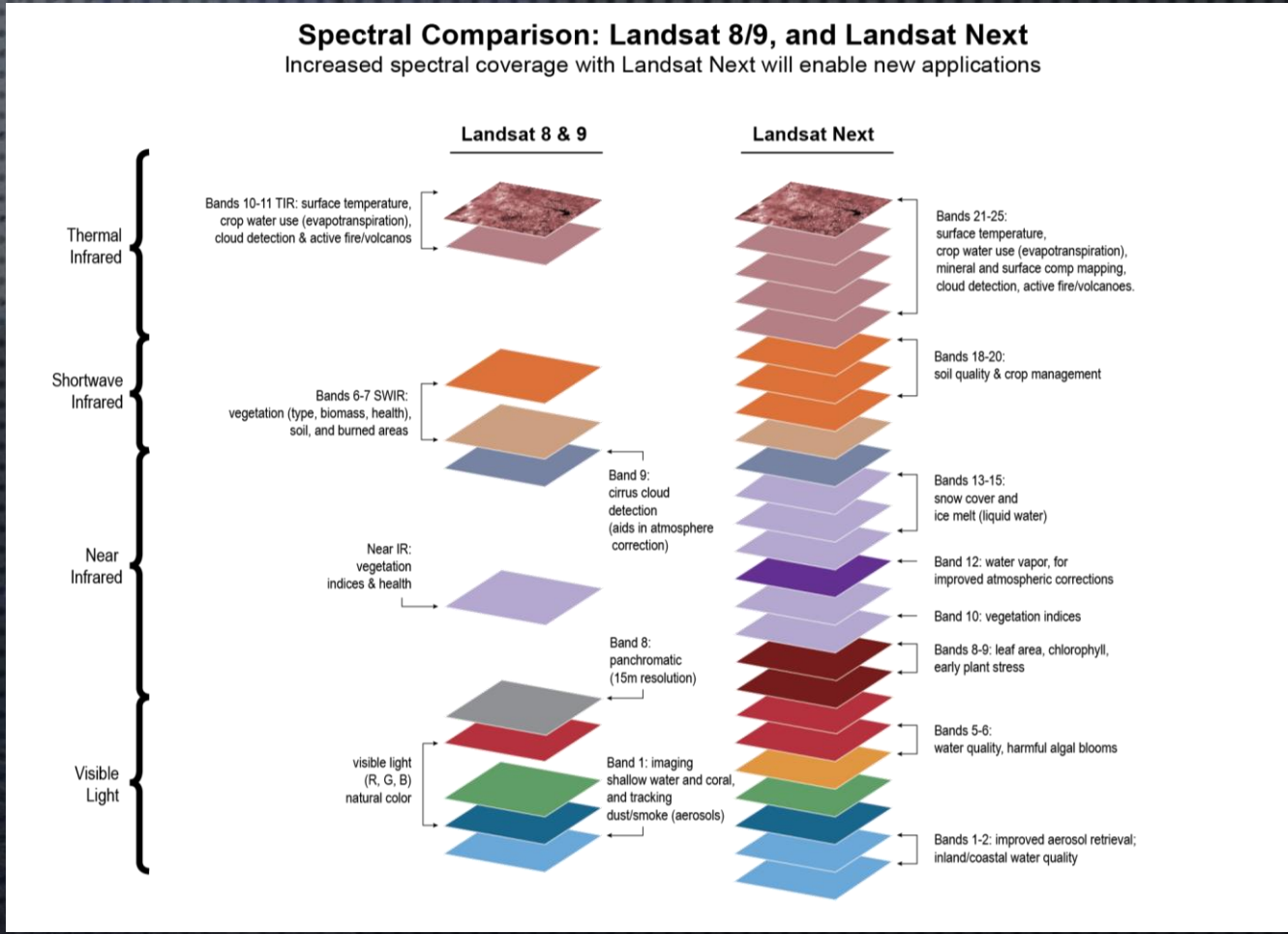
User need surveys provided a clear set of priorities for Landsat Next requirements to meet emerging needs at breakthrough effectiveness:

Improved Revisit Frequency. Dynamic phenomena (crop health & productivity, water quality, snow/ice state, wildfire) which require ~weekly clear views.

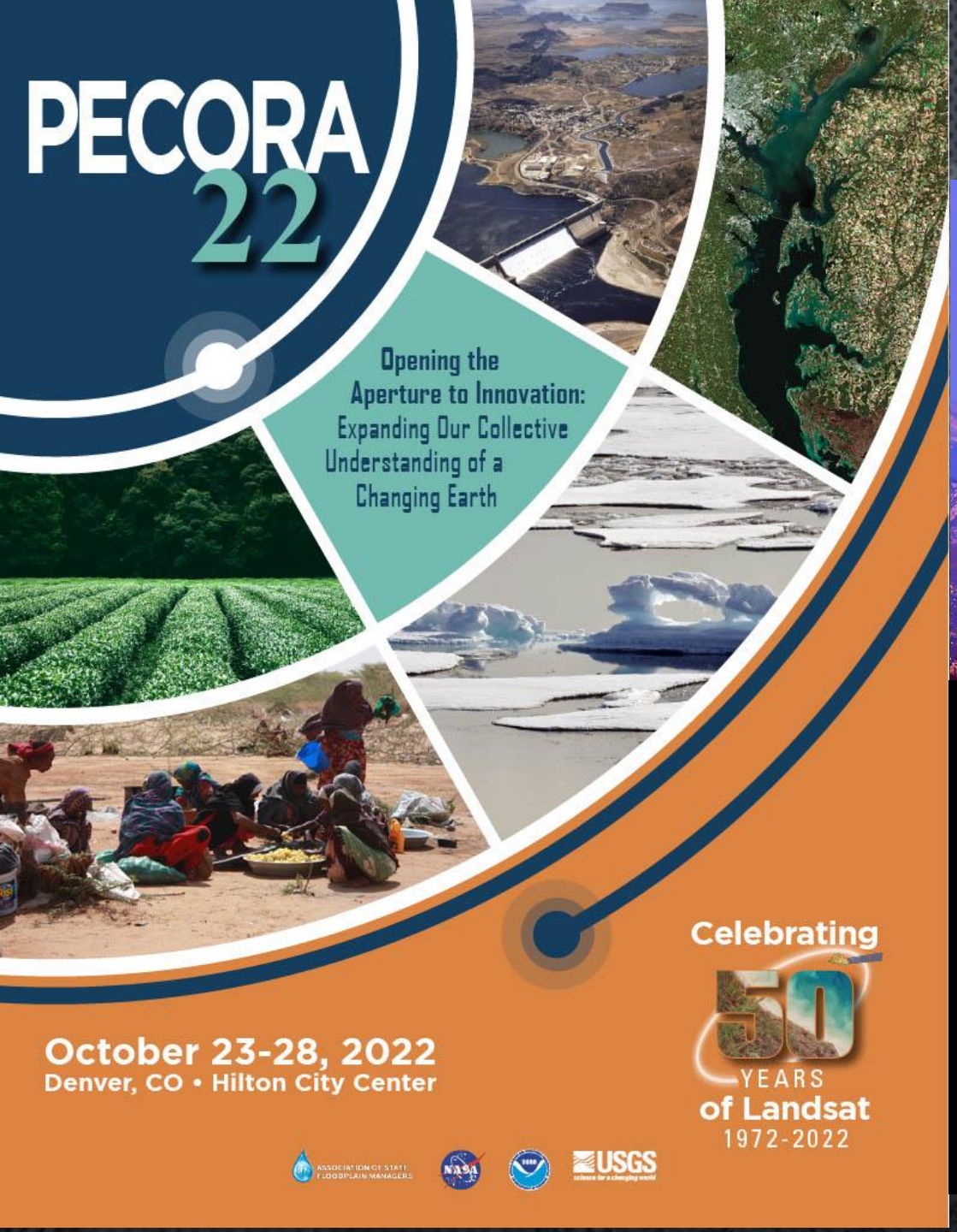
Higher Spatial Resolution. Experience with Sentinel-2 has underscored importance of 10-meter data for monitoring small agricultural fields, forest disturbance, urbanization, and other applications.

Additional spectral bands to support emerging applications in water quality, snow hydrology, soil mapping, and other areas.

Maintaining radiometric quality established by Landsat 8/9



Landsat Next will provide more than twice as many spectral bands, with resolution improved by a factor of 2, and with the repeat coverage of Landsats 8 and 9, *combined*



Pecora-22: October 23-28, 2022

Denver, Colorado

Celebrating 50 YEARS of Landsat

- Flagship land-imaging satellite applications conference; longstanding USGS-NASA partnership
- Highlights Landsat's 50th anniversary
- Features Landsat 9, Landsat Next and the many innovative developments in government and commercial land-imaging programs
- Inviting Secretary Haaland and NASA Administrator Nelson for Plenary & Evening Celebration on the 26th

Thank You!

tstryker@usgs.gov

Landsat 9 Image
Betsiboka River, Madagascar
December 7, 2021

ECOLOGICAL FORECASTING INTRODUCTION

Dr. Keith Gaddis
Program Manager
Ecological Forecasting Program

EARTH SCIENCE
APPLIED SCIENCES

Ecological Forecasting

Strengthening Ecosystems

Keith Gaddis, Program Manager

EUROPE

EARTH SCIENCE
APPLIED SCIENCES

SERVIR-Amazonia Guyana Mangrove Monitoring Service

Kelsey E. Herndon

August 9, 2022

EARTH SCIENCE
APPLICATIONS WEEK 2022

Guyana's Mangroves

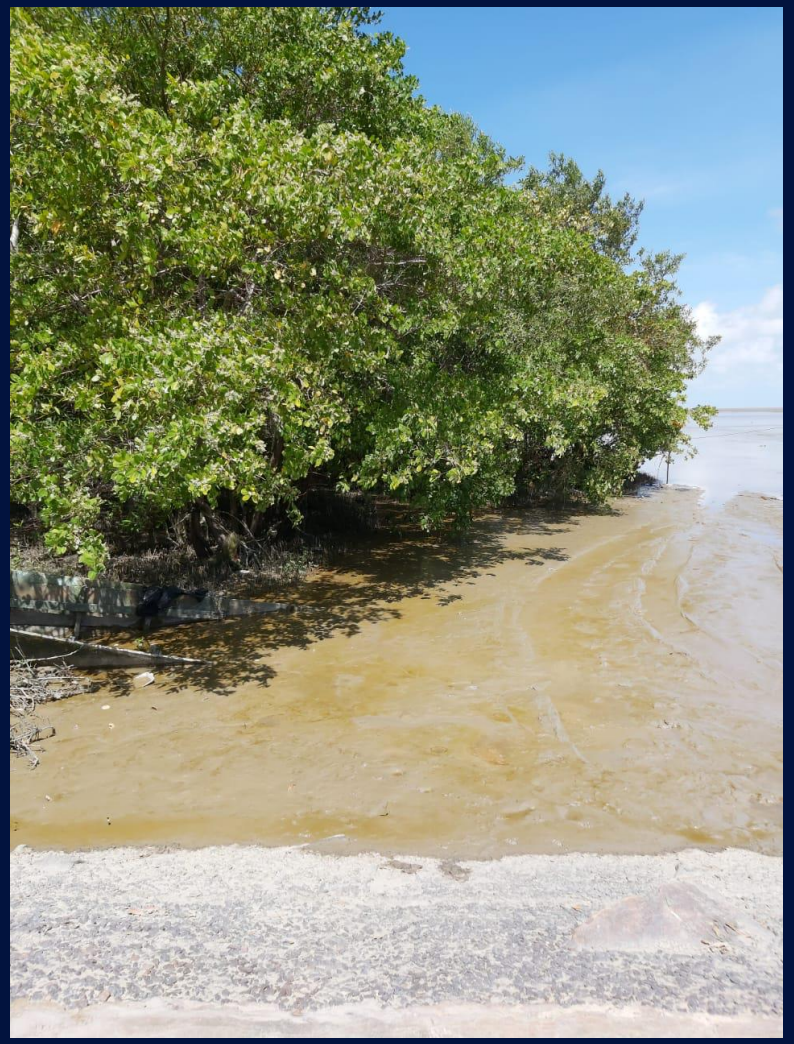


Photo c/o NAREI

- Coastal mangrove ecosystem
- Supports ocean defense, carbon sequestration, livelihoods, biodiversity
- Guyana's mangroves are under threat from agricultural and urban development and natural mud flat dynamics
- Guyana's **National Agricultural Research and Extension Institute (NAREI)** has the mandate to monitor and restore this important ecosystem

Service Objectives

Photo c/o NAREI

- Develop a **tool** to continuously monitor the extent and health of Guyana's coastal mangroves on an annual basis
- Provide a **transparent source of information** on the status of Guyana's mangroves
- Support NAREI as the expert source on all things pertaining to Guyana's mangroves by **building their expertise in cloud computing and remote sensing**

Guyana Mangrove Monitoring Service

- Series of **NASA-led trainings** on using SAR + Optical to monitor mangroves
- Tool **co-developed** with NAREI, SAMZ, NASA
- **Google Earth Engine**-based mangrove classification
- Web-based **GUI** in development

Photo c/o NAREI

Results: Tracking Deforestation of Coastal Mangroves

Photo c/o NAREI

Map c/o NAREI

- Preliminary results indicate +3000 ha mangroves lost between 2015 and 2020
- Large tracts of mangrove removal due to coconut farms confirmed during field validation

Results: Monitoring NAREI's Mangrove Restoration Sites

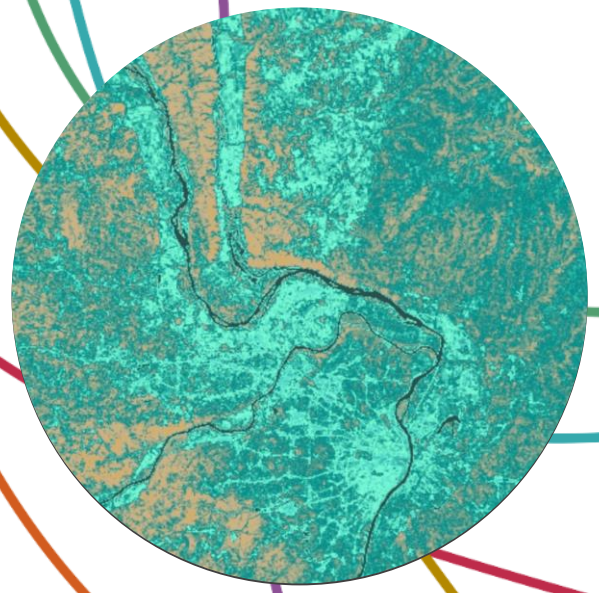
- NAREI initiated a mangrove restoration program in 2010
- Interventions applied at 22 sites between 2010 and 2020
- Significant increase in mangrove extent (177 ha) for 75% of restoration sites evaluated in pilot region

Next Steps

- Work with S-CAP to model biomass/carbon stocks
- Evaluate changes in forest fragmentation
- Better understand the impact of mud flat dynamics
- Release public data dashboard

For questions contact Kelsey E. Herndon via kelsey.e.herndon@nasa.gov

Lower Illinois Ecological Forecasting



Inundation Mapping of the Lower Illinois River Valley Using Synthetic Aperture Radar and Optical Satellite Imagery for Wetland Conservation and Restoration Prioritization Efforts

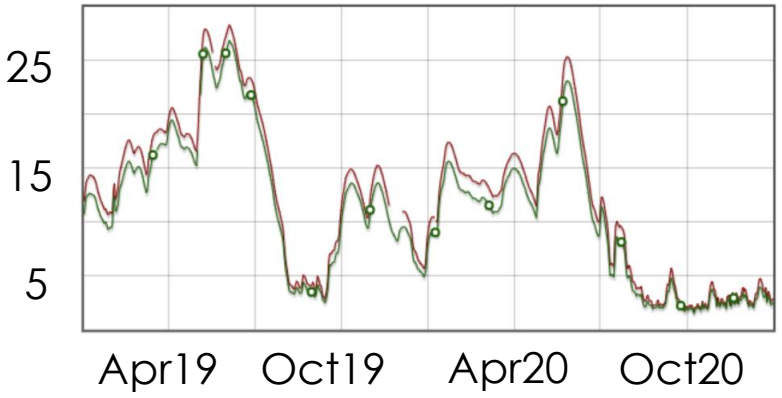
TEAM: Hannah Rigdon, Vanessa Machuca, Dana Myers, Christiana Saldana

ADVISORS: Dr. Bruce Chapman, Benjamin Holt

EARTH SCIENCE
APPLICATIONS WEEK 2022

Methodology: Thresholding

river gage
(height, ft)

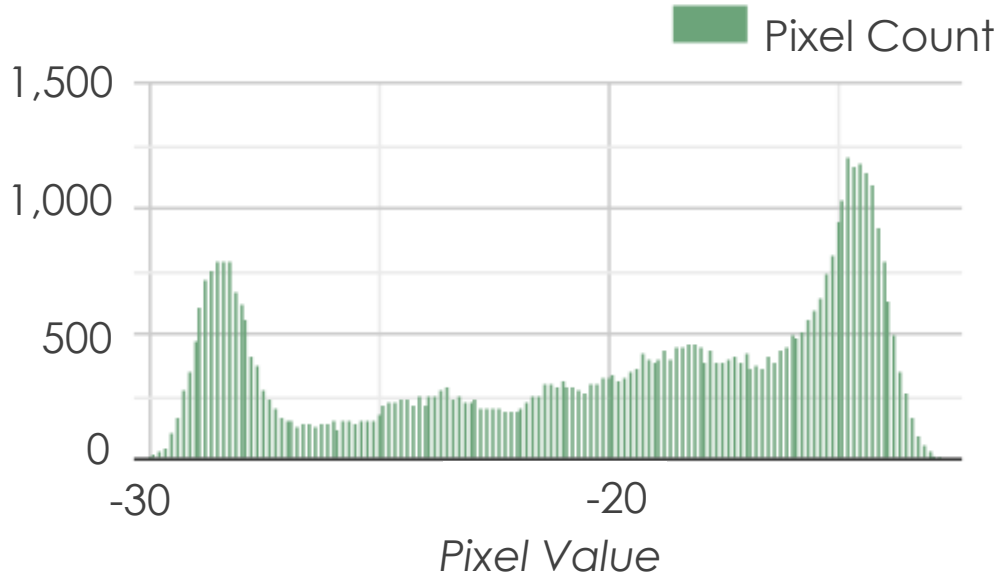


open water

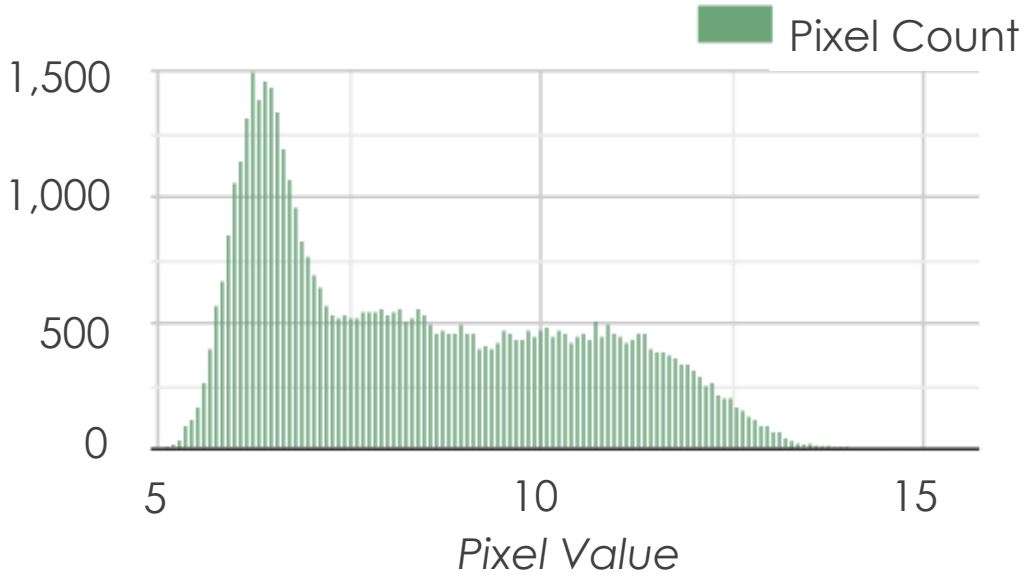
inundated vegetation

not inundated vegetation

Sample Site VH



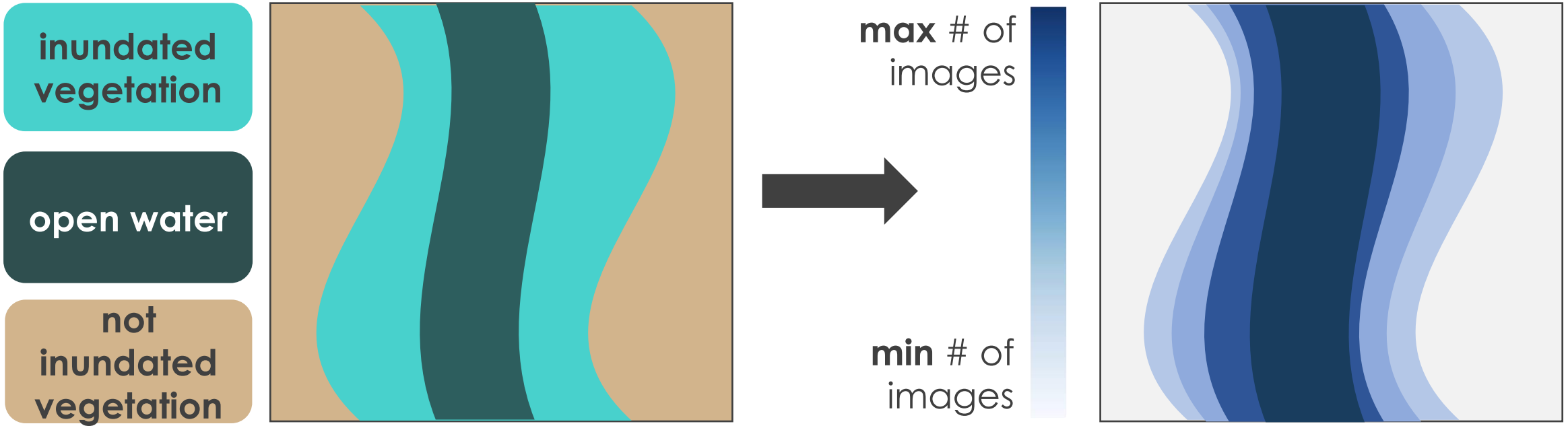
Sample Site VV/VH



Methodology: Generating Inundation Duration

count the number of times a pixel is classified as **inundated vegetation** and/or **open water** across a period

