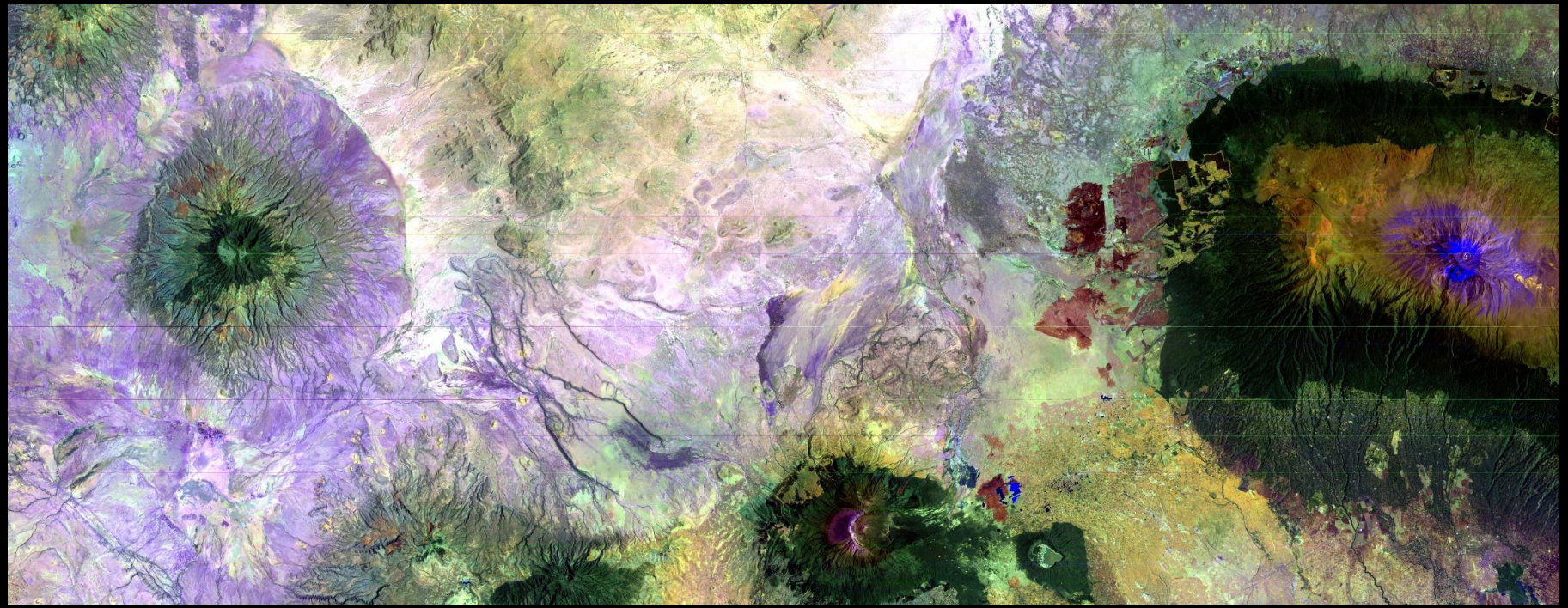
Implementing the Yurok Natural Resources Portal as a decision support system to inform tribal resource management

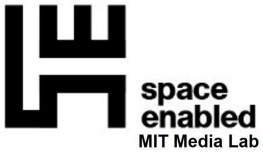
Image Credit: USGS, Dept. the Interior, https://eros.usgs.gov/earth-art/kilimanjaro

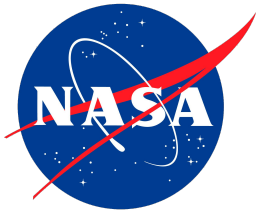


This project is based upon work supported by NASA Earth Action

Implementing the Yurok Natural Resources Portal as a decision support system to inform tribal resource management

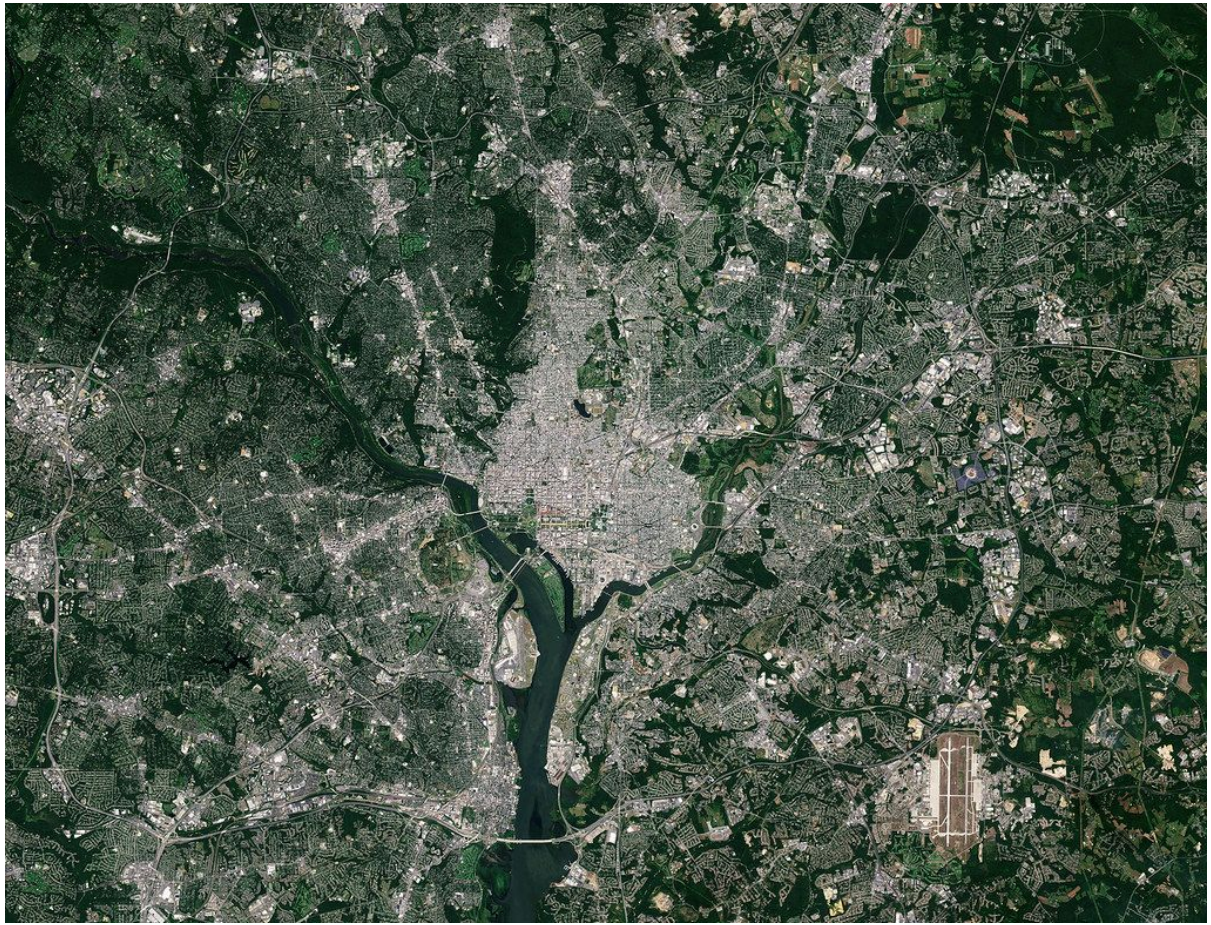
Danielle Wood (PI), Priscilla Baltezar, Lola Fatoyinbo, David Lagomasino, Seamus Lombardo, Chigo Ibeh, Molly Barth, David Bandrowki, Tim Hayden.





Land Acknowledgement

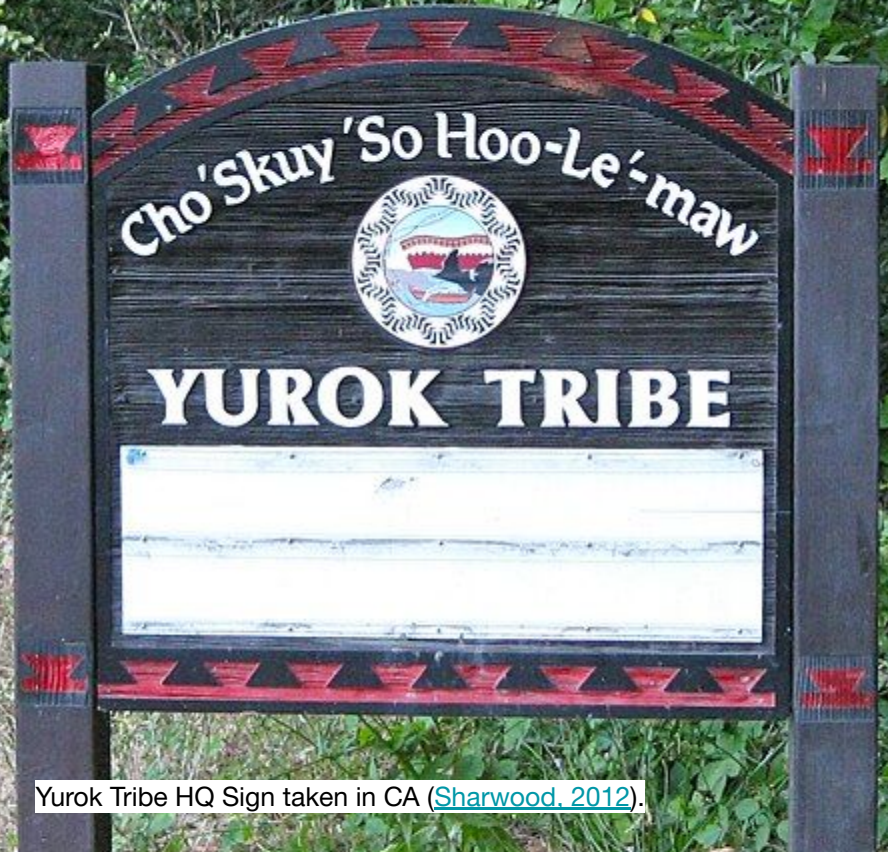
Washington D.C. area sits on the ancestral lands of the Nacotchtank, Piscataway, and Pamunkey peoples.