Classification



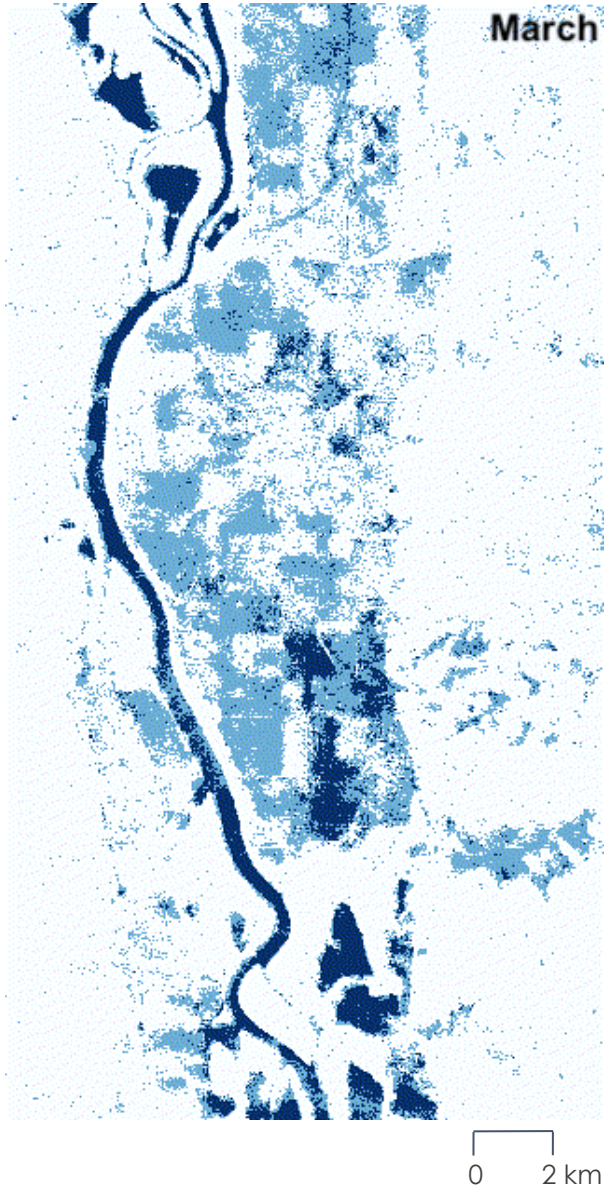
Results: 2019-2020 Inundation Extent/Duration

Inundation Extent:

Wet land both years

Wet land 2019 only

Dry land



Inundation Duration (2019):

100 % of the month

0 % of the month

DEVELOP & NPS Collaboration

- DEVELOP has partnered with NPS on over 70 projects addressing a multitude of topics:
  - vegetation and landscape disturbance
  - species habitat & invasive species modeling
  - water quality measurements
  - air quality monitoring
  - precipitation patterns and snowpack
  - wildfire fuel loading & wildfire smoke monitoring
  - monitoring cultural resources
  - modeling light pollution

- DEVELOP conducted 4 projects this summer

DEVELOP & NPS Collaboration

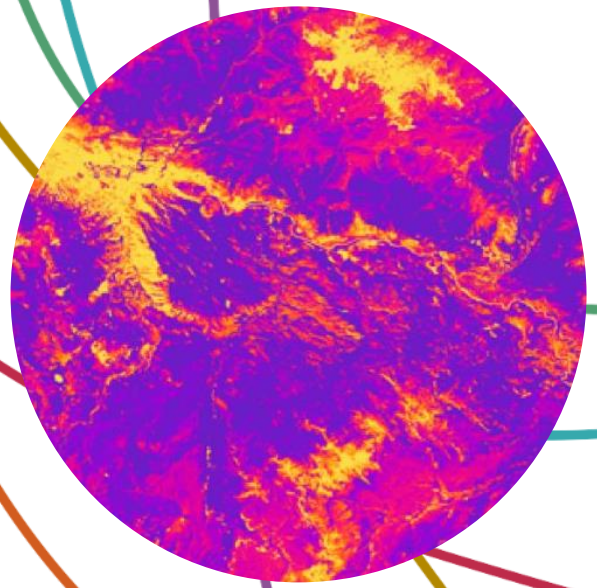
Randy Stanley

NPS Colorado Office (DOI Regions 6-8)
NR Funding & Reporting Coordinator

Image Credit: National Park Service / Dan Duriscoe

Yellowstone Ecological Forecasting

Assessing Change in Aspen Extent in Northern Yellowstone National Park



TEAM: Vanessa Bailey, Gabriella Boodhoo, Barry McLaughlin, Kyle Steen

ADVISORS: Dr. Marguerite Madden, Dr. Kunwar Singh

EARTH SCIENCE
APPLICATIONS WEEK 2022

Aspen in Yellowstone

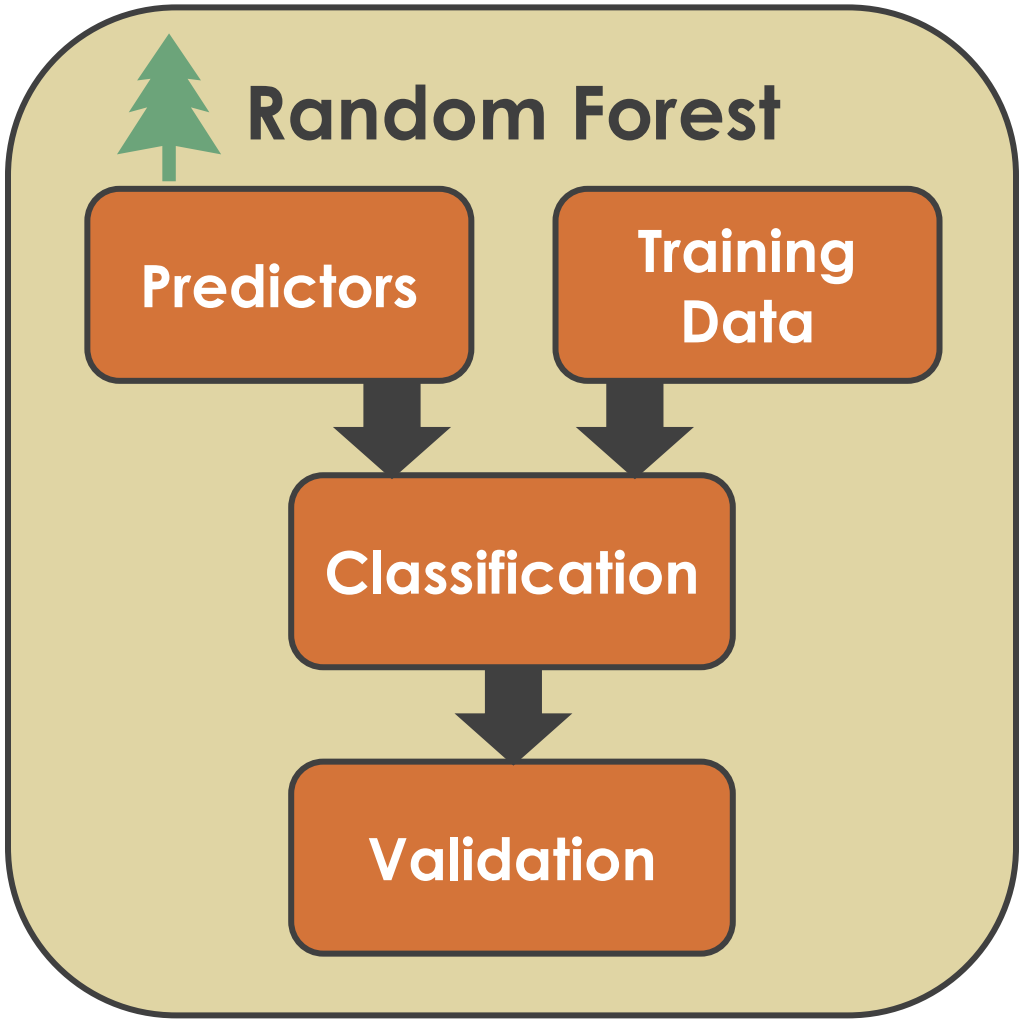
- Keystone species
- Ecosystem services at risk

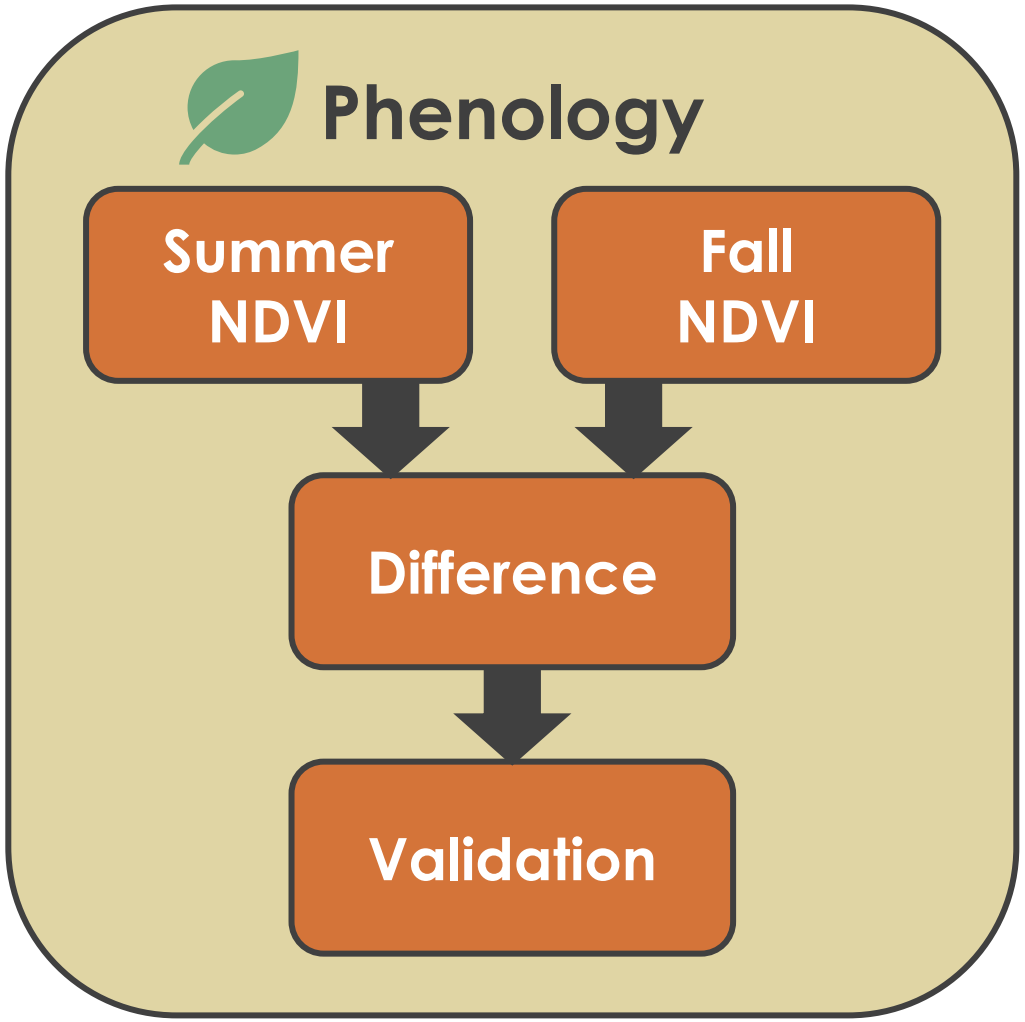
Objectives

- Determine aspen extent over time

Image Credit: Tranquiligold Jin

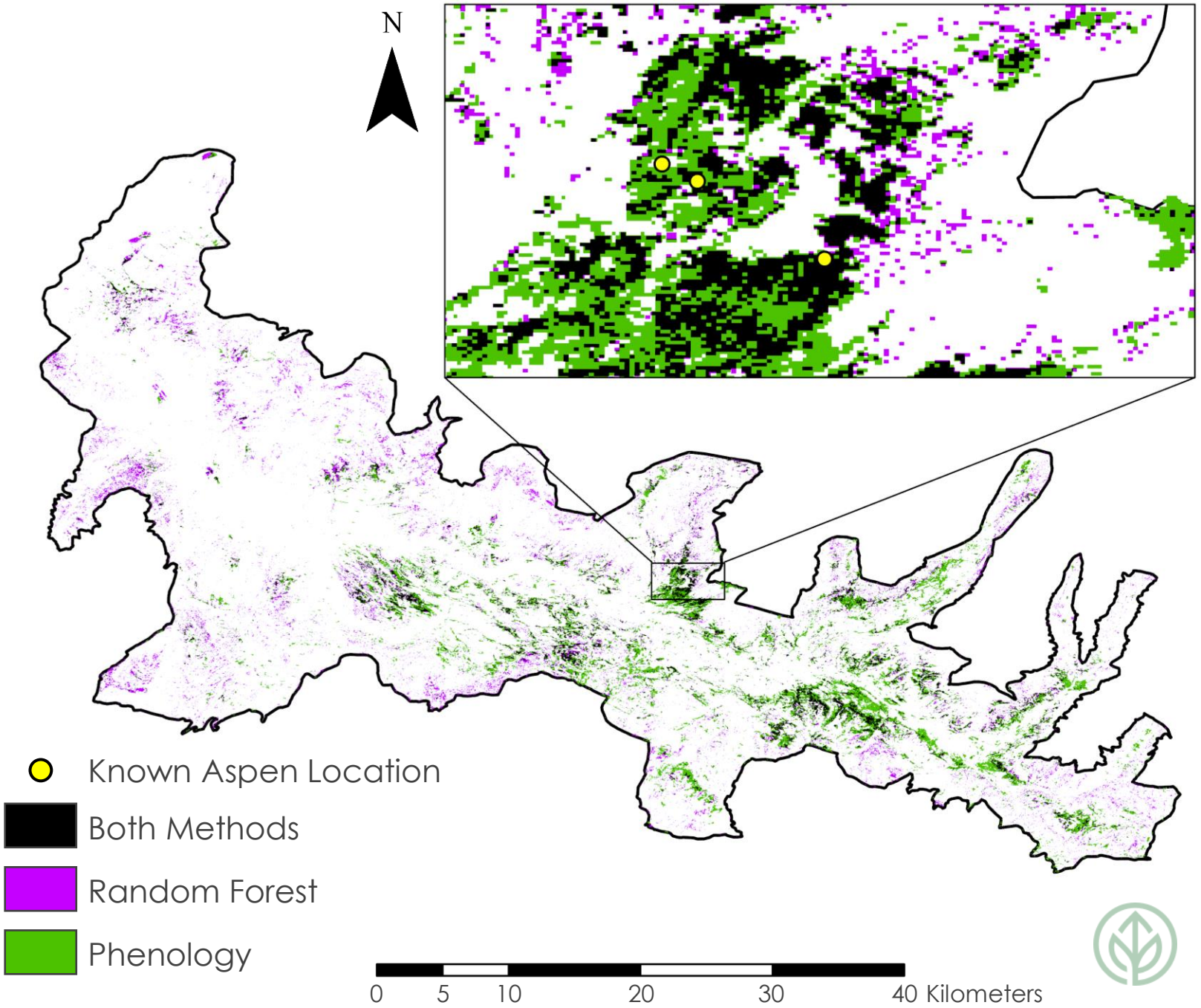
Methodology





Results & Conclusions

- Aspen expanded in some areas and contracted in others
- Methods identified different aspen extents
- Improved understanding of trophic cascades

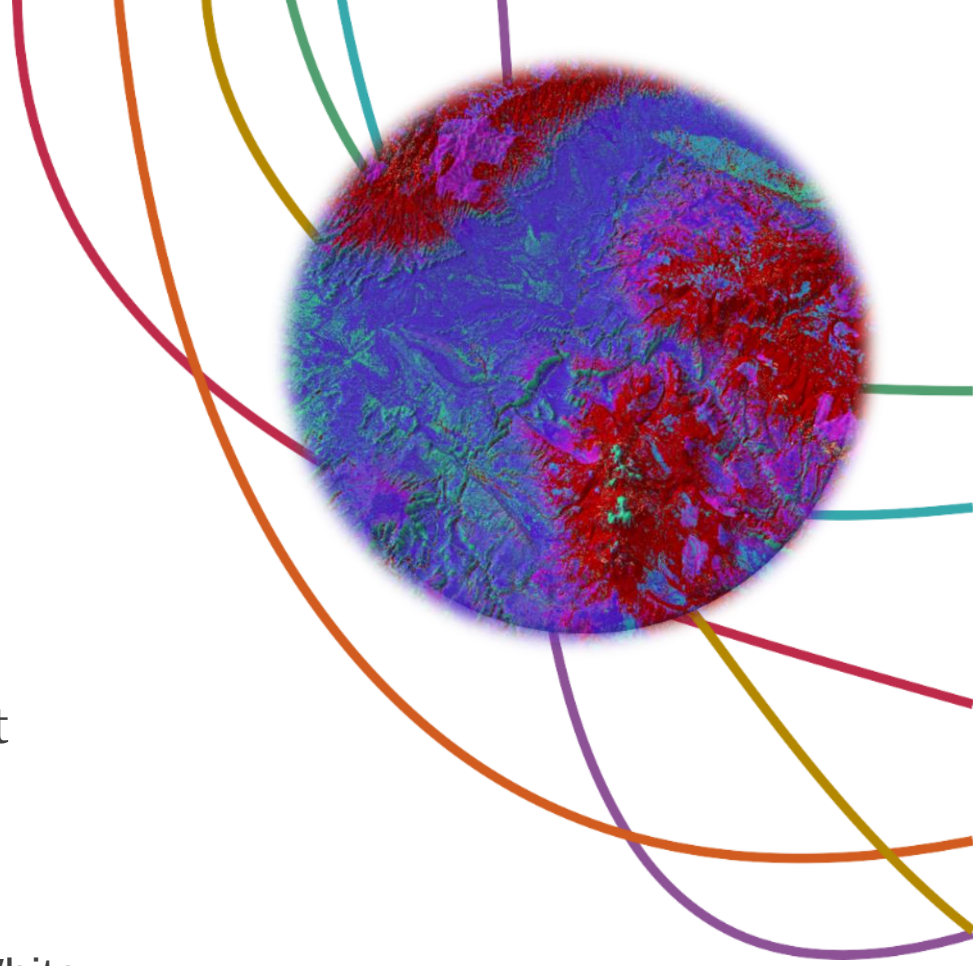


Grand Valley Ecological Forecasting

Forecasting Trends in Pinyon-Juniper and Sagebrush Habitat Relative to Wildfire, Drought, Beetle Disturbance, and Treatment Impact for Management Planning

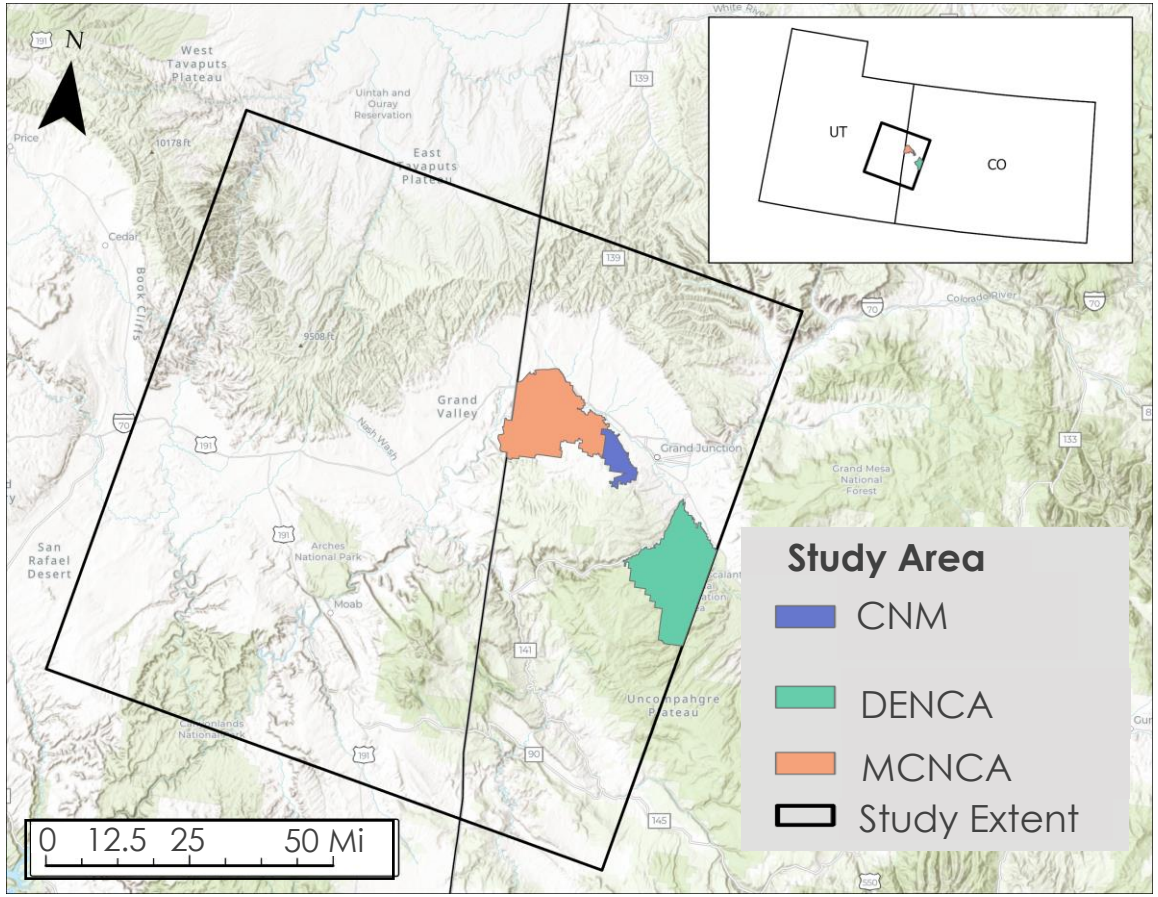
TEAM: William Curtiss, Sambadi Majumder, Rhea Martinez, Aliza White

ADVISORS: Keith Weber, Joseph Spruce



EARTH SCIENCE
APPLICATIONS WEEK 2022

PROJECT SUMMARY



Study Area:

- **Colorado National Monument (CNM) (NPS)**
- McInnis Canyons National Conservation Area (MCNCA) (BLM)
- Dominguez-Escalante National Conservation Area (DENCA) (BLM)

Objectives:

Forecast future landcover change

Field validate vegetation decline

METHODOLOGY

Predictor Variables

- Elevation
- Annual Temperature
- Aspect
- Precipitation

Response Variable

- Normalized Difference Vegetation Index (NDVI)

Training Data 1987–2013

Training Data Informs:

- Random Forest Regressor Algorithm
- Target Oriented Cross-Validation

Evaluation 1

Use R-squared to evaluate the variation in training data and compute the importance of variables.

Test Data 2014–2020

Evaluation 2

Apply the trained model on the test data to evaluate the forecasting ability of the model and check for overfitting.

Idrisi TerrSet Land Change Modeler (LCM)

RESULTS AND FIELD VALIDATION

- **Shrubs** had the greatest losses in CNM & MCNCA
- **Trees** had the greatest gains in CNM & MCNCA
  - Nearing complete conversion of **shrubs → trees** within CNM perimeter by 2040

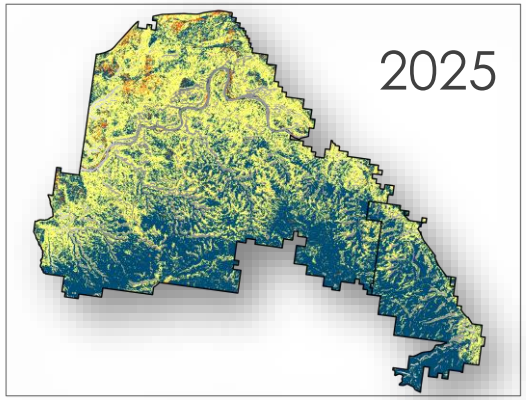
Shapefile + Survey123

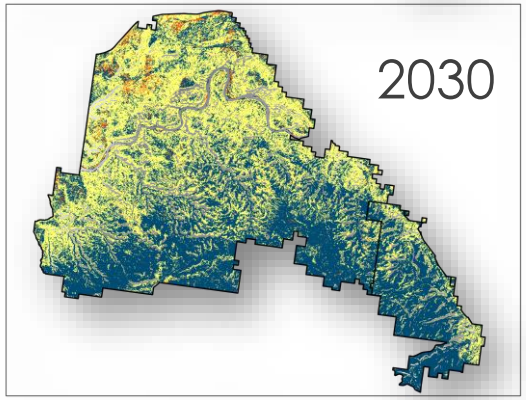
↓

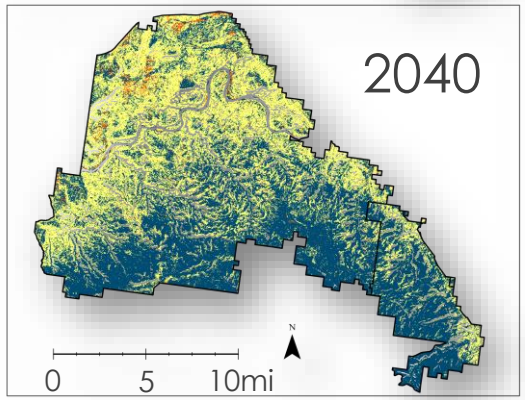
Ground validation of possible beetle infestation points

↓

Identify healthy vegetation control points



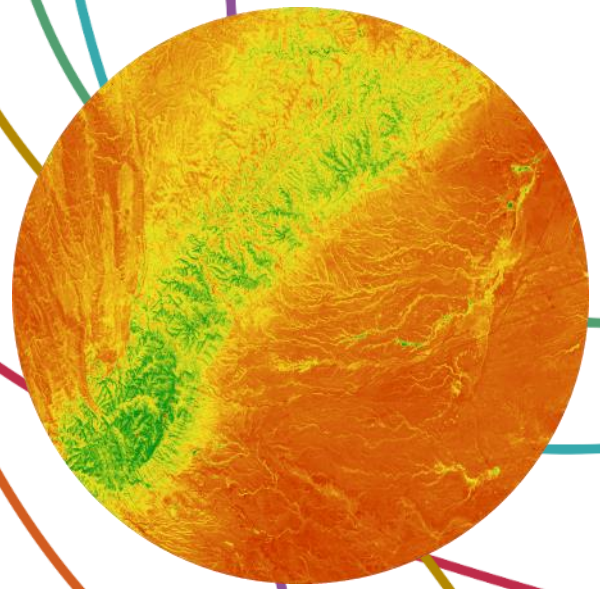




Tree Shrub Grass & Forb

Delaware Basin Ecological Forecasting

Identifying Vegetation Trends and Atmospheric Stressors in the Guadalupe Mountains and Carlsbad Caverns National Parks



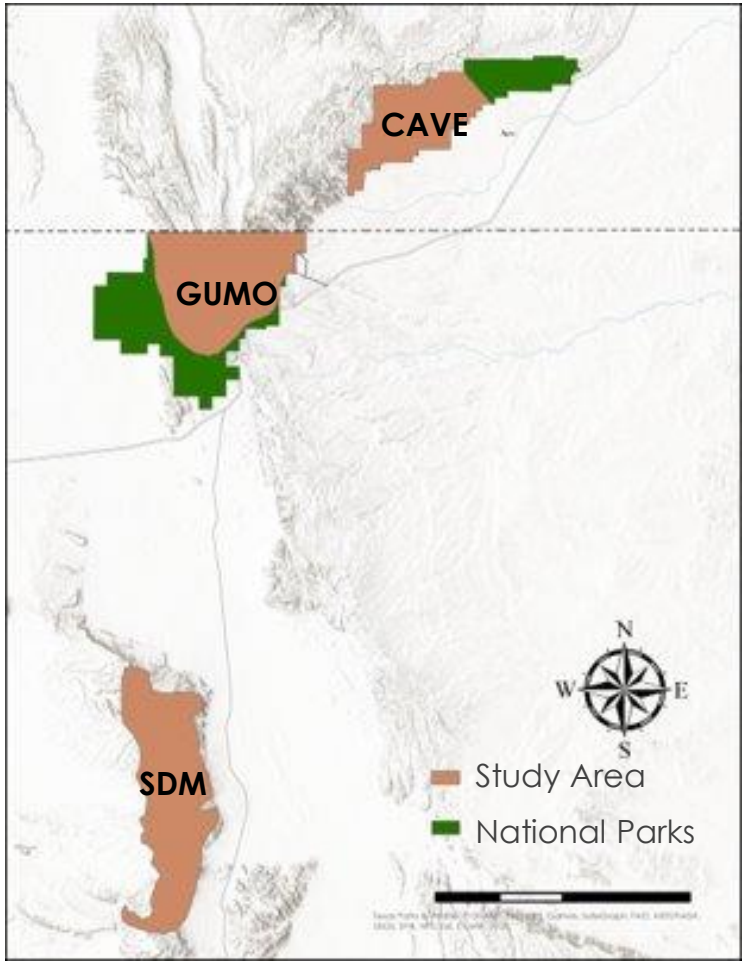
TEAM: Gillian McNamara, Jack Mezger, Mark Bossinger, Quinn Heiser

ADVISORS: Joseph Spruce, Dr. Kenton Ross, Dr. Elizabeth Wiggins

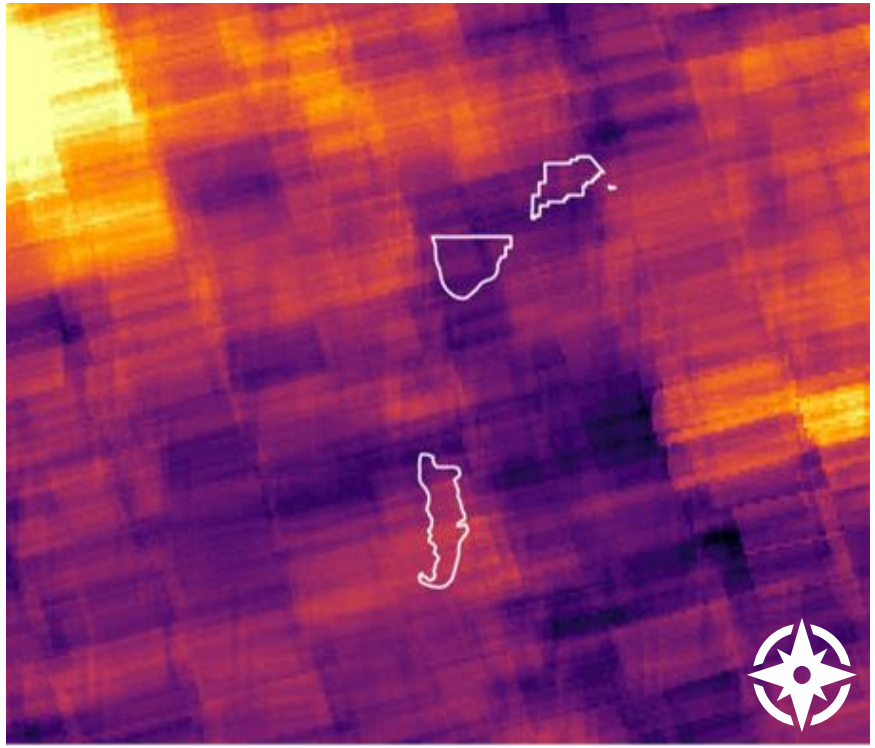
EARTH SCIENCE
APPLICATIONS WEEK 2022

COMMUNITY CONCERNS & PARTNERS

Study Areas & Reference Area



Spring 2011 NO_2 - OMI



Molecules/cm^2

National Park Service Intermountain Region

Guadalupe Mountains National Park **(GUMO)**

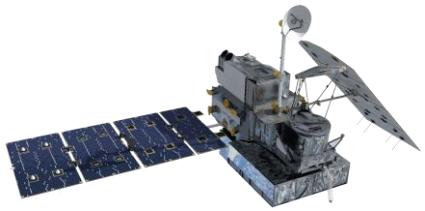
Carlsbad Caverns National Park **(CAVE)**

Partner Concerns:

- Vegetation degradation due to NO_2 pollution
- Vegetation degradation due to drought
- Decline in park tourism

METHODOLOGY

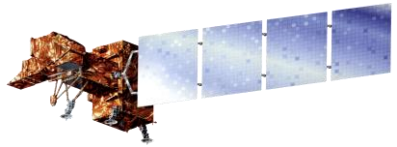
GPM IMERG
2010-2021



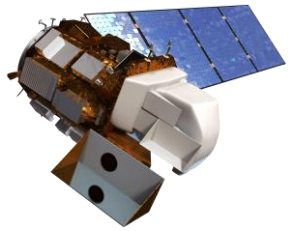
Download	Download monthly data 2010 – 2021
Aggregate	Aggregate precipitation to study area
Create	Create line graphs showing precipitation time series

Landsat 5 TM
2010-2012

Landsat 7 ETM+
2012-2013



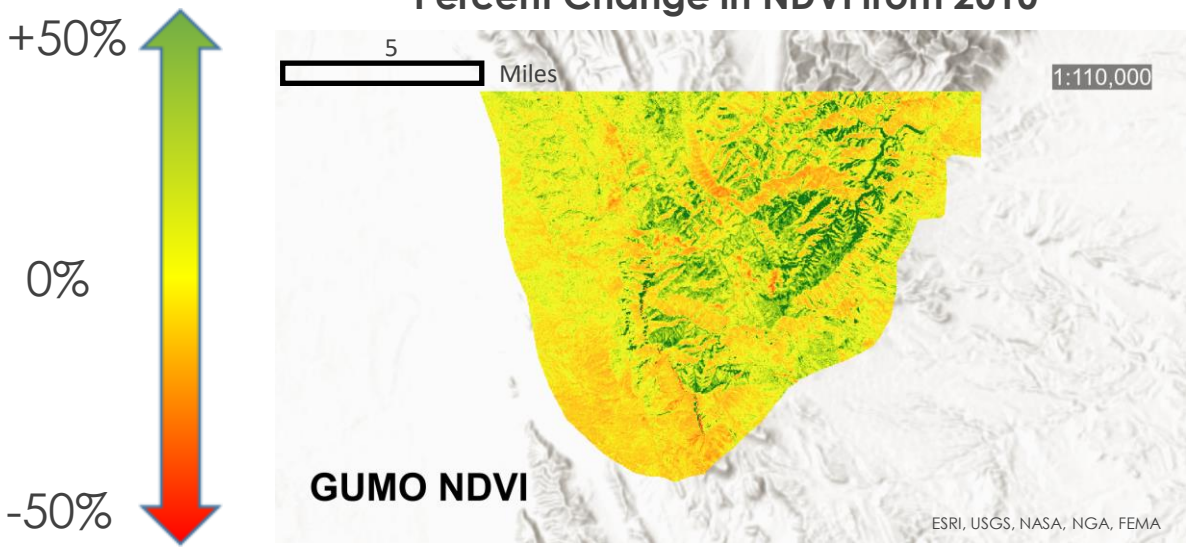
Landsat 8 OLI
2013-2021



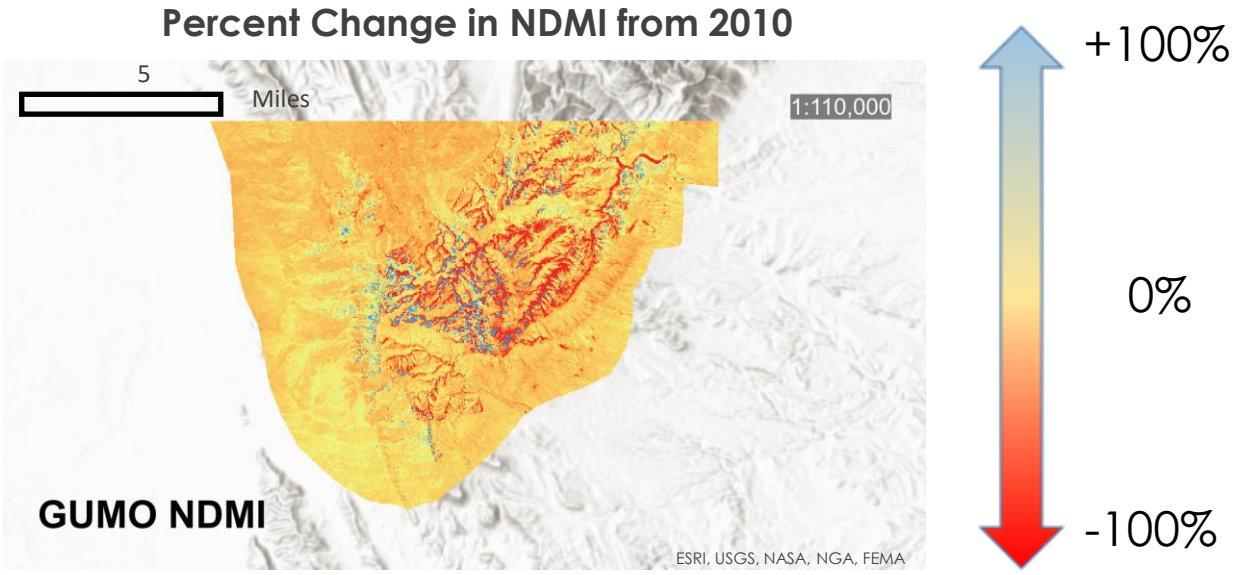
Download	Download seasonally 2010–2021
Derive	Derive NDVI and NDMI
Clip	Clip to study area
Create	Create yearly change detection maps