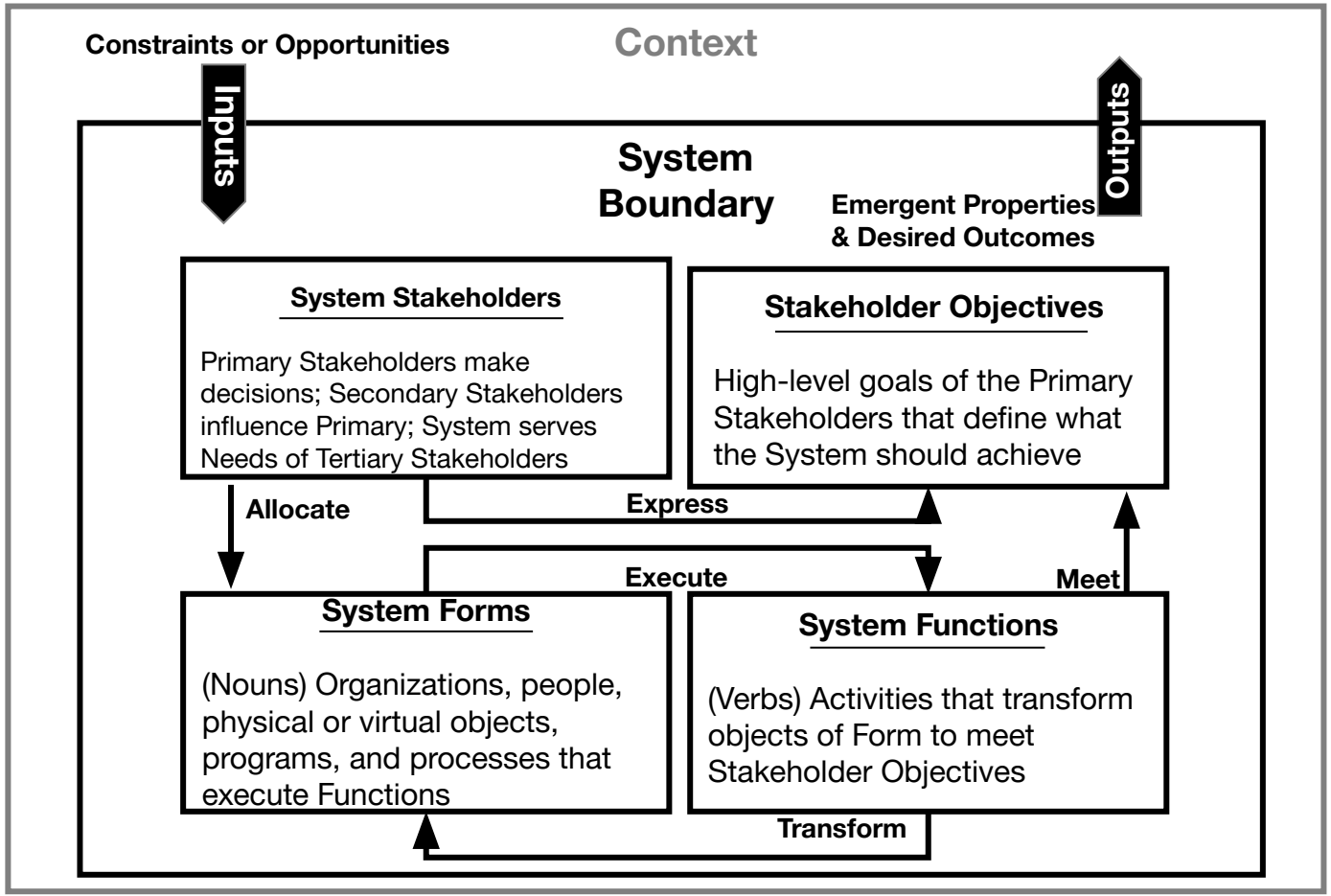
Modified Copernicus Sentinel mosaic of Washington D.C. (2015), processed by ESA.

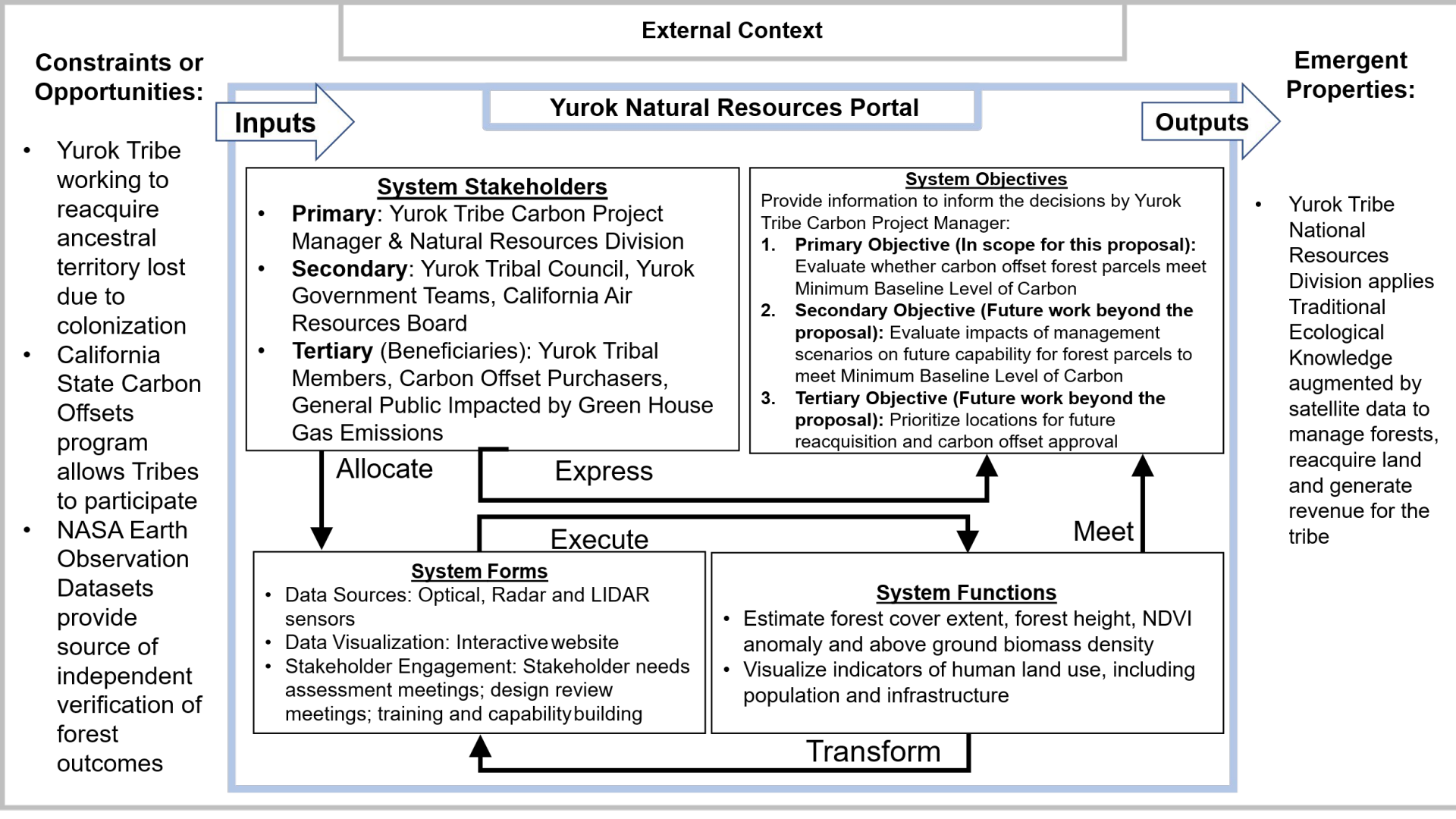
Yurok Tribal Mission

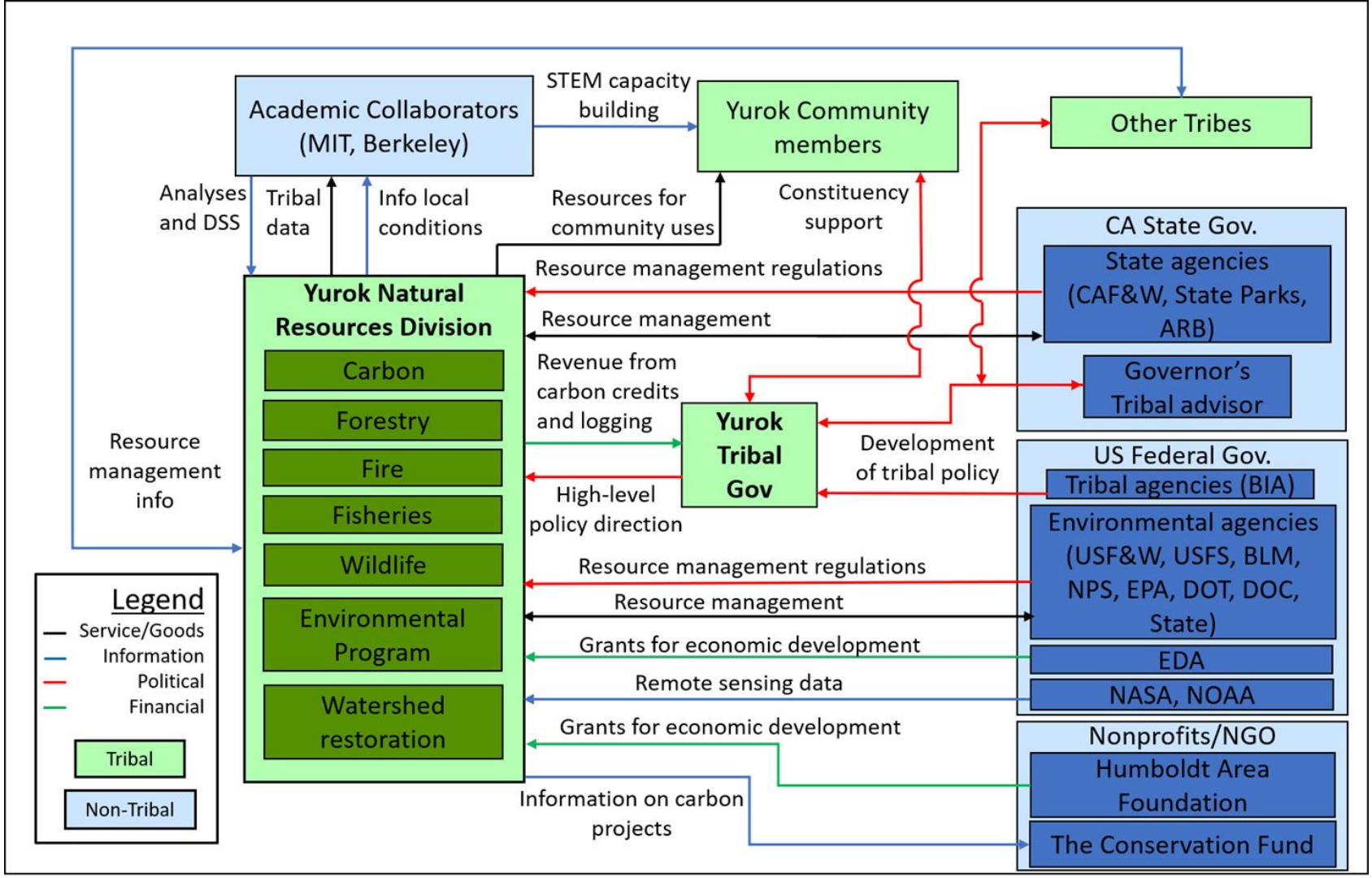
To exercise their aboriginal and sovereign rights in perpetuity through Tribal traditions of self-governance, cultural-spiritual preservation, and stewardship of Yurok lands (Yurok Tribe Mission Statement, 2024).

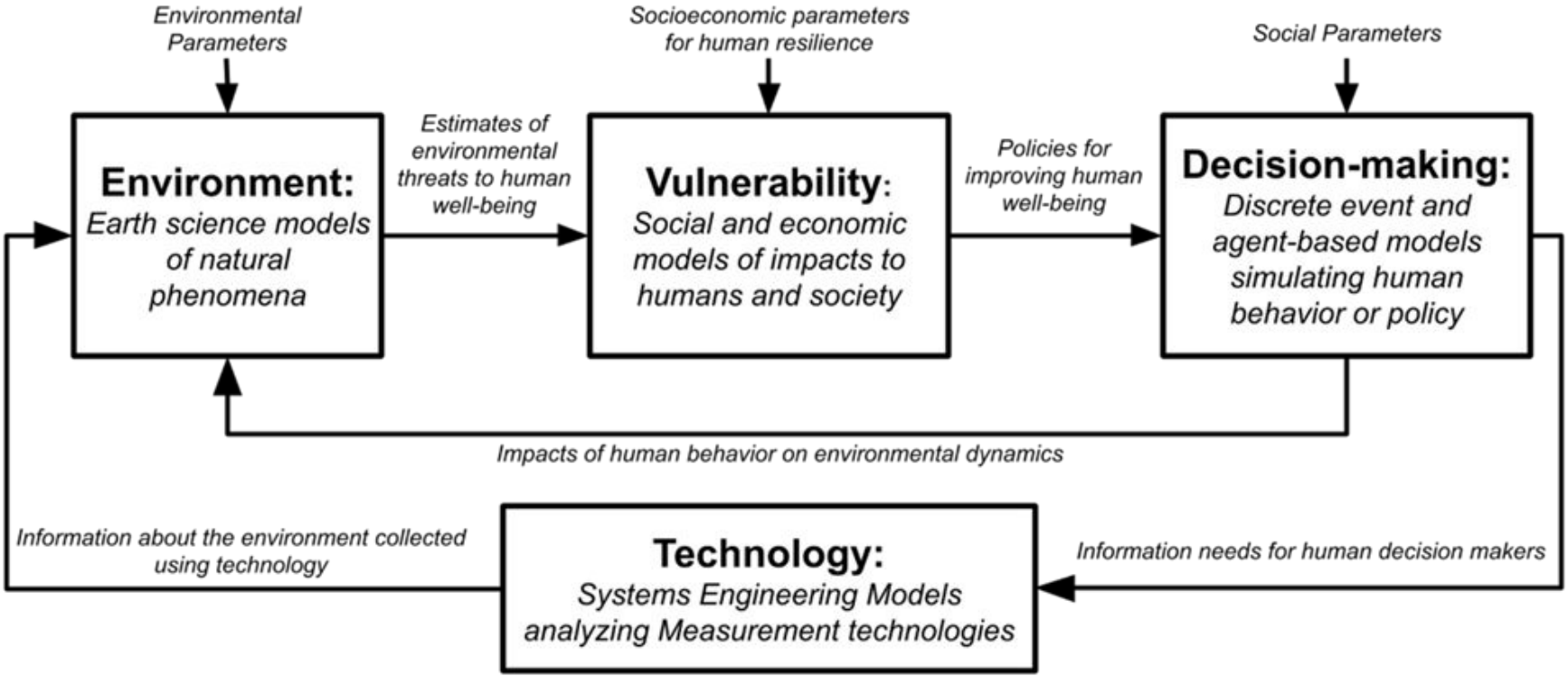


Yurok Tribe HQ Sign taken in CA (Sharwood, 2012).


Constraints or Opportunities
Context
Inputs
System Boundary
Outputs
Emergent Properties & Desired Outcomes
System Stakeholders
Primary Stakeholders make decisions; Secondary Stakeholders influence Primary; System serves Needs of Tertiary Stakeholders
Stakeholder Objectives
High-level goals of the Primary Stakeholders that define what the System should achieve
Allocate
Express
Execute
Meet
System Forms
(Nouns) Organizations, people, physical or virtual objects, programs, and processes that execute Functions
System Functions
(Verbs) Activities that transform objects of Form to meet Stakeholder Objectives
Transform


External Context
Constraints or Opportunities:
Yurok Tribe working to reacquire ancestral territory lost due to colonization
California State Carbon Offsets program allows Tribes to participate
NASA Earth Observation Datasets provide source of independent verification of forest outcomes
Inputs
Yurok Natural Resources Portal
Outputs
Emergent Properties:
Yurok Tribe National Resources Division applies Traditional Ecological Knowledge augmented by satellite data to manage forests, reacquire land and generate revenue for the tribe
System Stakeholders
Primary: Yurok Tribe Carbon Project Manager & Natural Resources Division
Secondary: Yurok Tribal Council, Yurok Government Teams, California Air Resources Board
Tertiary (Beneficiaries): Yurok Tribal Members, Carbon Offset Purchasers, General Public Impacted by Green House Gas Emissions
System Objectives
Provide information to inform the decisions by Yurok Tribe Carbon Project Manager:
1. Primary Objective (In scope for this proposal): Evaluate whether carbon offset forest parcels meet Minimum Baseline Level of Carbon
2. Secondary Objective (Future work beyond the proposal): Evaluate impacts of management scenarios on future capability for forest parcels to meet Minimum Baseline Level of Carbon
3. Tertiary Objective (Future work beyond the proposal): Prioritize locations for future reacquisition and carbon offset approval
Allocate
Express
Execute
Meet
System Forms
Data Sources: Optical, Radar and LIDAR sensors
Data Visualization: Interactive website
Stakeholder Engagement: Stakeholder needs assessment meetings; design review meetings; training and capability building
System Functions
Estimate forest cover extent, forest height, NDVI anomaly and above ground biomass density
Visualize indicators of human land use, including population and infrastructure
Transform