RESULTS & CONCLUSION

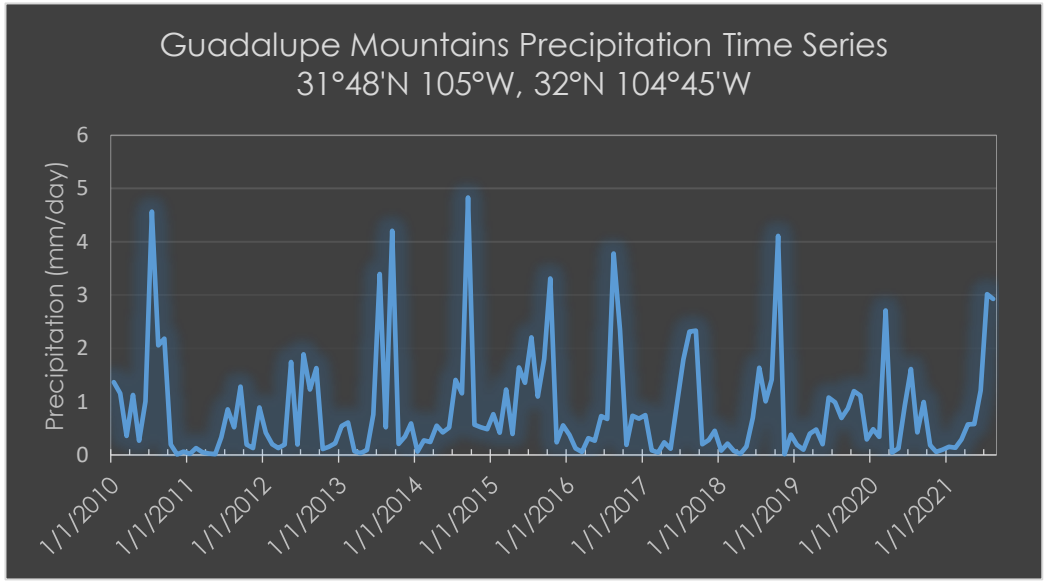
Percent Change in NDVI from 2010



Percent Change in NDMI from 2010



- Potential effects of **NO_2 plumes** on vegetation are inconclusive
- Increasing **water stress**
- Decreasing **precipitation**
- Trends in **elevation** and **vegetation type**

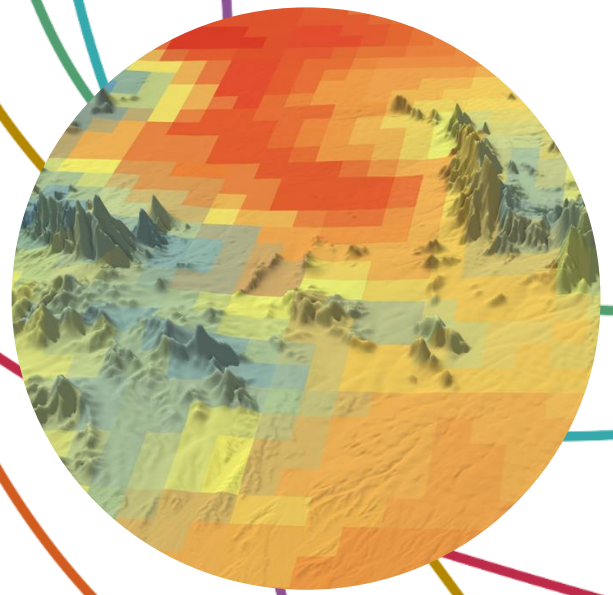


Western Sonoran Desert Water Resources

Evaluating Rock Pool Hydroperiod Fluctuation using Climate Variables to Inform Habitat Monitoring and Protection in the Western Sonoran Desert

TEAM: Anne Britton, Charles Nixon, Deirdre An, Seamus Geraty

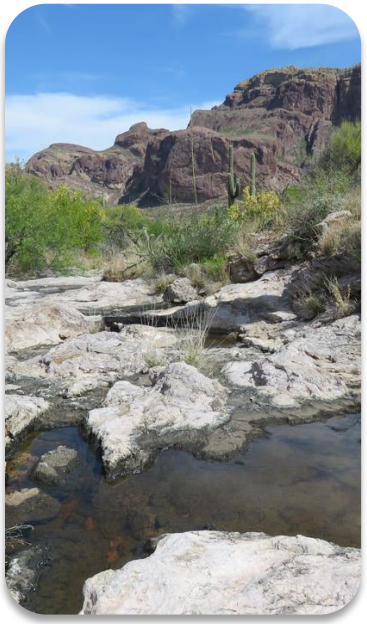
ADVISORS: Dr. Douglas Rao, Molly Woloszyn



EARTH SCIENCE
APPLICATIONS WEEK 2022

Community Concerns & Project Partner

Climate trends lead to shorter hydroperiods



Biodiversity hotspots with limited research

Key feature for the Tohono O'odham Nation

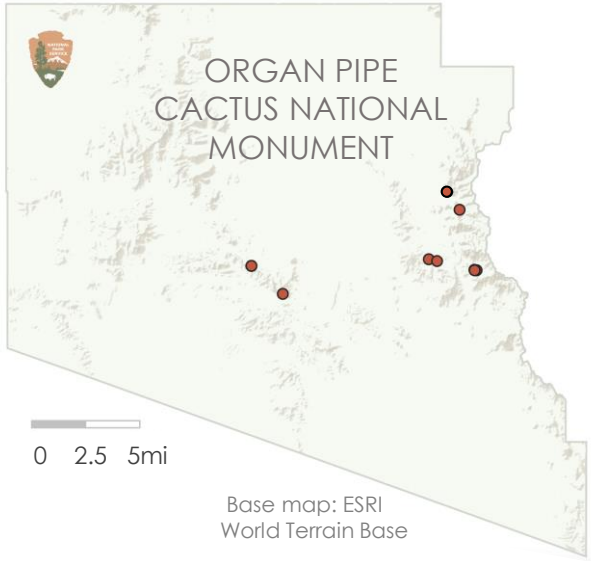
Increased stress on organisms

Image Credit: Susan Washko; NPS (right)

SONORAN DESERT

ORGAN PIPE CACTUS NATIONAL MONUMENT

TINAJA LOCATION



Base map: ESRI World Terrain Base

Methodology & Results

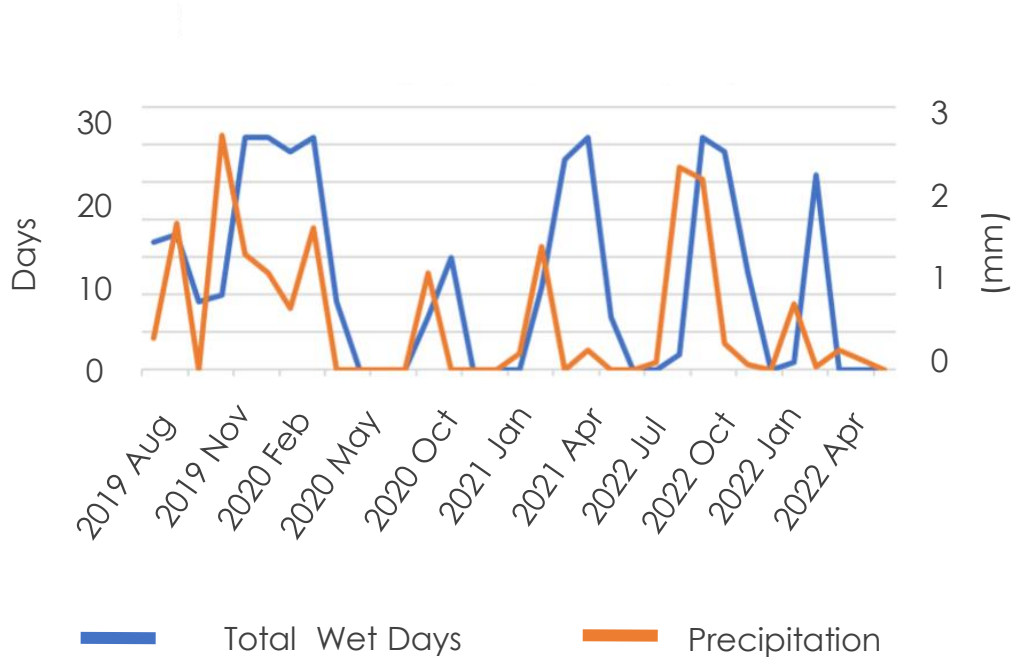
Hydroperiod Trend Analysis

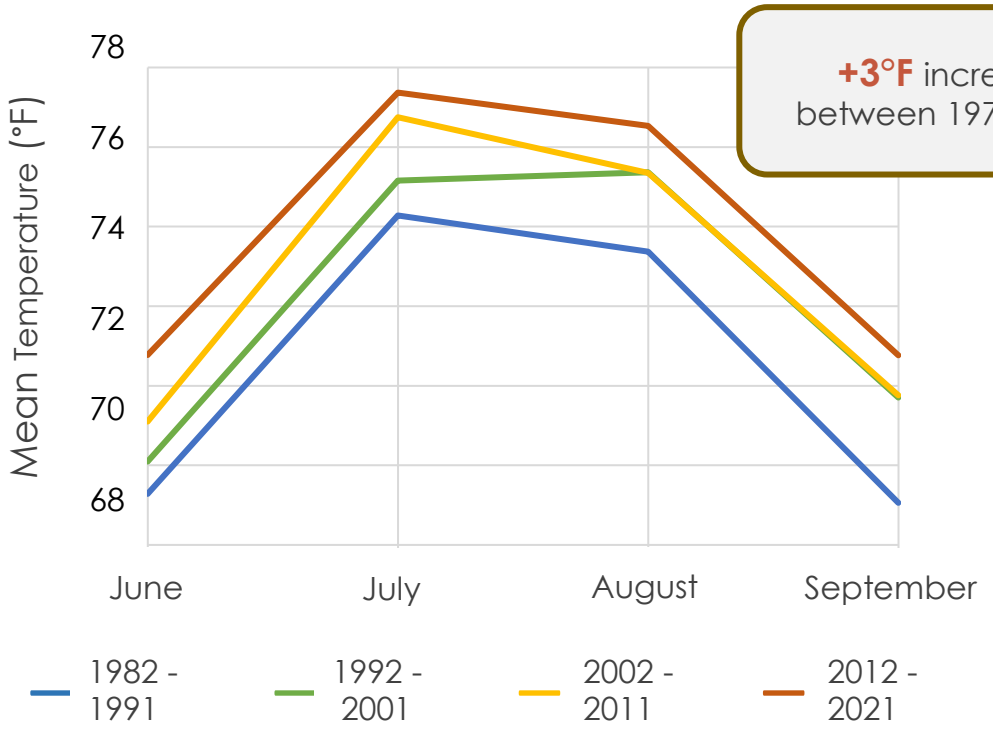
2019 → 2022
in situ data & OpenET

Climatology Maps and Timeseries

1979 gridMET → 2022

2002 MODIS → 2022

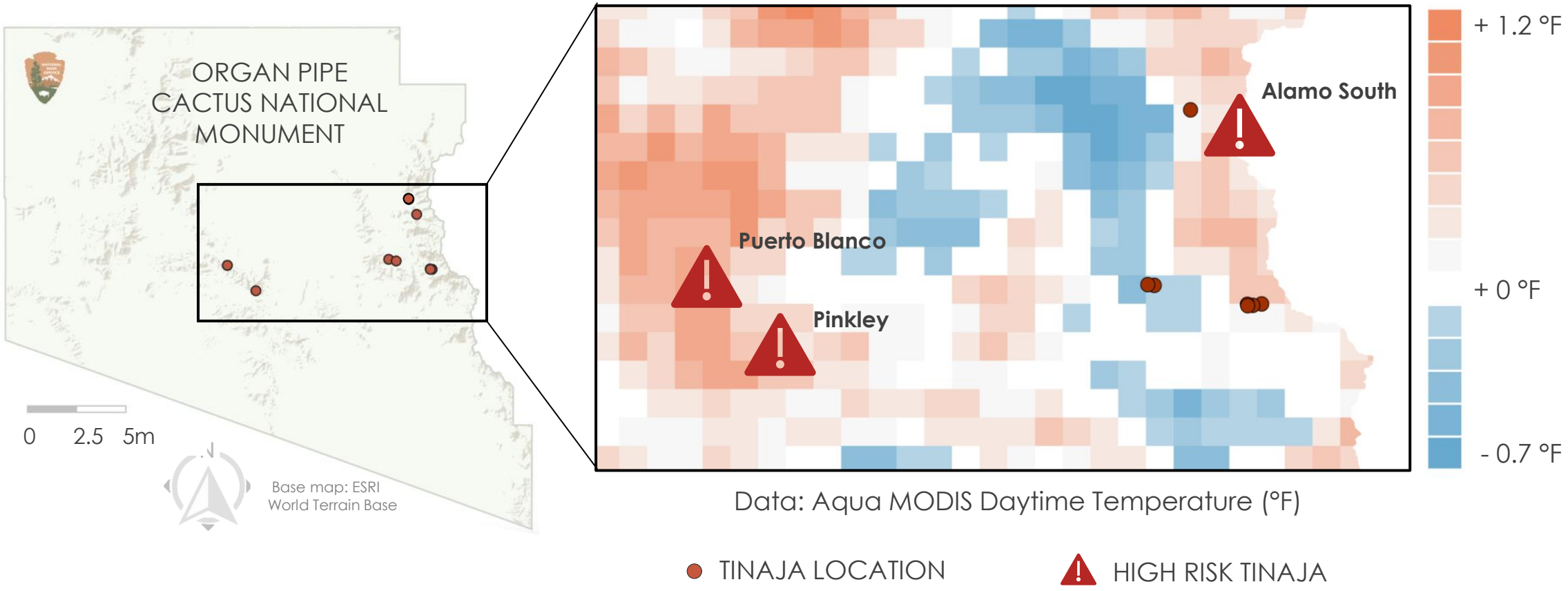




Results & End Use

Tinajas at High Risk due to Increasing **Daytime Temperatures (°F)**

Period = 2012-2021 minus 2002-2011



NASA WILDLAND FIRE PROGRAM & FIRESENSE PROJECT

Dr. David Green
Program Manager
Wildland Fires Program

Outline

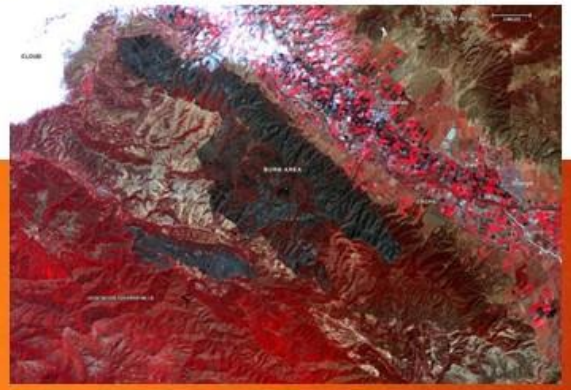
- **Science for Action**
  - **Learning to Manage and Live with Fires**
  - ***Earth System Observation for Fire Prone Areas***
  - ***Tracking and Predicting Fire Behavior and Impact***
  - ***Guiding Smart Recovery for a Changed Landscape***

  - ***Enabling Collaboration and Communities-of-Practice***
  - ***Creating Actionable Fire Science Information AFSI***

- **Making FireSense**

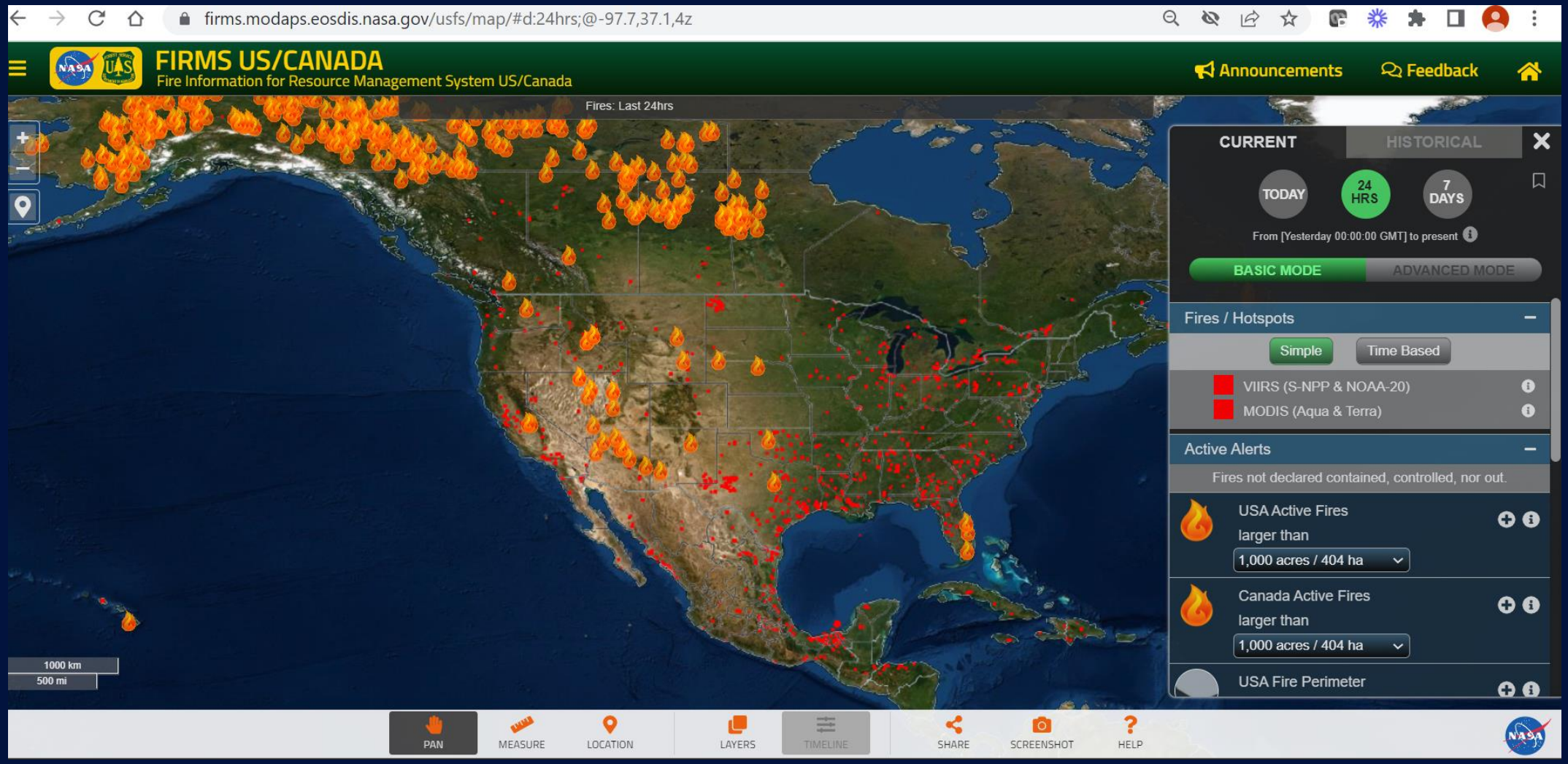
Science Applied

Wildfires and cascading impacts for the Wildfire Urban Interface WUI



It is estimated that the wildland-urban interface is the fastest growing land-use type in the conterminous United States

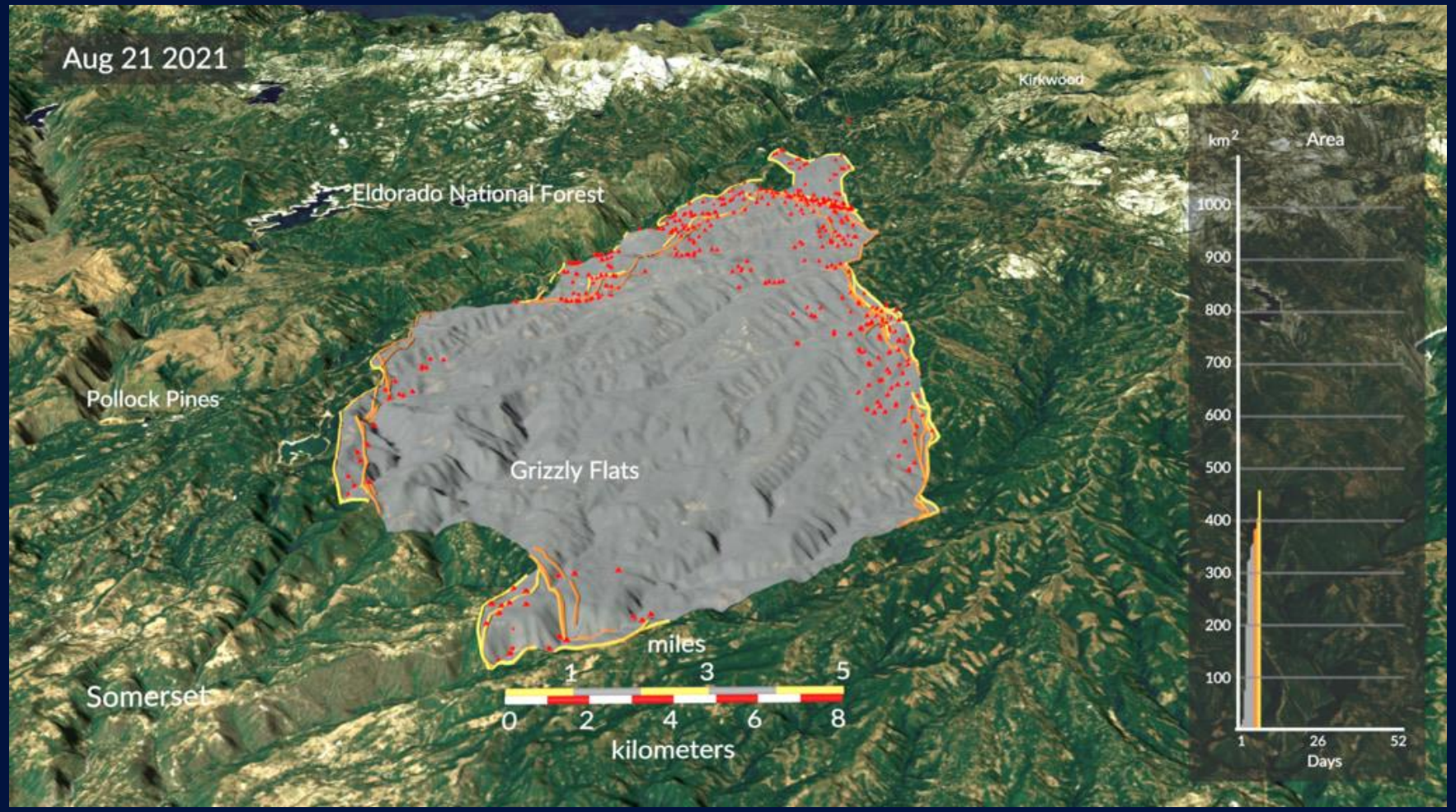
Fire Information for Resource Management System (FIRMS)



https://firms.modaps.eosdis.nasa.gov/usfs/map/#d:24hrs;@-97.7,37.1,4z

Fire Behavior, Impact and Recovery –

Spread of the Caldor Fire – Aug 11, 2021

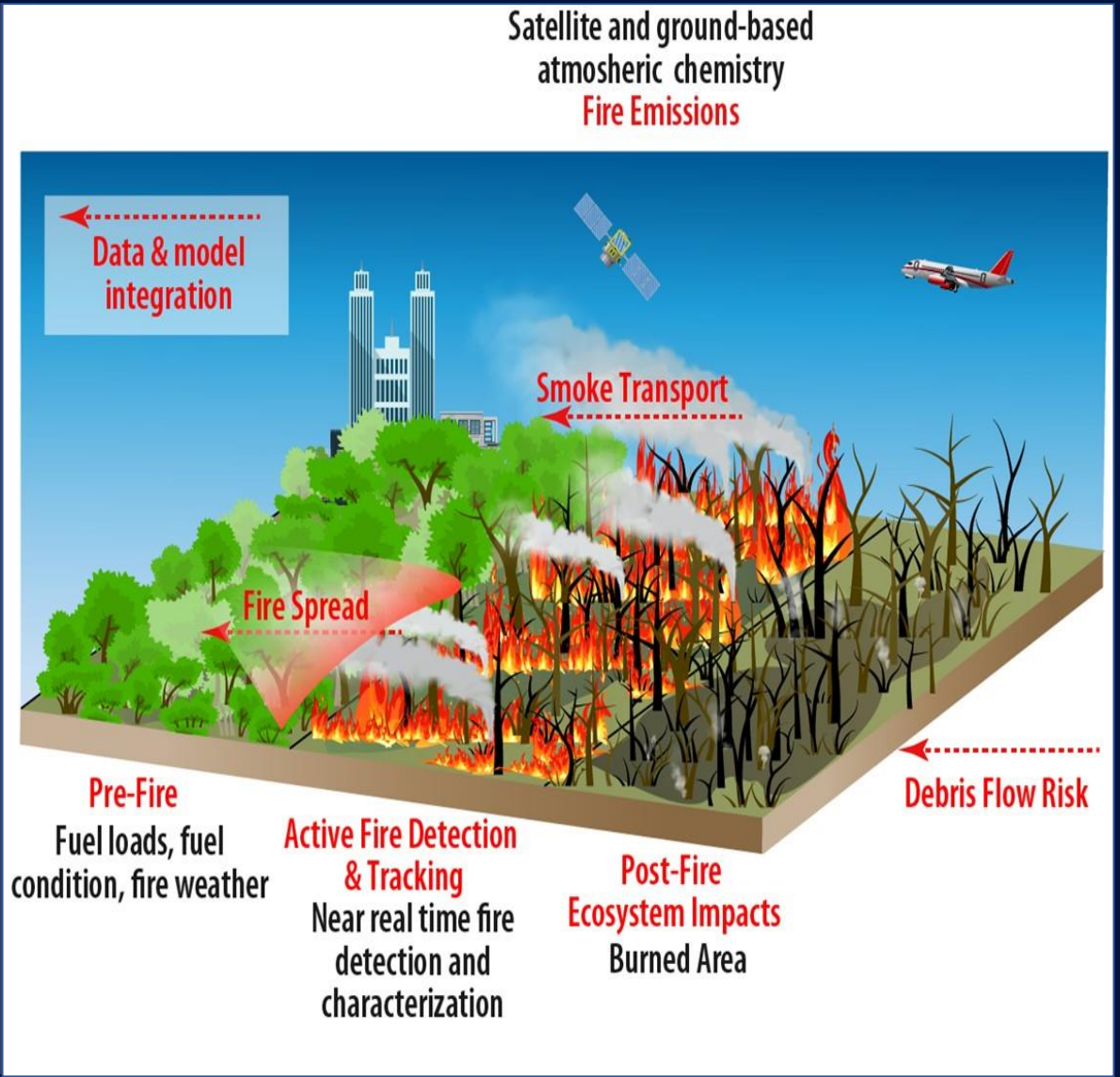


Creating Sustainable Futures: Living with Wildland Fire

Greater Value

Integrating Earth Systems Science for the Full Wildland Fire Cycle

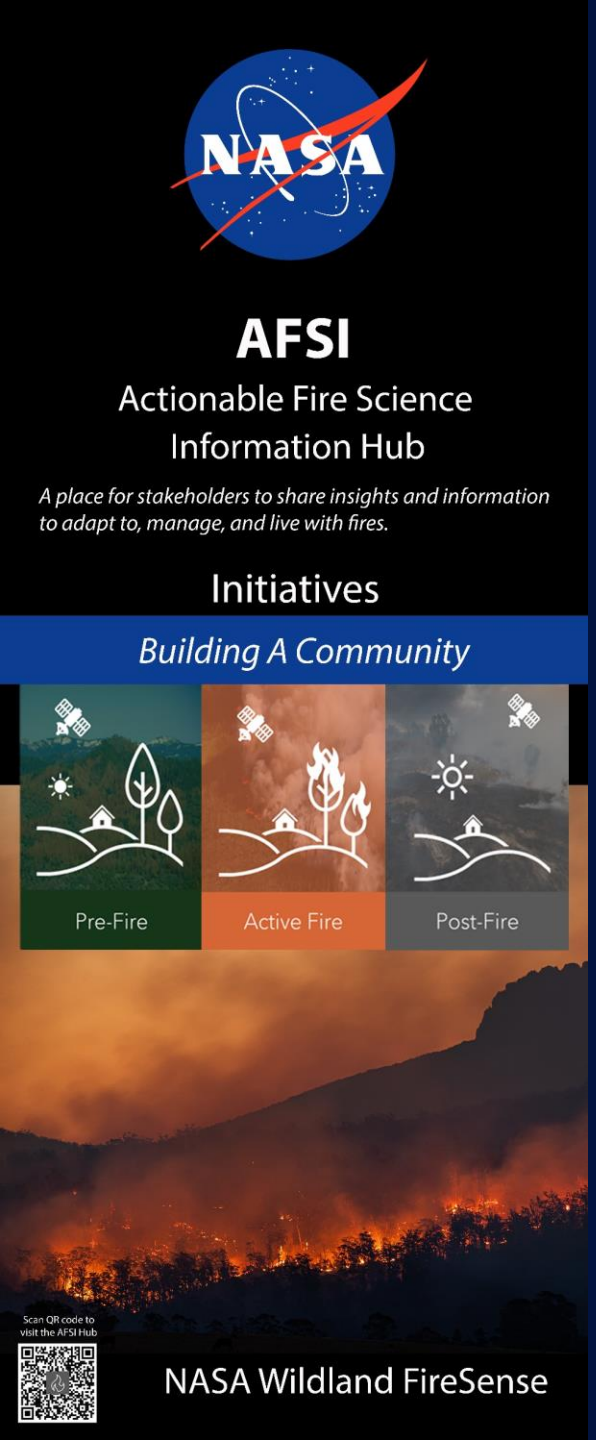
- Use-inspired Applications
- Integrated Fire Science
- Technology
- Data

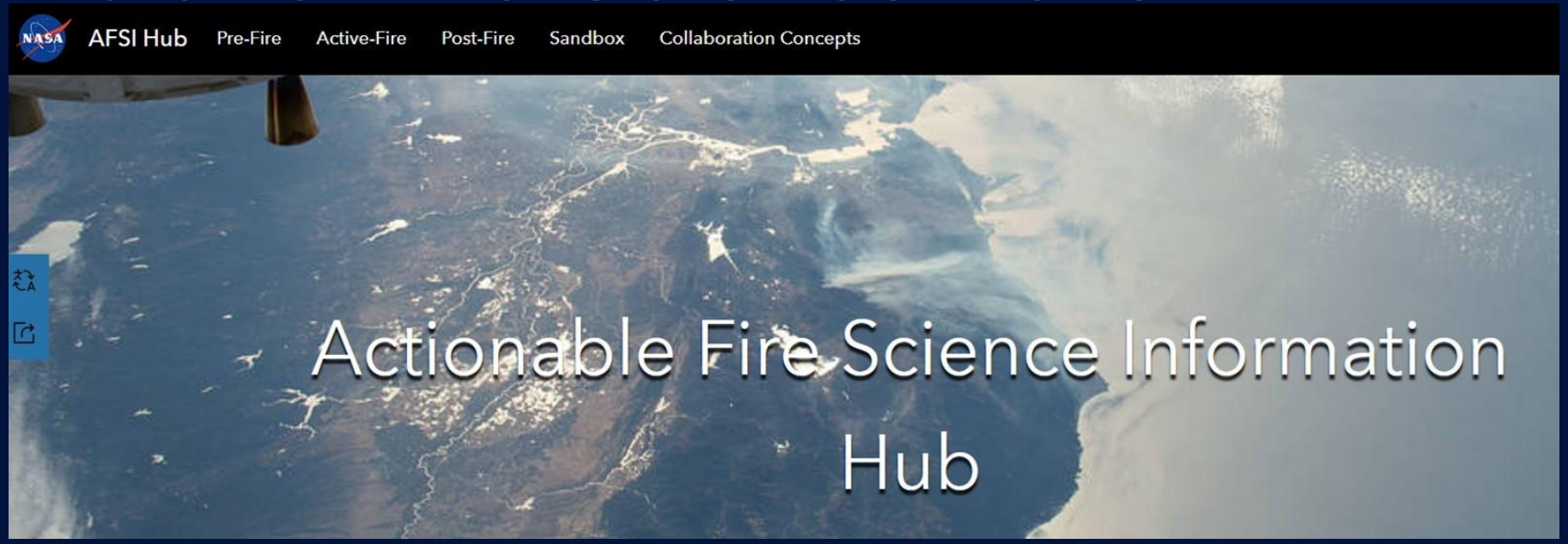


Wildland Fire Program
Enabling Living with and Managing Fire

Enabling Collaboration: Projects and Hub

Wildland Fire Science Action





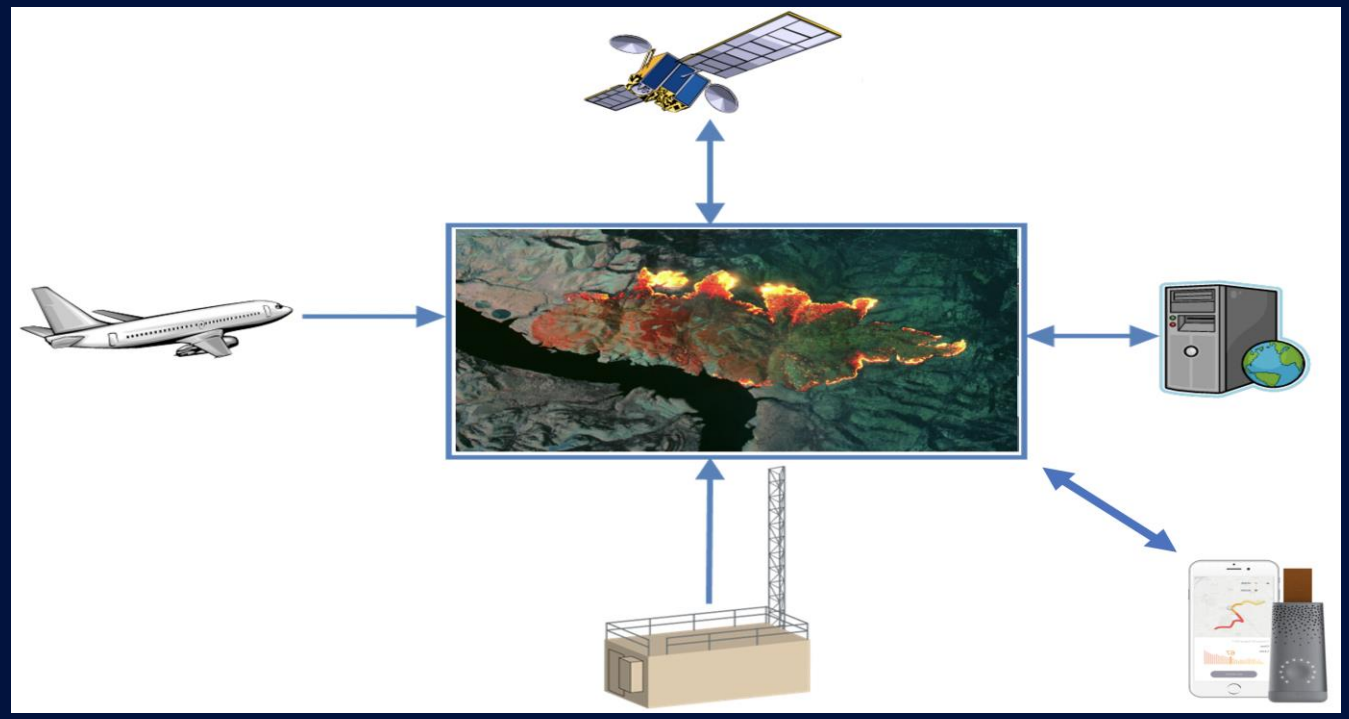
- Resource and Land Management
- Ecosystem/Fuels analysis, Soil and Water
- Atmospheric analysis, Smoke and Health
- Digital Networks, AI/ML techniques
- Flight and Earth Data Systems
- Geospatial Analytics and Visualization
- Risk Management and Restoration

https://cec-ash-prof-services.hub.arcgis.com/

Wildland Fire Program
Transitioning Research to Application

Community Building and AFSI Hub Expansion to demonstrate integrated earth systems utility

- Fire Prone Areas (communities and infrastructure)
- Fire Behavior and Smoke
- Transformed landscapes and smarter sustainable recovery



Ecosystem

Atmosphere

Technology

Application

Wildland FireSense

Science Mission Directorate, Earth Science Division's FireSense Project demonstrates the unique value of a Comprehensive and Transformative S&T Approach for **Action** – one that **accelerates, empowers and improves wildland fire adaptation and community planning, monitoring and restoration for collective outcome of living sustainably with fire**

Thank you

- Interns
  - Madeline Duhnoski, Dartmouth – *Assessing scope & need thru Fire/River Interactions*
  - Maya Saidel, Macalester College – *Wildland Fire and Indigenous Knowledge*
  - Katrina Sharonin, UC Berkeley – *State of Active Fire Tracking Tech*
  - Jenessa Stemke, Oregon State – *Factors Exacerbating Megafires & Increased Fire Intensity*
  - Paige Wirth, Texas A&M – *Fire Ecology and a Safe Return of Fire in the Landscape*
- Mentors
  - Jessica McCarty, Univ. MiamiOH
  - Cindy Schmidt, NASA Ames
  - Liz Wiggins, NASA LaRC
- Unsung Hero
  - Rachel Owens, NASA Intern Program Coordinator

EARTH SCIENCE
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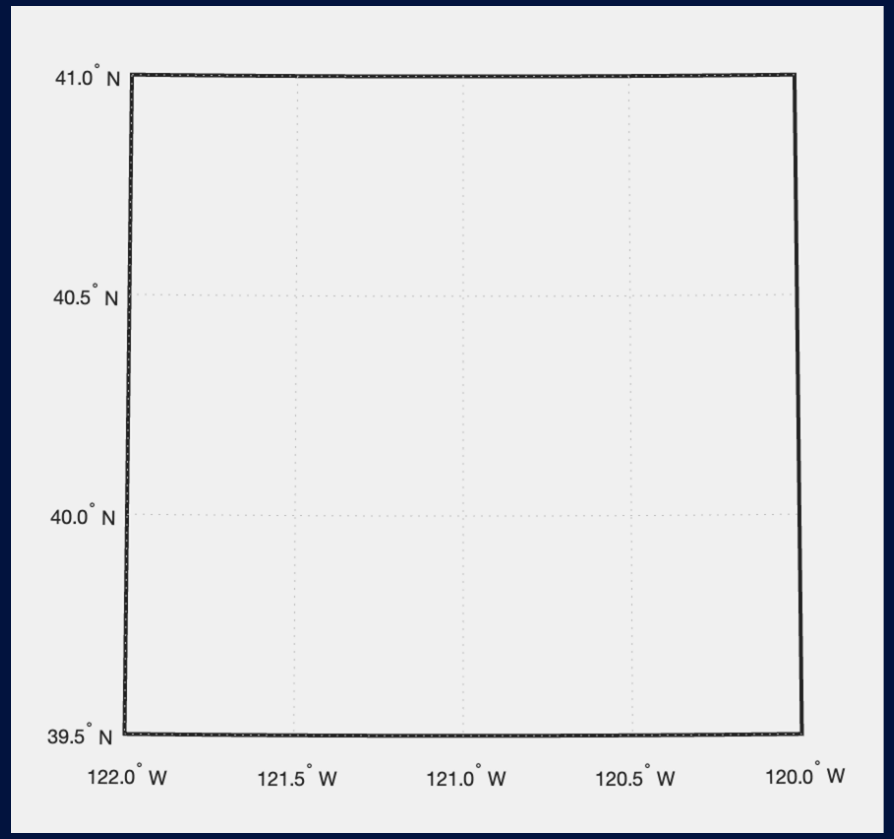
NASA & STAKEHOLDERS: STATE OF ACTIVE FIRE TRACKING TECH