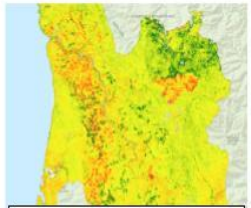

Academic Collaborators (MIT, Berkeley)
STEM capacity building
Yurok Community members
Other Tribes
Analyses and DSS
Tribal data
Info local conditions
Resources for community uses
Constituency support
CA State Gov.
State agencies (CAF&W, State Parks, ARB)
Governor's Tribal advisor
Resource management regulations
Resource management
Yurok Natural Resources Division
Carbon
Forestry
Fire
Fisheries
Wildlife
Environmental Program
Watershed restoration
Revenue from carbon credits and logging
Yurok Tribal Gov
Development of tribal policy
Resource management info
High-level policy direction
US Federal Gov.
Tribal agencies (BIA)
Environmental agencies (USF&W, USFS, BLM, NPS, EPA, DOT, DOC, State)
Resource management regulations
Resource management
Grants for economic development
EDA
Remote sensing data
NASA, NOAA
Grants for economic development
Nonprofits/NGO
Humboldt Area Foundation
Information on carbon projects
The Conservation Fund
Legend
Service/Goods
Information
Political
Financial
Tribal
Non-Tribal



The **EVDT (Environment-Vulnerability-Decision-Technology) Modeling Framework** of the Space Enabled Research Group

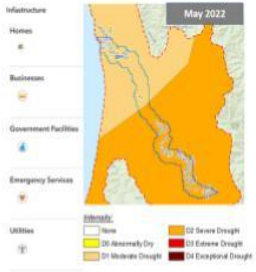
(Courtesy of the Yurok Tribe)

Satellite remote sensing data and field observations of forest and fire phenomena



Sustained Tree Cover Change (NDVI - MA)

Local socioeconomic data on land use and information on cultural value of resources



Policy Constraints & Opportunities such as funding and coordination with State and Federal agencies

(Courtesy of the Yurok Tribe)

Environment: *Tree cover and species analyses, modeling of carbon stocks and forest structure*

Environmental dynamics

Vulnerability: *Visualizations of socioeconomic data and environmental analyses*

Environmental dynamics and estimates of socio economic impact

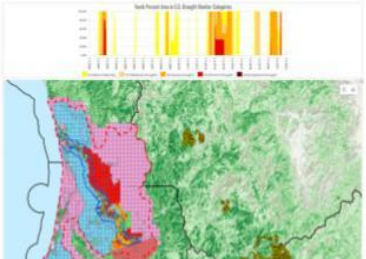
Decision-making: *Balancing revenue, resilience, and cultural values in forest management practices*

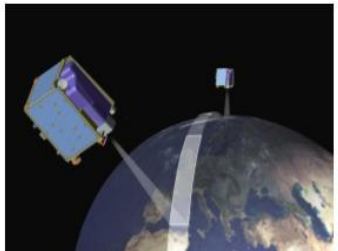
Policy actions related to forest management

Technology:
Development of Yurok Natural Resources Portal DSS

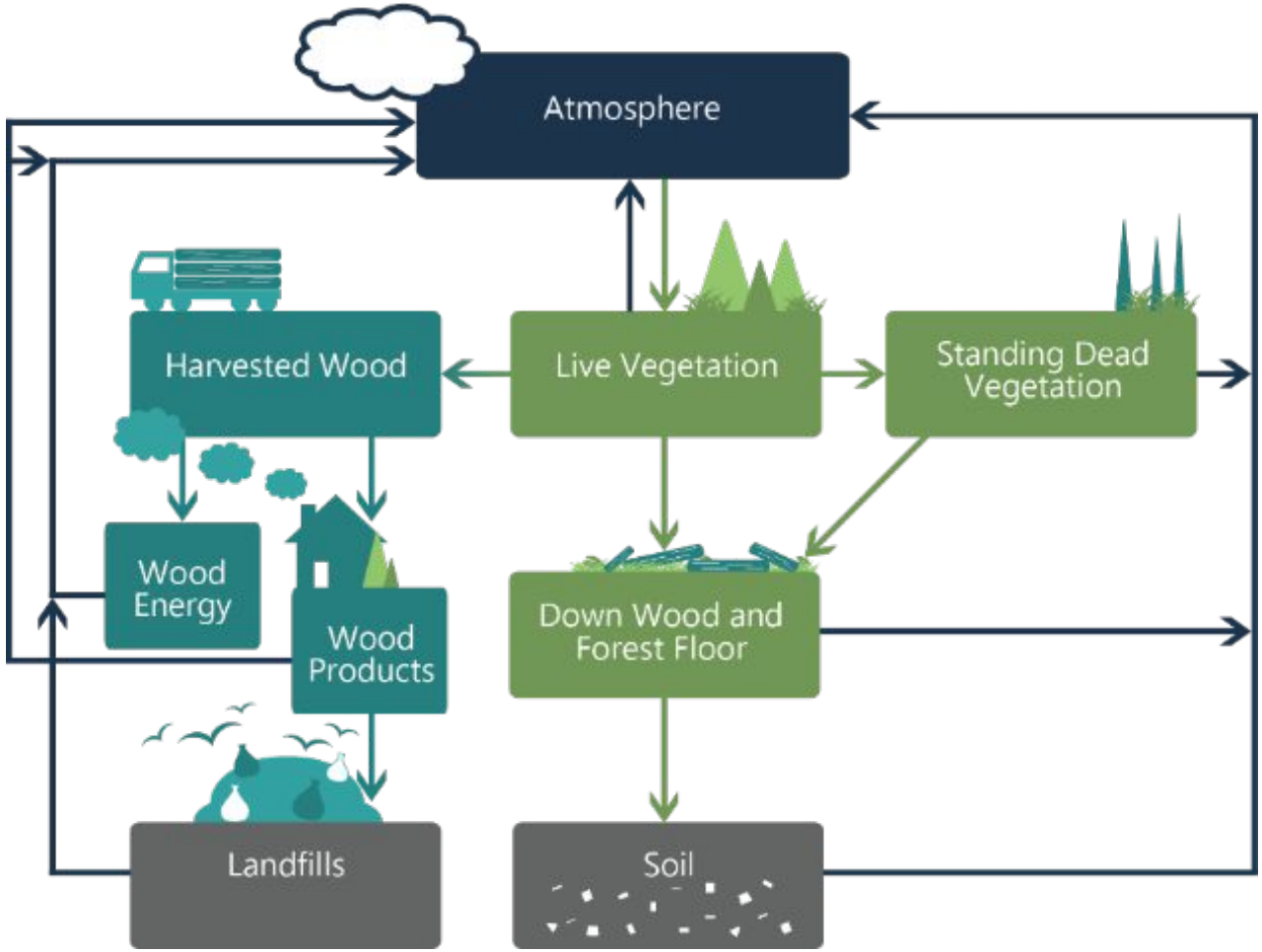
Decision support for improved forest management and fire response

Additional data and insights for forest management and fire response





Forest Sector Carbon Cycle



CALIFORNIA AIR RESOURCES BOARD

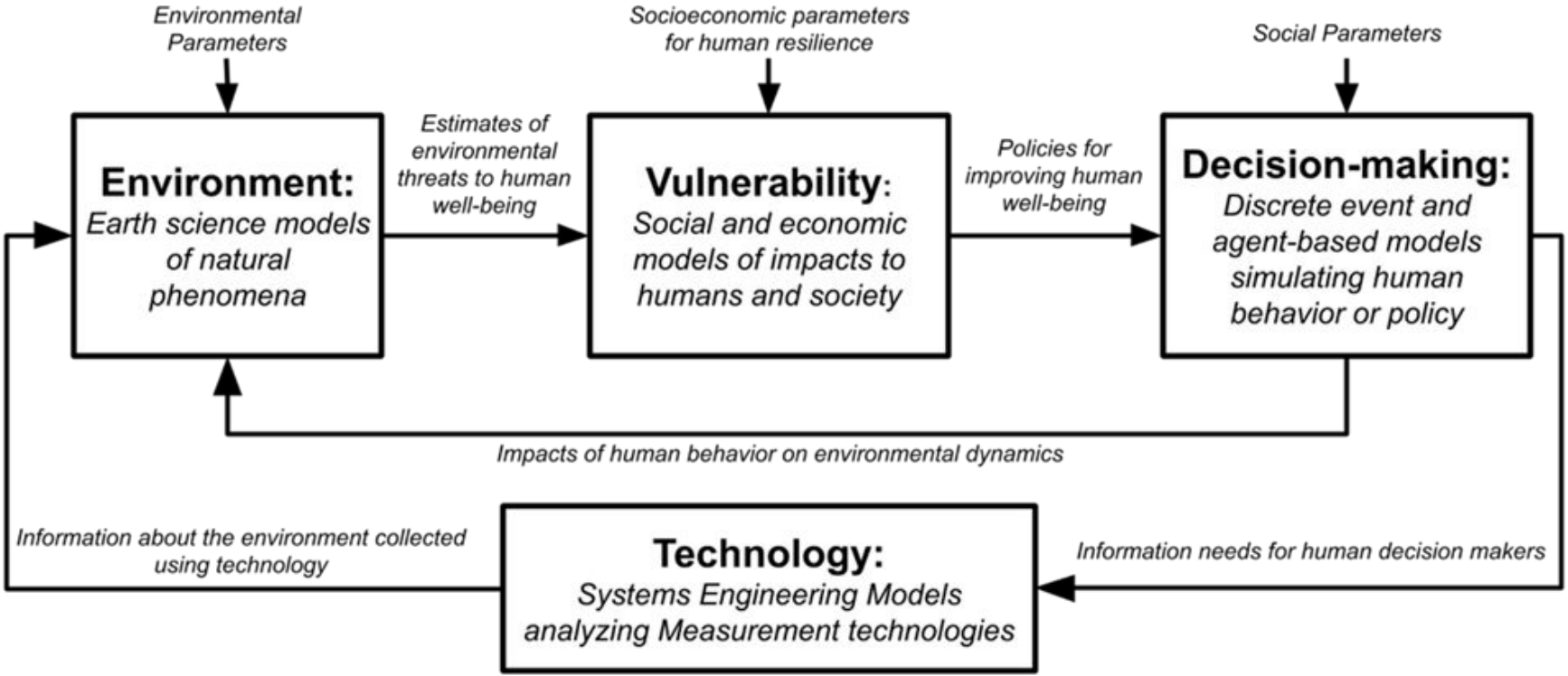
01	Improved Forest Management (IFM)	• Increasing carbon sequestration above regional baseline, tree stocking, extended harvest rotations, and reduced timber harvesting
02	Avoided Conversion	• Forest preservation that would otherwise be conferred to non-forest use
03	Afforestation	• Forests restored on land that have been non-forested > 10 years

Decision Making Opportunities

- To what extent do currently held forested land satisfy carbon storage expectations?
- What are the potential impacts of severe disturbances & historical/current forest management?
- Where can the Yurok Tribe prioritize land acquisition and why?