Katrina Sharonin

August 10, 2022

State of Active Fire Tracking

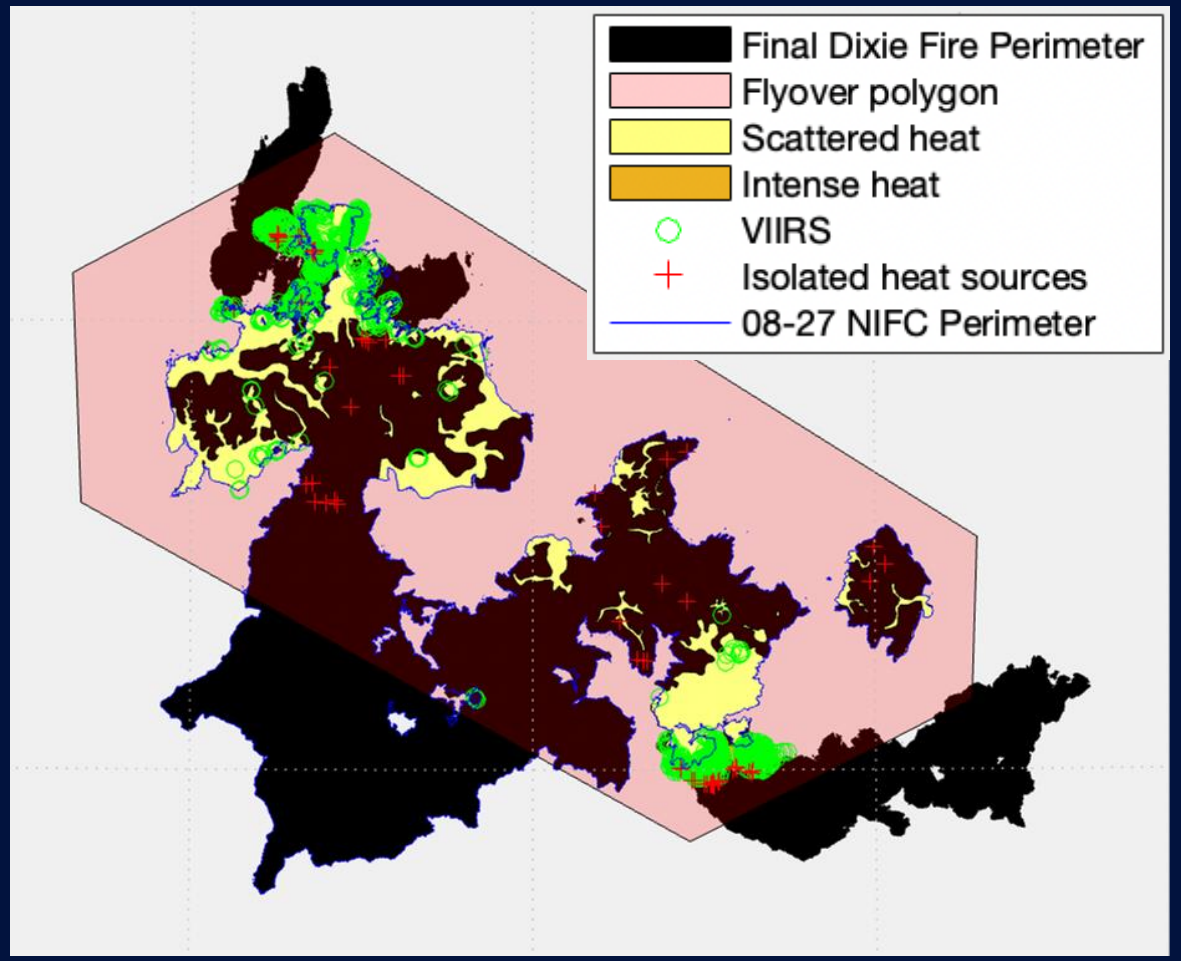
- Needs:
  - Update active fire perimeter
  - Track burned area
- Popular methods used by agencies
  - Hand-drawn maps
  - GPS-walked/driven
  - Infrared operation flights (DRTI, NIROPS)
- Challenges:
  - Limited snapshots of perimeter progression
    - Intermediate growth? Real-time?
  - Time intensive and costly
  - Inconsistent archives (missing days)



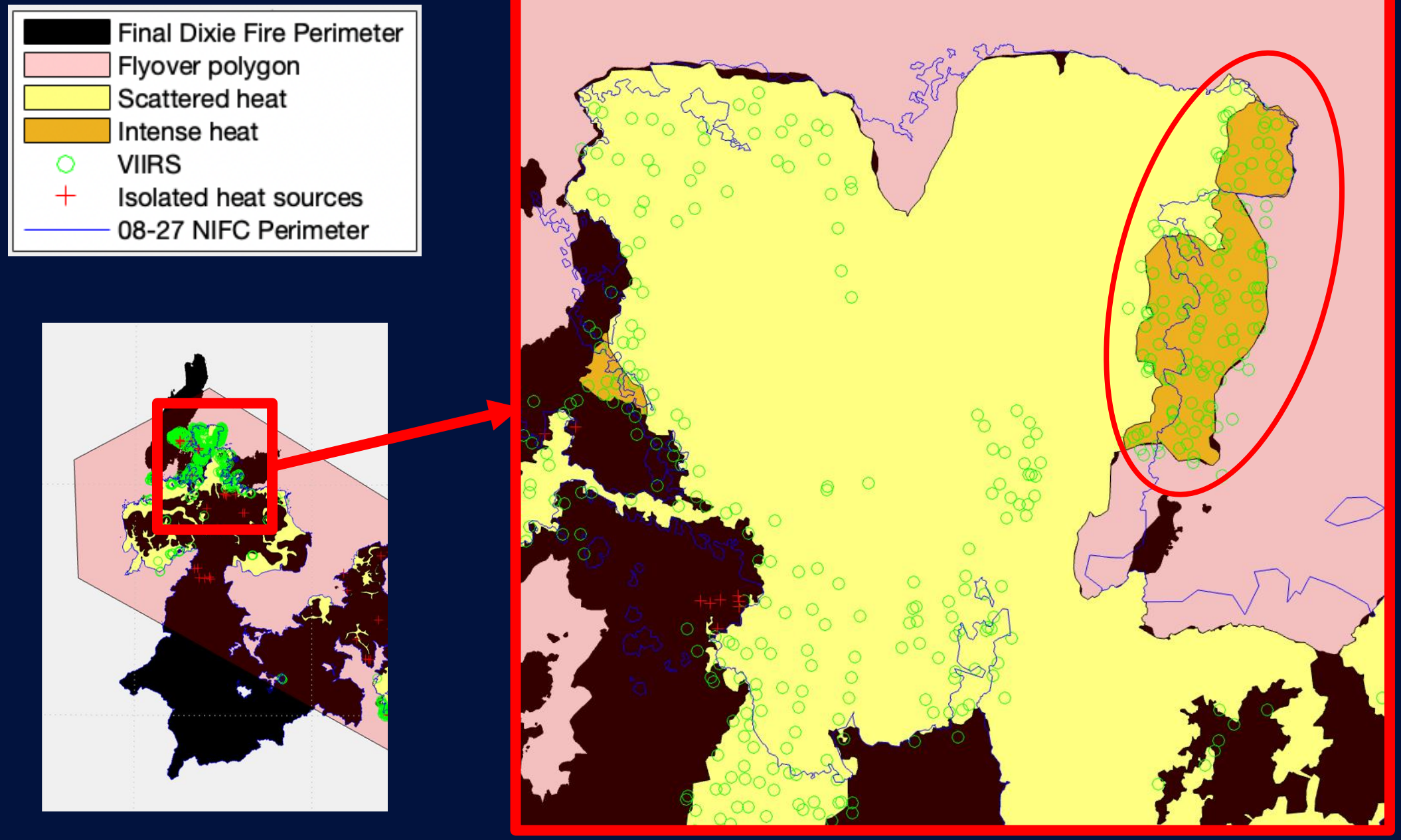
Ex. NIFC Dixie Fire perimeters

Project Work: Showing NASA's Potential

- Created program to compare MODIS, GOES, VIIRS & agency data on Dixie Fire in a single environment
  - Allow agencies to visualize and analyze NASA tech performance in comparison to current methods
- Alpha shape algorithm with satellite detections to estimate fire perimeters

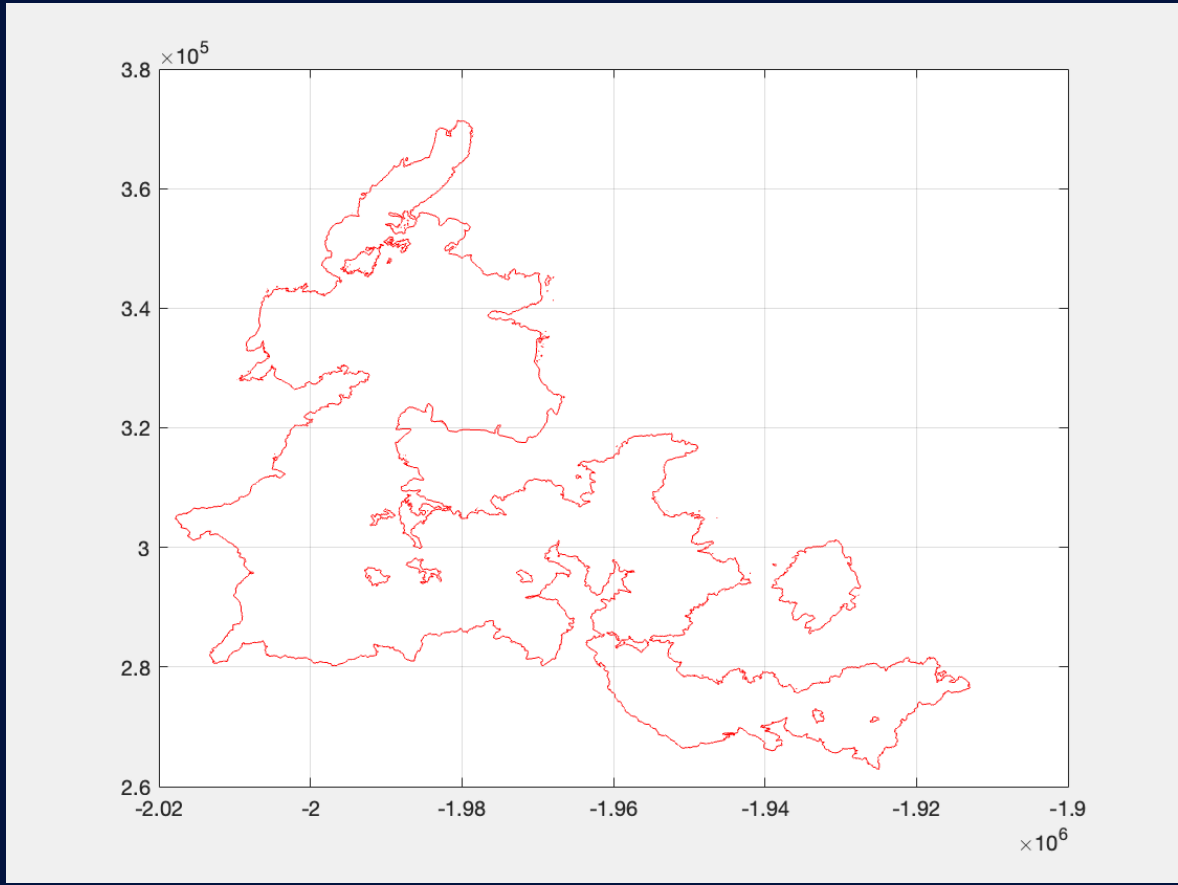


08-27: Infrared data used by CAL FIRE vs. VIIRS

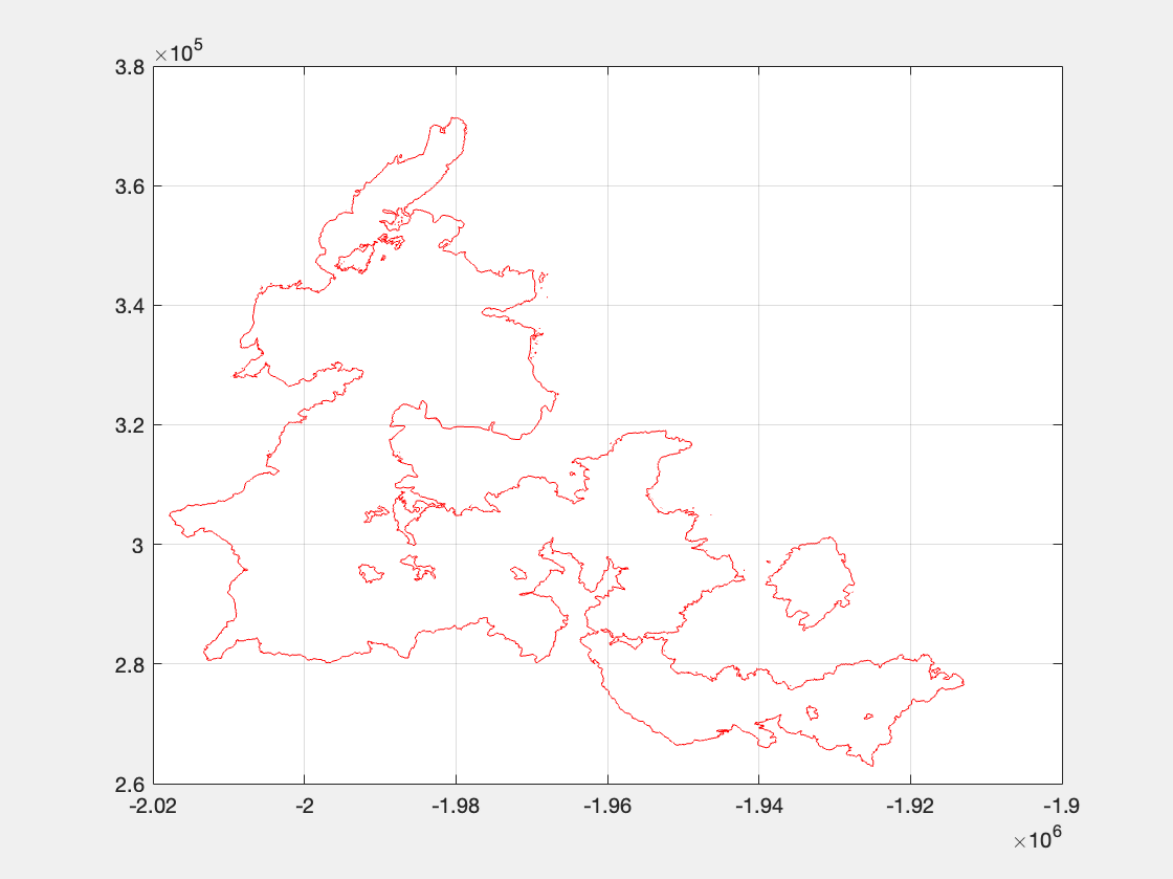

Final Dixie Fire Perimeter
Flyover polygon
Scattered heat
Intense heat
VIIRS
Isolated heat sources
08-27 NIFC Perimeter

Dixie Fire 2021: Alpha Shapes vs. perimeters

GOES (2 km resolution)



VIIRS (0.375 km resolution)



Green = official perimeter, red/pink = active FRP detection + alpha shape

Takeaways

- Learning limits & capabilities of NASA active fire detection
- Identifying data-gaps and challenges with current datasets
- Understanding current agency methods and potential areas of collaboration

- Next steps:
  - Knowing challenges and needs → develop software program to automate and accelerate data pulling and comparison
  - Conversation with stakeholders about long term data record keeping and structures
  - Integration with stakeholder activity

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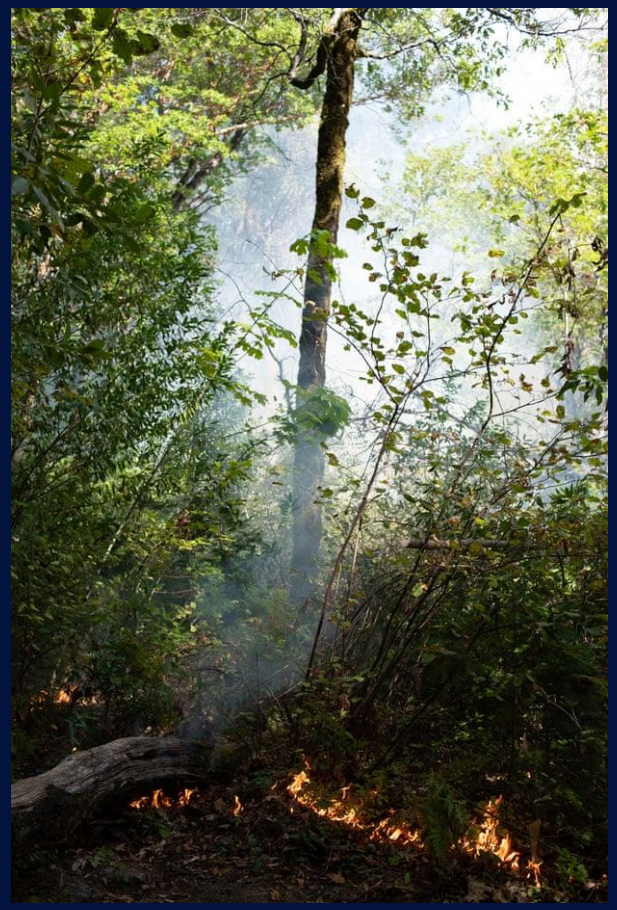
NASA FireSense: The Intersection of Wildland Fire and Indigenous Communities

Maya Saidel

August 10, 2022

Broadening Wildland Fire Perspectives

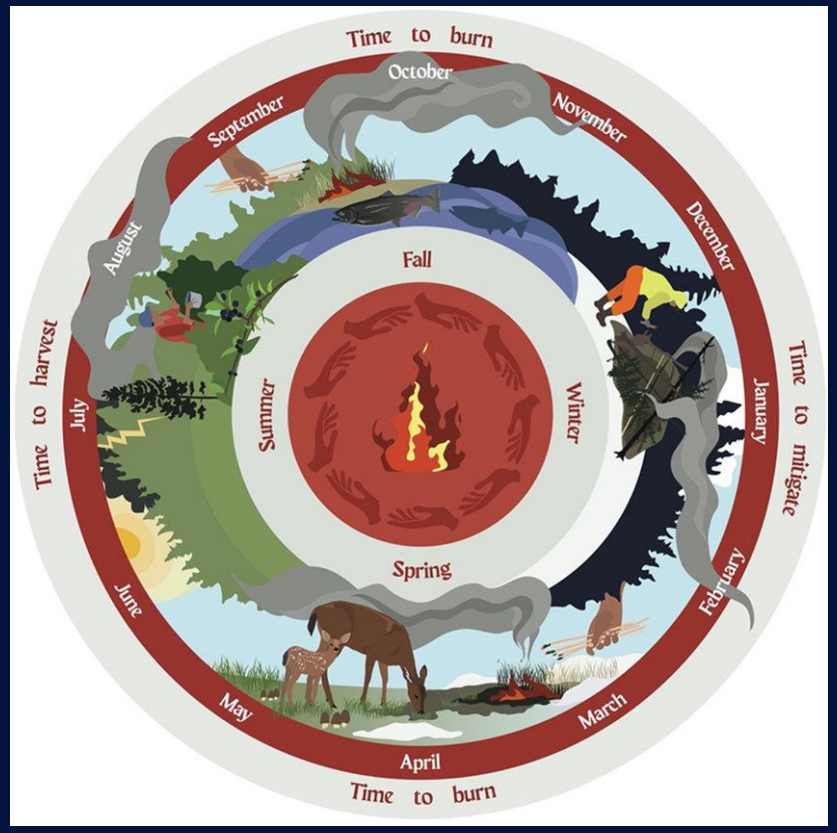
- How can NASA rethink our approach to engaging with Indigenous communities?
- Listening to Native American tribes
  - 6x more likely than other racial groups to live in wildfire prone areas (Davies et al., 2018)
  - Importance of traditional land management and cultural burning for social and ecological health (Long et al., 2021)



View of a cultural burn conducted by the Yurok tribe in California. Photo by Alexandra Hootnik.

Indigenous and Western Knowledge: Synergies and Challenges

- Research objectives:
  - Report on the importance of traditional ecological knowledge for the Wildland Fire Program
  - Examine what the “integration” of Indigenous knowledge into Western systems of environmental science truly means
  - Consider what the program must know in order to begin the process of learning from Indigenous communities



A seasonal calendar illustrating aspects of Indigenous fire stewardship. Image concept by K.M. Hoffman and A.C. Christianson, design and illustration by Alexandra Langweider of Align Illustration.

Takeaways

- Knowledge cannot be separated from its cultivators
- Understanding the full story of wildland fires across their lifecycles is crucial
- Working across multiple programs to coordinate efforts and learn together has tremendous value
- Next step:
  - Implement new framework to achieve optimal alignment and congruence

First Nations continue to use fire to promote the growth of cultural foods such as black huckleberry. Photo by Heather Stewart.

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Factors Exacerbating Megafires & Increased Fire Intensity

Jenessa Stemke
NASA FireSense Intern

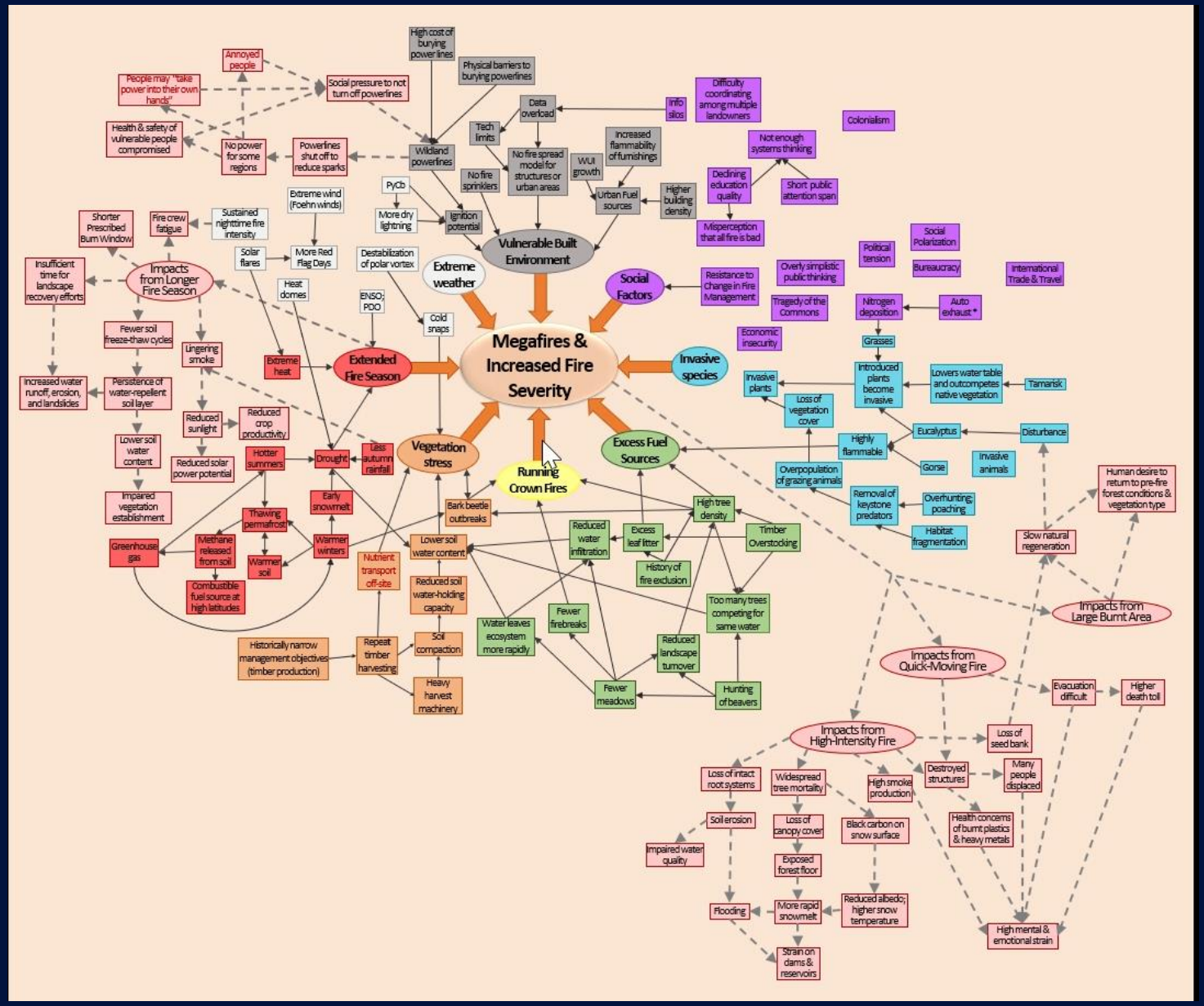
August 10, 2022

Understanding & Addressing Megafires

<u>Challenge</u>: Public fear of fire and smoke and resistance to prescribed burning; perception that climate change is the primary driver of increasing fire severity

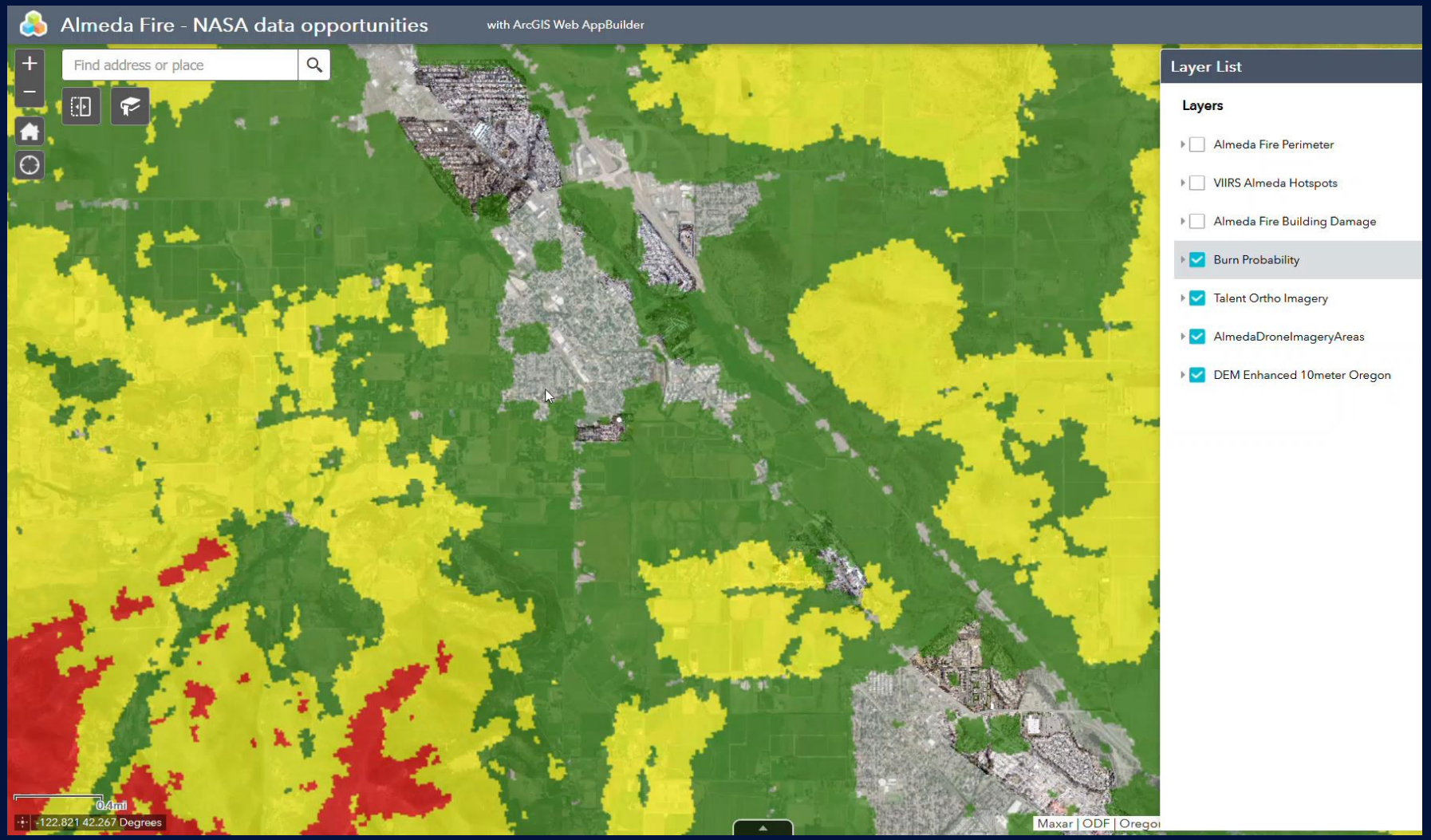
<u>Reality</u>: Fires are increasing in severity for many reasons in addition to climate change

<u>Project description</u>: Interactive diagram of factors influencing megafires, urban fires, and increasing fire intensity; resources for monitoring; and solutions



Many Factors Affect Megafires

Data Gap: Urban Fire Models



Data Sources

Burn Probability Model: OSU Extension Fire Program

Fire Detection: VIIRS hotspots

Building Damage: Jackson County

Fire Perimeter: Jackson County

Aerial imagery: Jackson County Fire Response

Elevation: Oregon Dept. of Forestry

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NASA FireSense: Assessing scope and need through fire/river interactions

Madeline Duhnoski

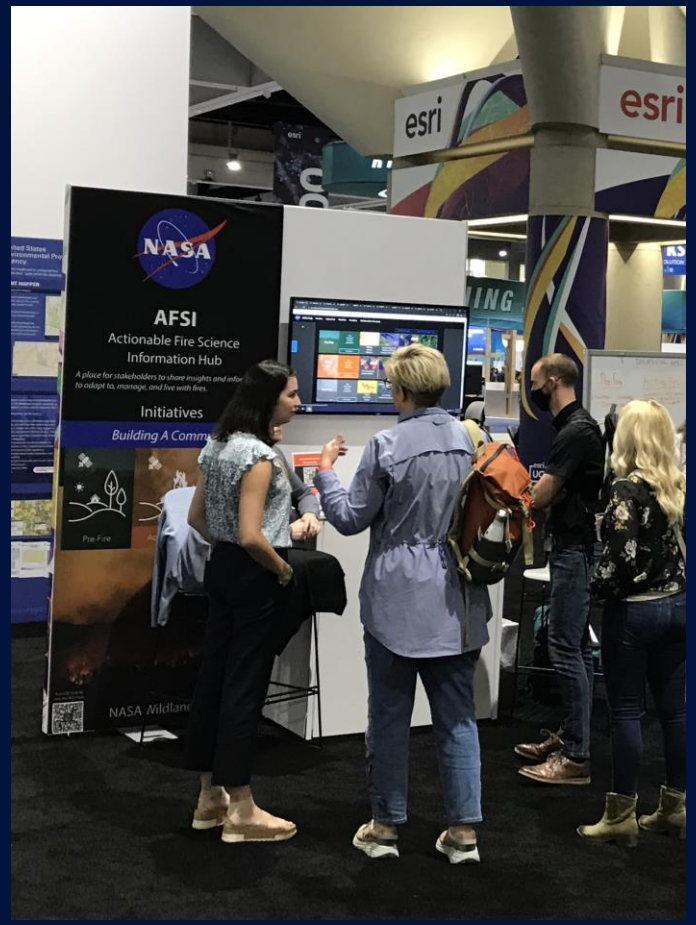
August 10, 2022

Fire and Fluvial Sciences

- Where is the overlap? To what extent?
- (Geo)morphologists, sedimentologists, thermochronologists, disaster specialists, ecologists…
- Existing research robust but with gaps
- Where does NASA best fit in?

ESRI User Conference

- Spreading the work about the AFSI Hub (Actionable Fire Science Information)
- Communicating directly with stakeholders
- Gathering feedback from current and future users



Takeaways

- Science (and non-science) problems are never one-sided
- There are always more perspectives to include and more to research
- NASA scientists are always learning from each other

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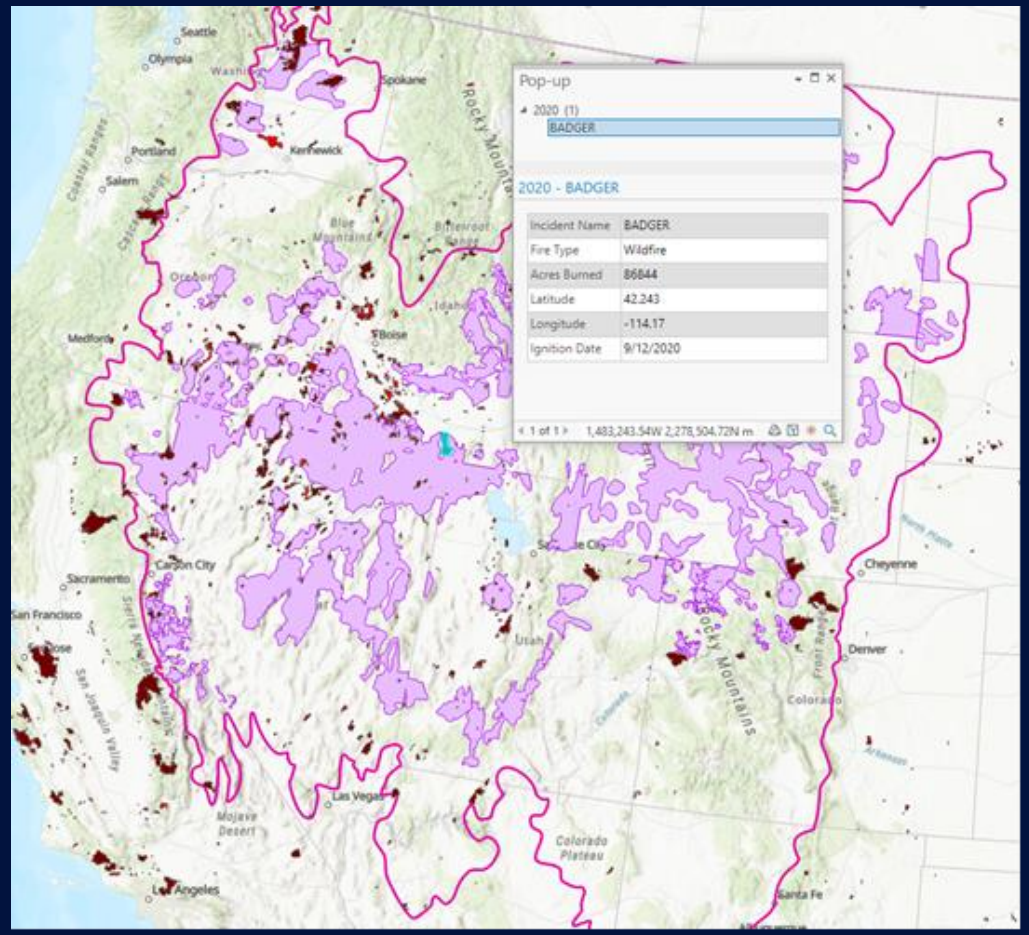
NASA FireSense: Fire Ecology and a Safe Return of Fire in the Landscape

Paige Wirth

August 10, 2022

Ecological Importance of Fire

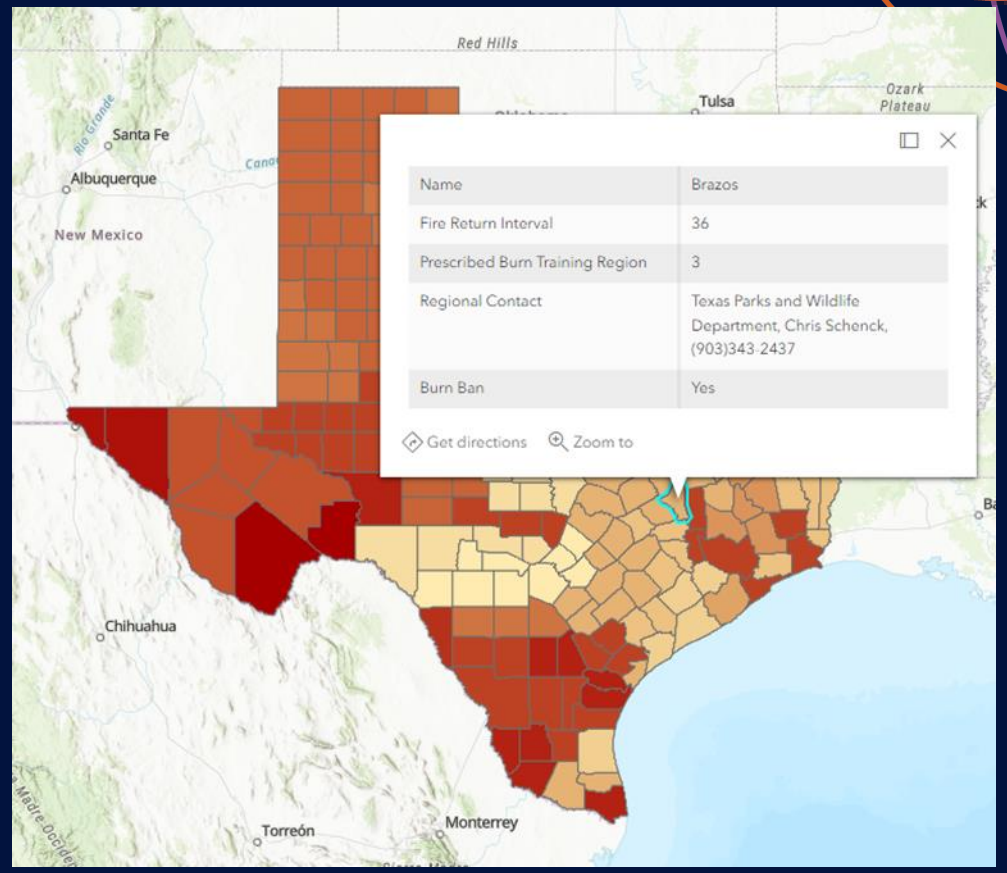


Data from MTBS and Fish and Wildlife Services

- Redirecting the conversation around fire to it being a part of an ecosystem
- Learning to live with fire rather than fear it
- Creating educational tools around different ecosystem's relationships with fire
  - Starting with a pilot in the sagebrush ecosystem

Returning Fire to the Landscape

- Creating a prescribed burning tool for landowners to utilize
- Easily accessible education on fire in their ecosystem
- Resources specific to their region
- Future:
  - Expanding out of Texas
  - Including other NASA products such as ECOSTRESS and GFWED on the Storymap



Data from Landfire and the Texas Department of Agriculture

Takeaways

- Everyone has a stake in fire science
- Collaboration with stakeholders in the fire community is key to improving projects
- Knowing what questions to ask is more important than knowing all of the information
- Networking is fun when everyone loves earth science