- Total study area is 1919 km2 (Ramos, 2021)
- Ecosystem type: California Coastal Redwood Forest and Mediterranean California and Mixed Evergreen Forest
- CARB Improved F. Mngt. Plots
  - CAFR0064-Early Action
  - CAFR5011-Compliance
  - CAFR5090-Compliance
- Ke'pel Creek
  - 2,424 acres plot repatriated to tribe

Credit: Yurok G.I.T Department



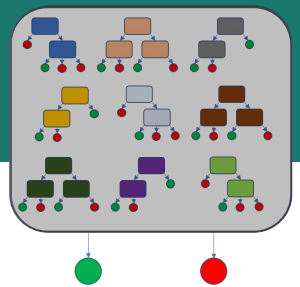
The **EVDT (Environment-Vulnerability-Decision-Technology) Modeling Framework** of the Space Enabled Research Group

Research Activity 1

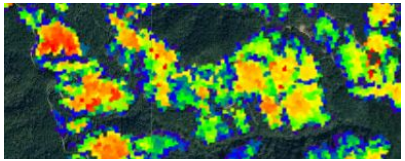
Random Forest Land Cover Mapping

Establish forest cover extent using a multi-sensor multi-temporal supervised classification approach

- **Random Forest Classification Model**



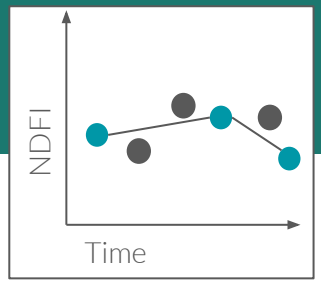
Research Activity 2



LandTrendr Temporal Segmentation

Landsat-based Detection of Trends in Disturbance and Recovery (LandTrendr) algorithm selected to analyze the magnitude of change and the year of change in forest areas.

- **Temporal Segmentation & Change Detection**

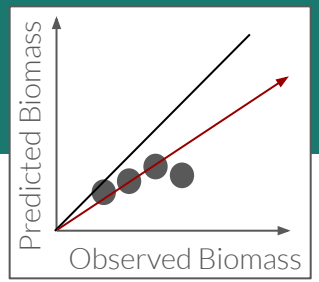


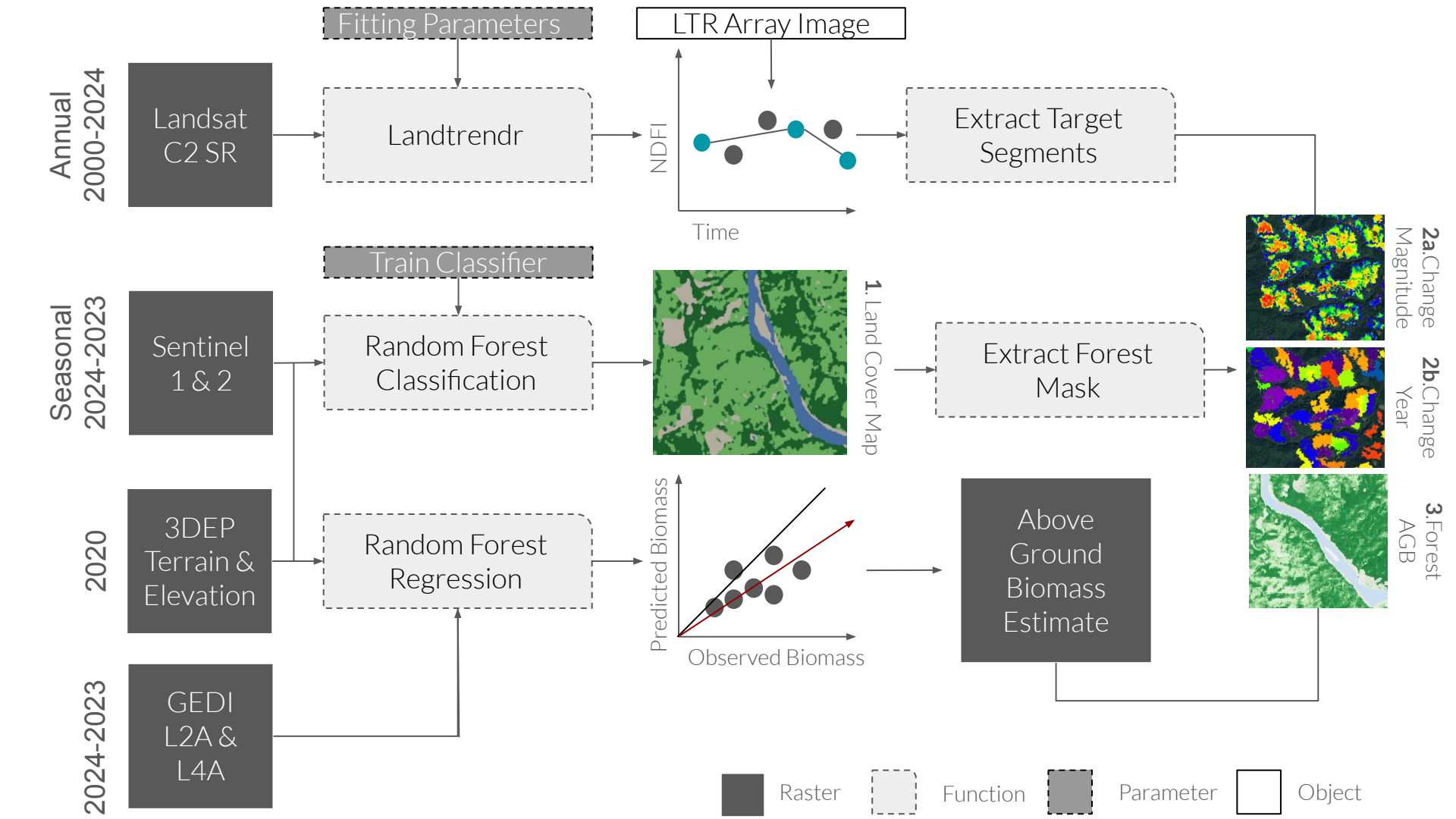
Research Activity 3

GEDI Above Ground Biomass Modeling

Estimate AGB to understand forest carbon stocks using Global Ecosystem Dynamics Investigation (GEDI) LiDAR instrument, Sentinel-2 optical using a Random Forest Regression (RFR).

- **Random Forest Regression**



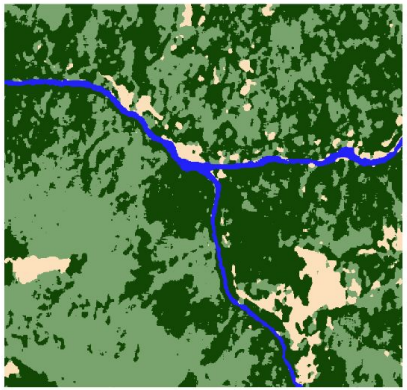

Annual
2000-2024
Landsat
C2 SR
Fitting Parameters
Landtrendr
LTR Array Image
NDFI
Time
Extract Target
Segments
Seasonal
2024-2023
Sentinel
1 & 2
Train Classifier
Random Forest
Classification
1. Land Cover Map
Extract Forest
Mask
2a. Change
Magnitude
2b. Change
Year
2020
3DEP
Terrain &
Elevation
Random Forest
Regression
Predicted Biomass
Observed Biomass
Above
Ground
Biomass
Estimate
3. Forest
AGB
2024-2023
GEDI
L2A &
L4A
Raster
Function
Parameter
Object

Research Activity 1

Land Cover Land Use Mapping

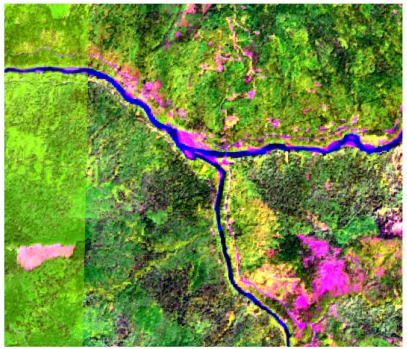
- Input: Sentinel-2, Sentinel-1, 3DEP DEM, 3DEP Slope, 3DEP Aspect
- Output: Random forest model and land cover classification for 2023 May-Oct