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NASA & STAKEHOLDERS: STATE OF ACTIVE FIRE TRACKING TECH

Katrina Sharonin

August 10, 2022

State of Active Fire Tracking

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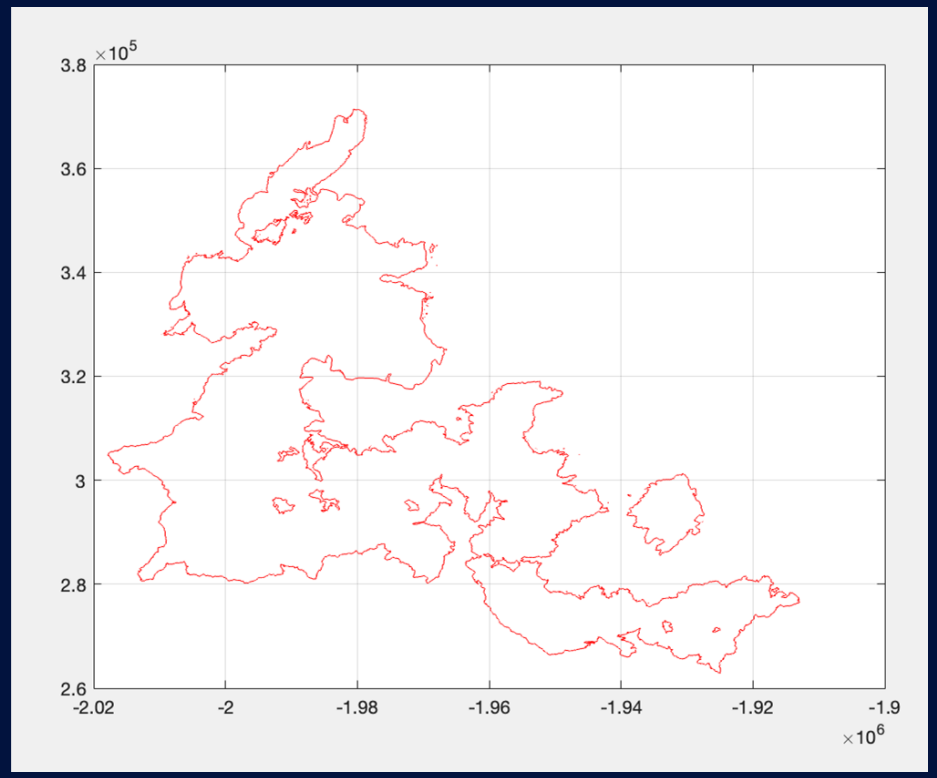
  - VIIRS, GOES, MODIS
- Challenges:
  - Limited snapshots of perimeter progression
  - Time intensive and costly
  - Inconsistent archives (missing days)
  - Varying perimeter sizes for same DOY

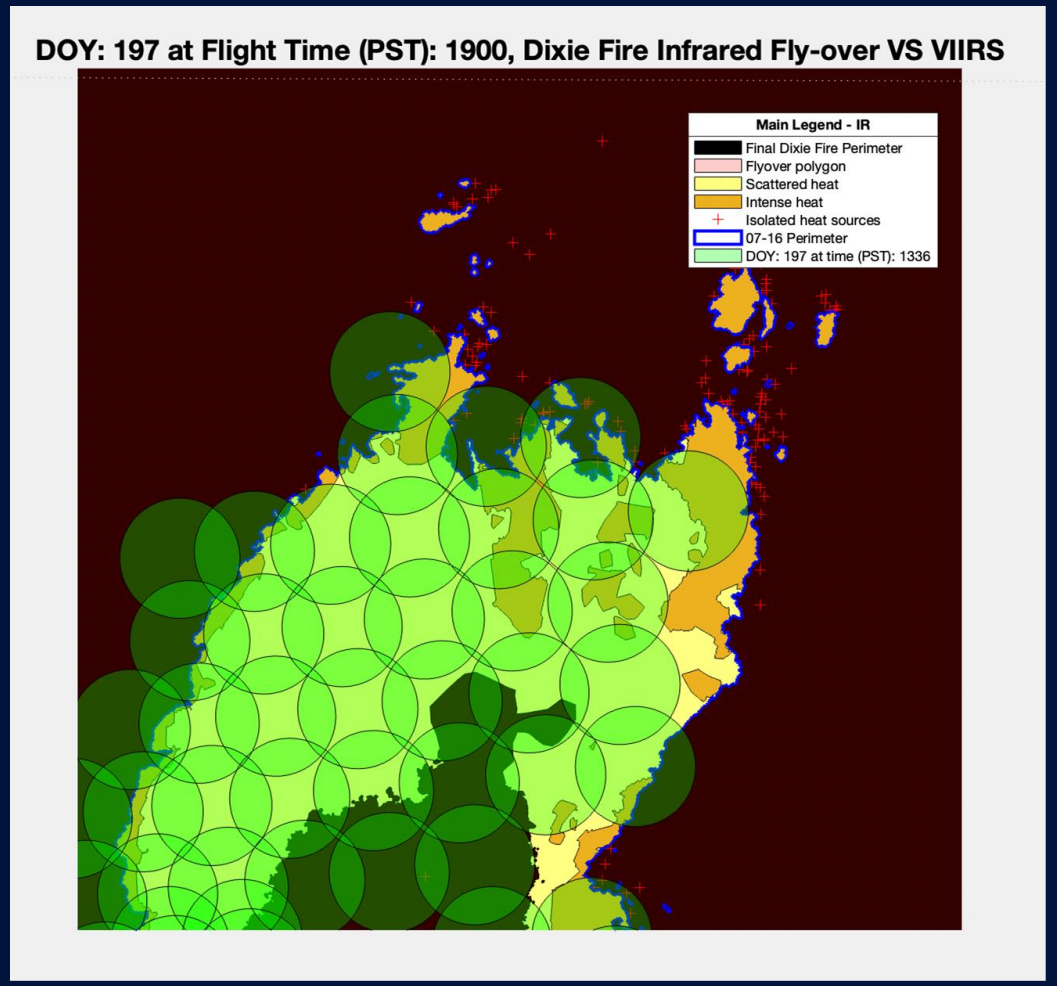


VIIRS Alpha shapes VS NIFC Perims

Green = official perimeter, red/pink = active FRP detection + alpha shape

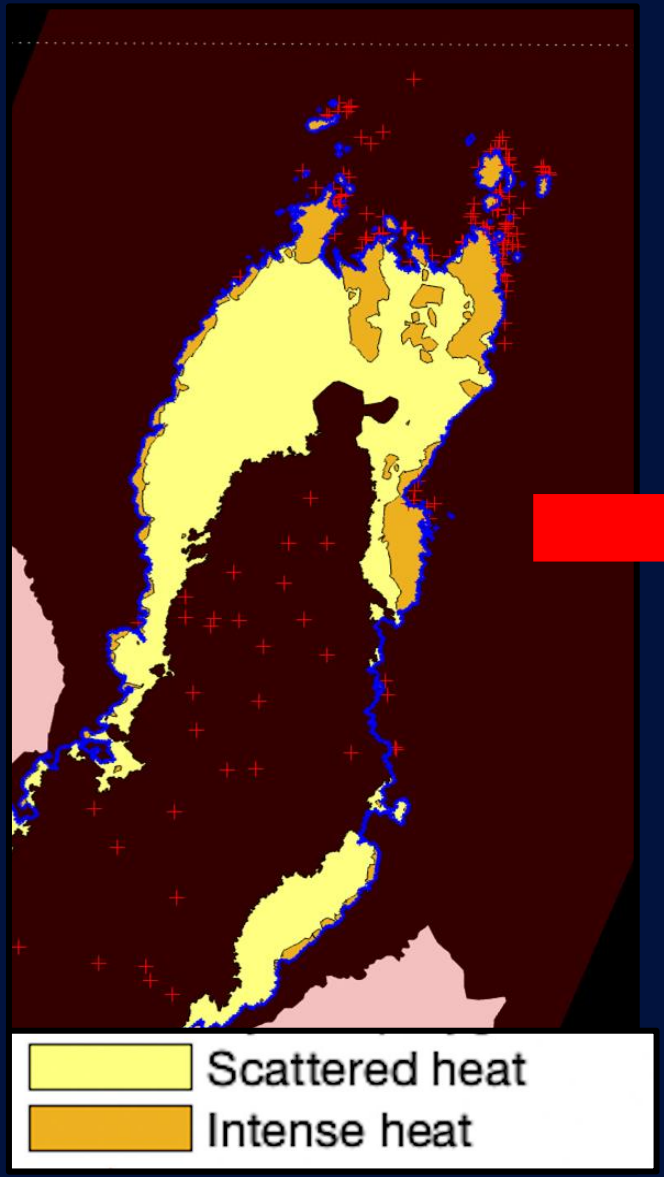
Project Work: Showing NASA's Potential

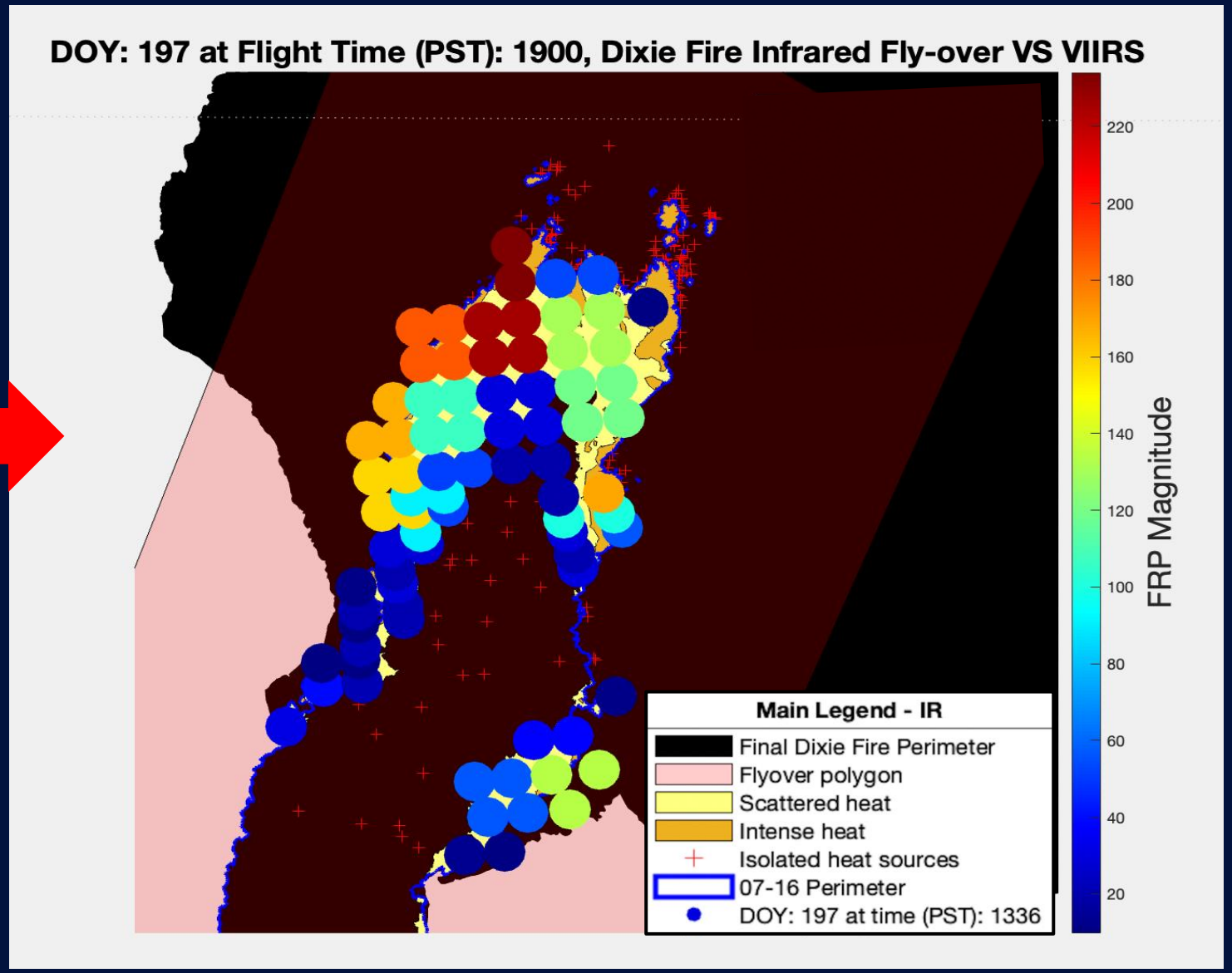
- Need to identify precise errors and causes for agencies
- Project: program to compare MODIS, GOES, VIIRS & precise agency data on Dixie Fire in a <u>single environment</u>
  - FRP magnitude V.S. flyover radiation
  - Location and range per detection
  - Missing heat signatures



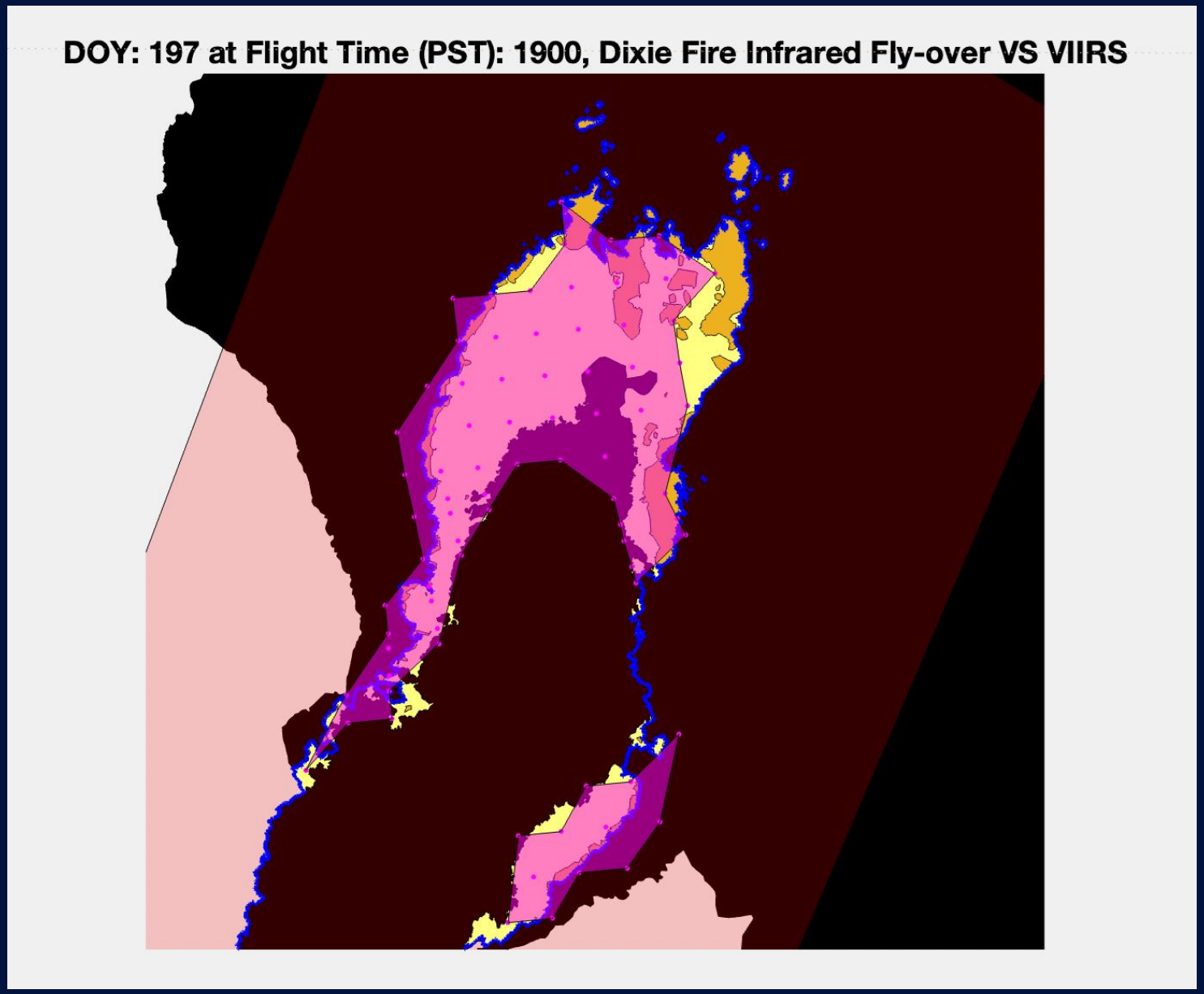
07-16: Infrared data used by CAL FIRE vs. VIIRS

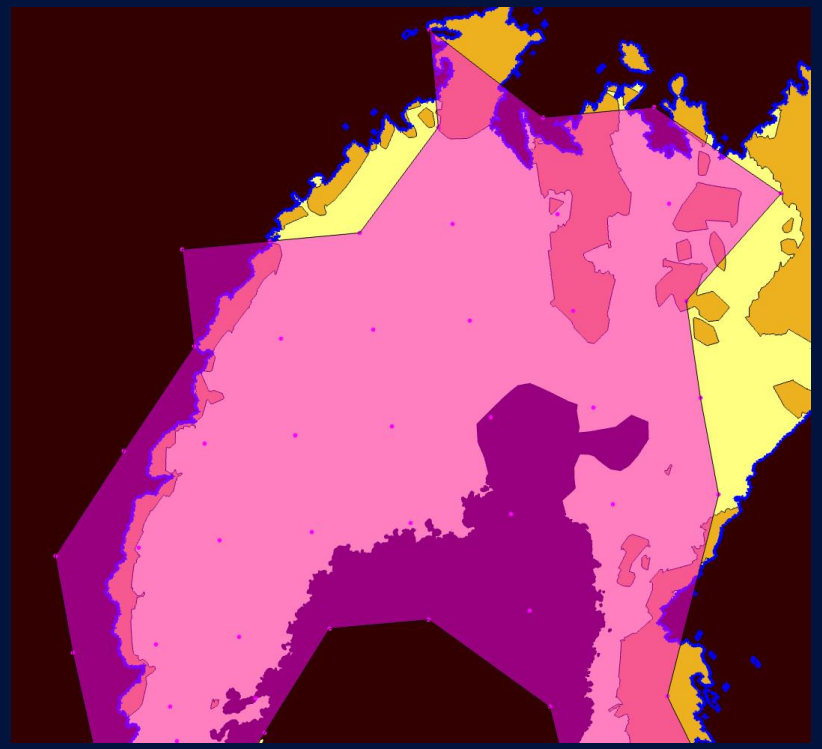
VIIRS VS. NIROPS heat signature magnitudes

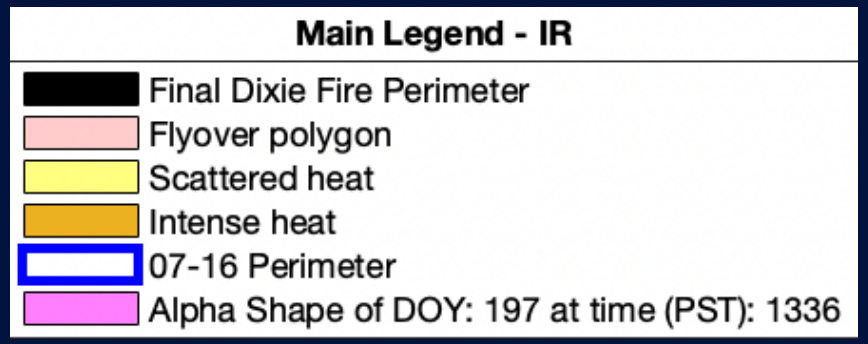




Alpha Shape VS. IR Flight Error







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- Next steps:
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  - Conversation with stakeholders about long term data record keeping and structures
  - Integration with stakeholder activity: where does VIIRS belong?

Thank you

RETURN AT 2:45PM EDT