A



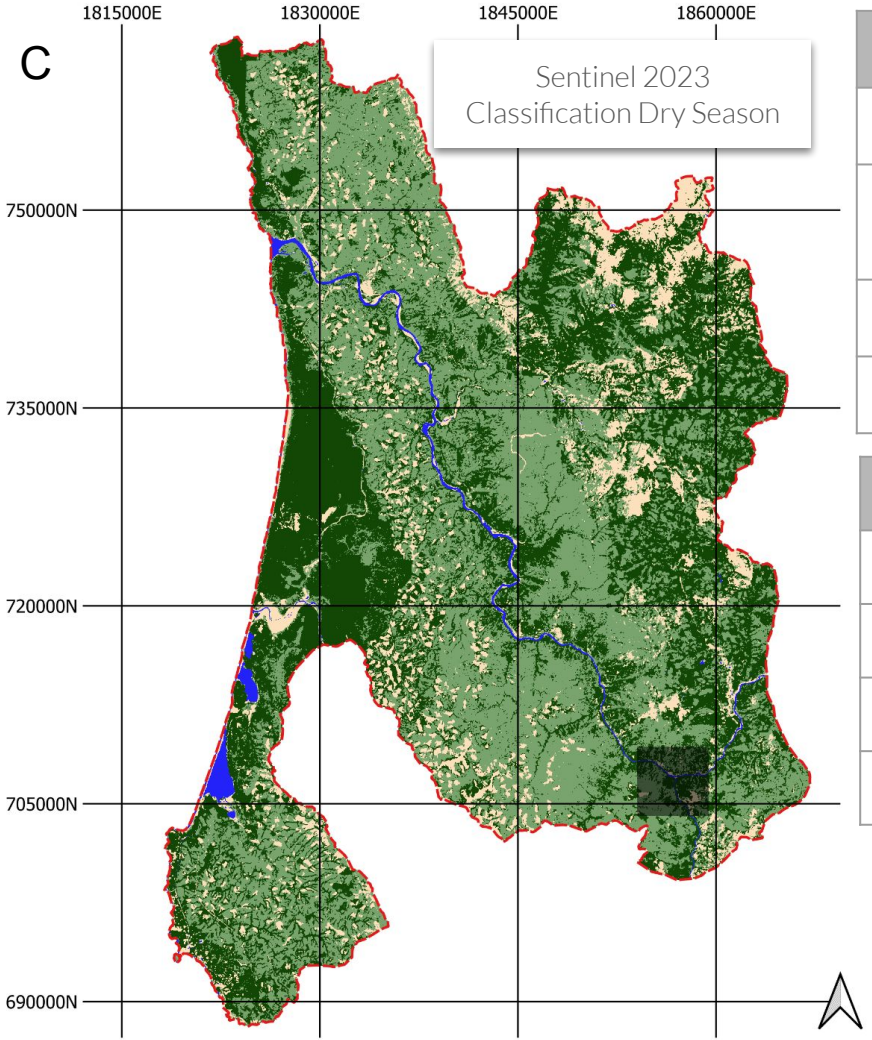
Sentinel 2023 Classification

B



Sentinel 2023 False RGB

C



Class	Area (Acres)
Water	6,919
Non-Vegetation	59,552
Trees-Mixed	223,877
Trees	202,379

Metric	Percent
Accuracy	83.2
Precision	90.2
Recall	90.3
F1-Score	90.2

Yurok Ancestral Territory

Yurok Land Cover

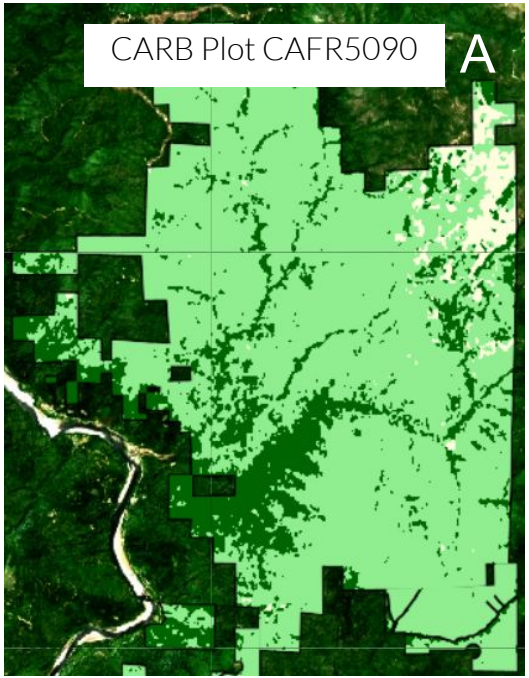
- Water
- Barren
- Mixed Forest
- Forest

Credit: Priscilla Baltezar,
MIT Space Enabled Research Group

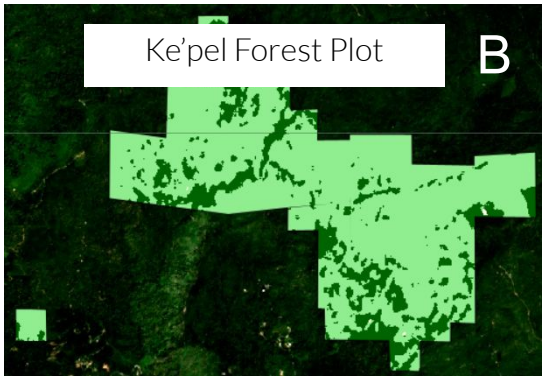
0 8 16 km

NAD83 / California zone 1

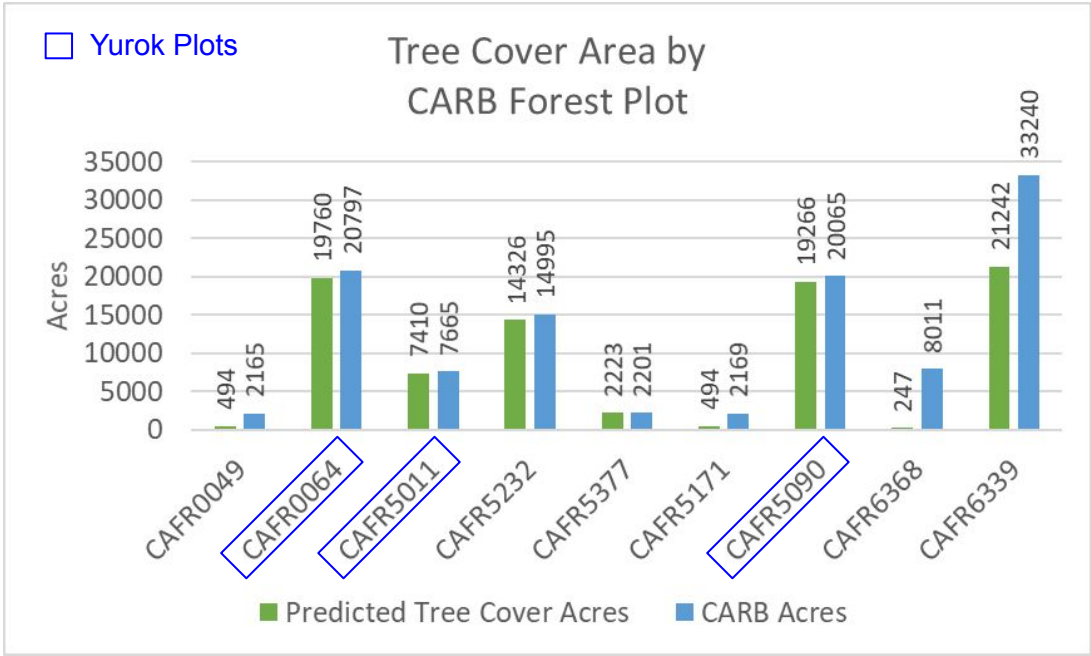
Research Activity 1



Sentinel Land Cover Classification 2023



Sentinel Land Cover Classification 2023



Project	Predicted Tree Cover Km2	Predicted Tree Cover Acres
Ke'pel Creek	11	2718.16

Research Activity 1 shows extent estimates that align well with the CARB third-party extent estimates

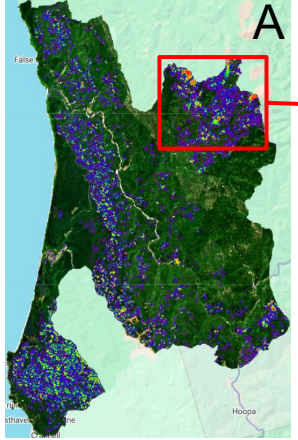
Research Activity 2

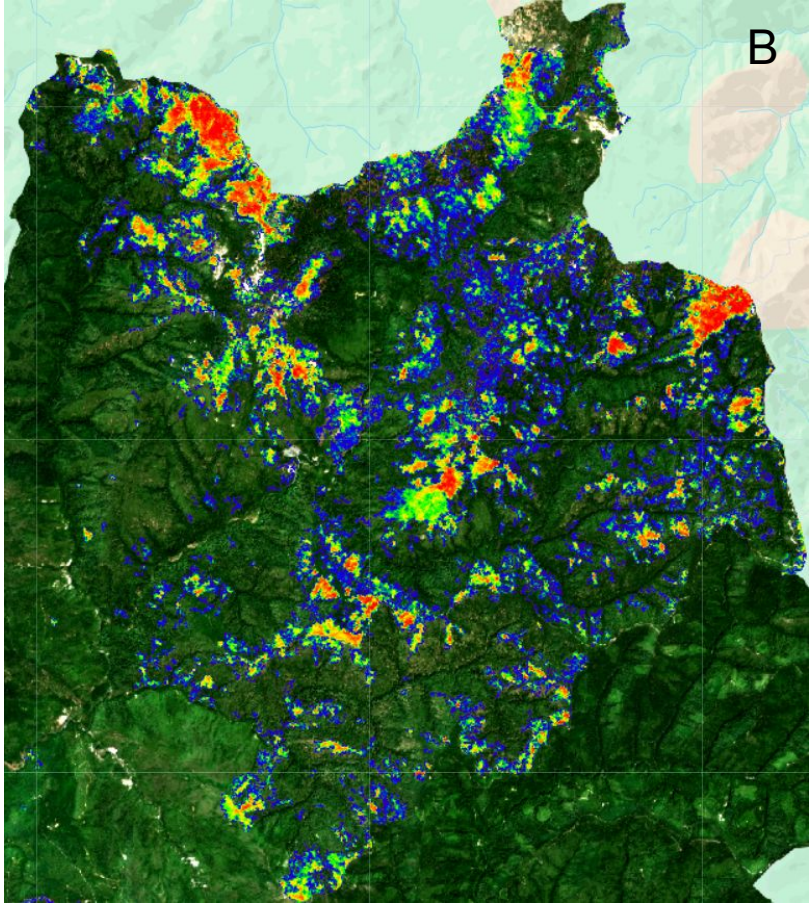
LandTrendR Year of Maximum Loss and Change Magnitude

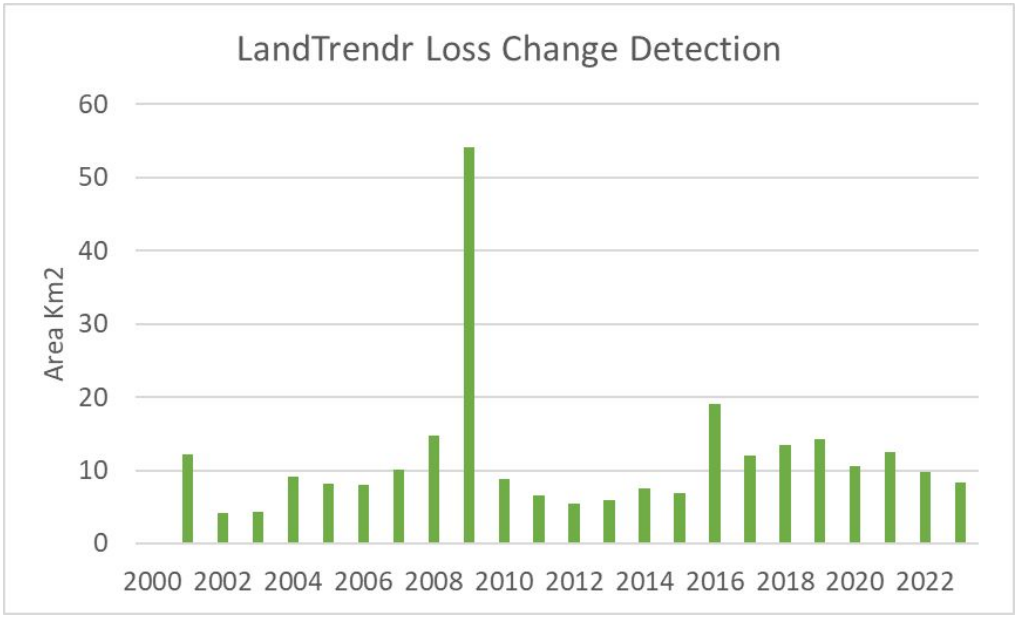
- Input: Landsat Array Annual Image Stack, Index: Normalized Difference Fraction Index, forest mask
- Output: Magnitude of Maximum Loss and Year of Maximum Loss

LandTrendr Change Detection

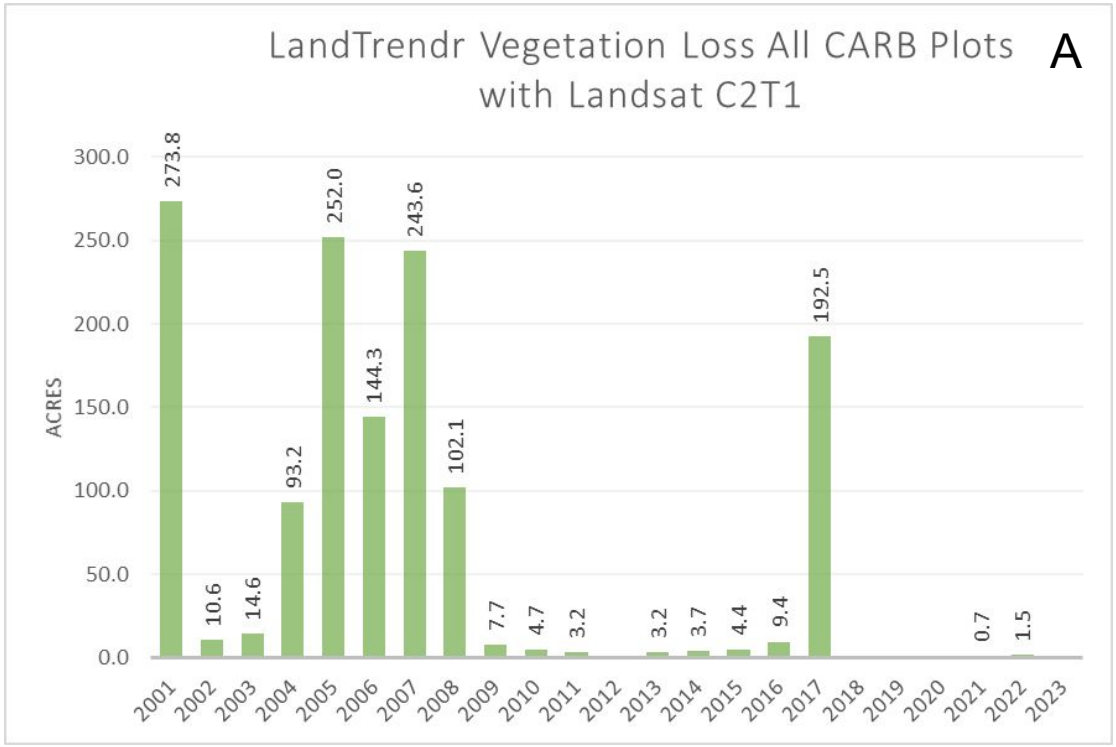
- Year with greatest loss detected in 2009
- Loss was detected as a high magnitude Event in Yurok territory in North West corner

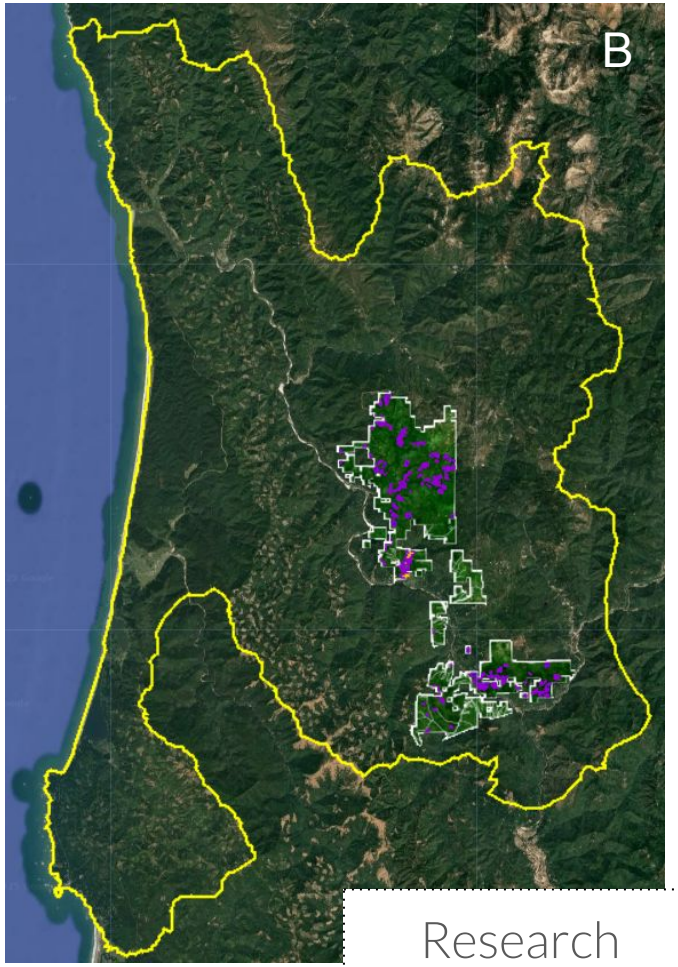






Research Activity 2





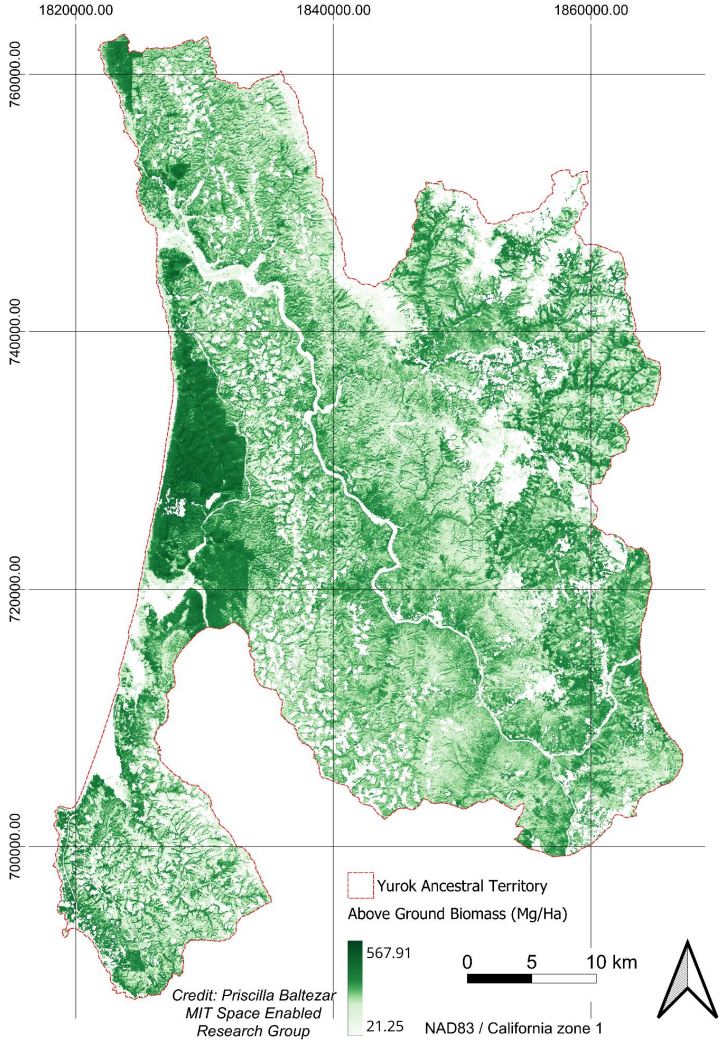
Most recent loss occurred in 2017 in forest with most disturbance found in CARB Plot ID CAFR5011

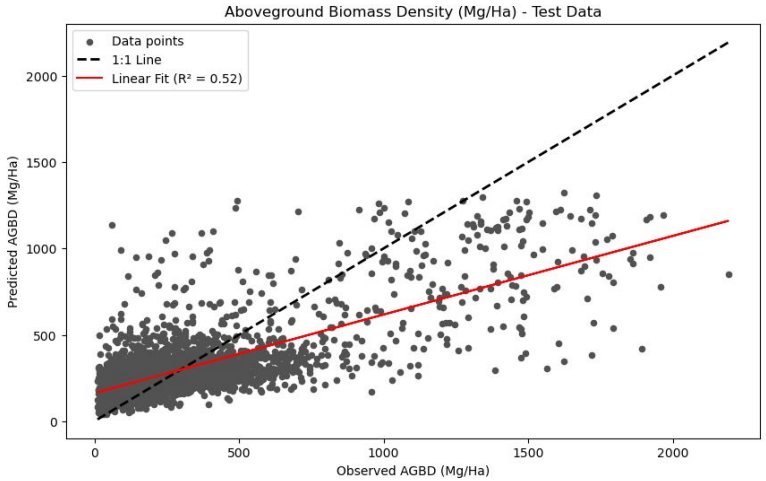
Research Activity 2

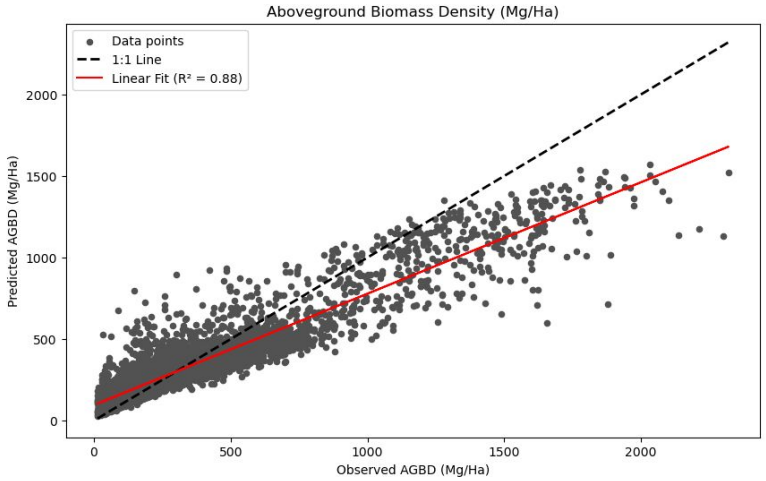
Research Activity 3

GEDI Above Ground Biomass Modeling

- Input: GEDI L4A, Sentinel-2, Sentinel-1, 3DEP DEM, 3DEP Slope, 3DEP Aspect, forest mask
- Output: Above Ground Biomass raster estimate for study area (1,919 km2)





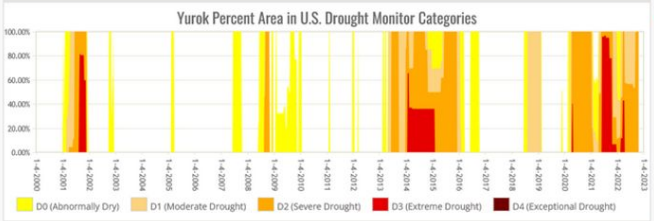


AGBD Metric	Value
Mean	457.04
Median	256.65
Standard Deviation	450.14
Min	22.29
Max	2122.35

Research Activity 3 shows initial methods to build a LiDAR-based AGBD

Environmental Data

Historical Drought Intensity - Yurok Tribal Area



Historical Drought Intensity - Yurok Tribal Area

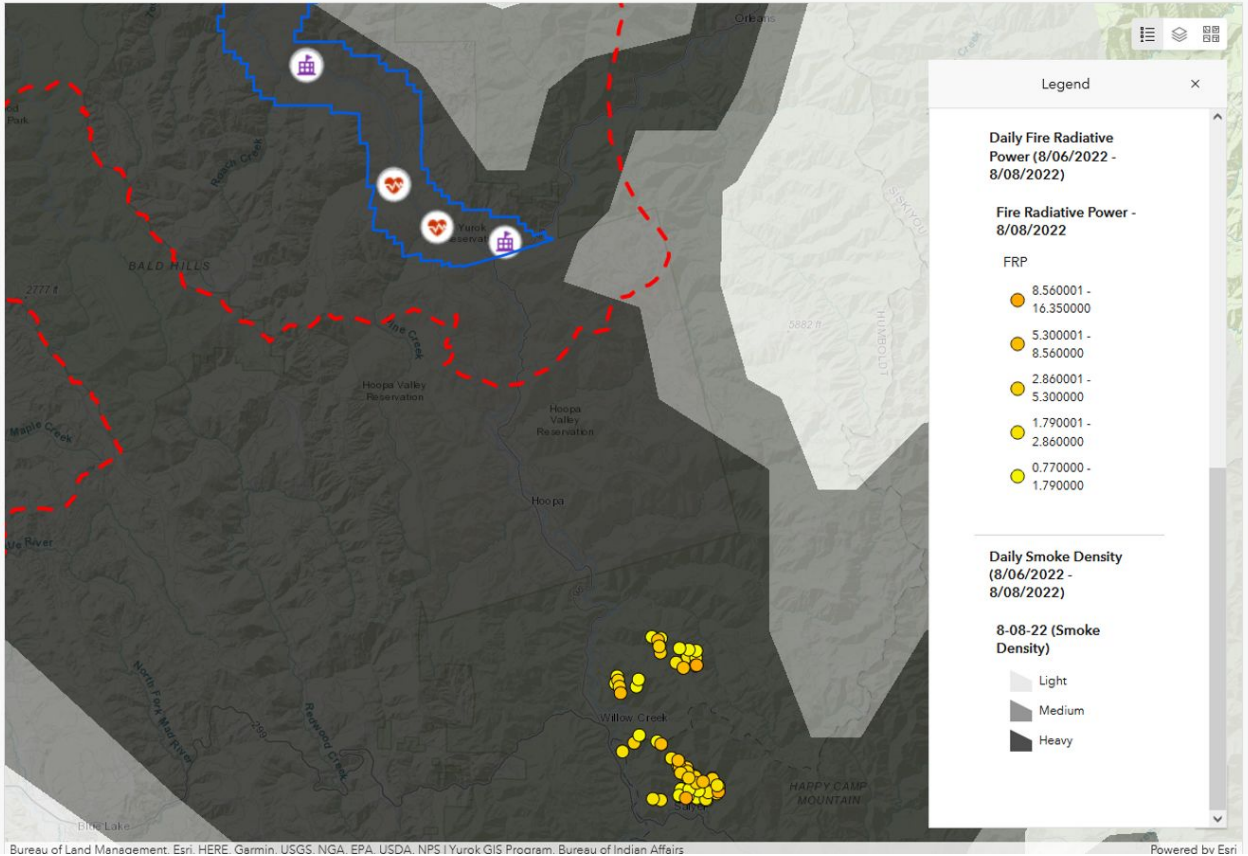
Socioeconomic Data

Emergency Assistance Funds

Requested Emergency Assistance	Available funds per Tribal Member
Food/Clothing/Hygiene	$80
Fuel/Utilities	$300
Shelter/Rent/Mortgage Assistance	$500
Vehicle/Home Repair	$500
Medical Transportation	$350

Emergency assistance

Geospatial data: environmental and socioeconomic




N901CA

- ~86.5% of Yurok ancestral territory is forested (~426,256 acres)
- Yurok Tribe holistically manages 75,000 acres of forested areas
- Around 65,730 acres of forest area were lost from 2000 to 2023
- Large disturbance event detected in 2009 in territory and in 2017 for Yurok CARB Forest Plots

(Redwood National Forest, 2016)

References

Kennedy, R.E., Yang, Z., Gorelick, N., Braaten, J., Cavalcante, L., Cohen, W.B., Healey, S. (2018). Implementation of the LandTrendr Algorithm on Google Earth Engine. Remote Sensing. 10, 691.