



Jet Propulsion Laboratory
California Institute of Technology

Ecological Projection Analytic Collaborative Framework (EcoPro)

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June 21, 2023

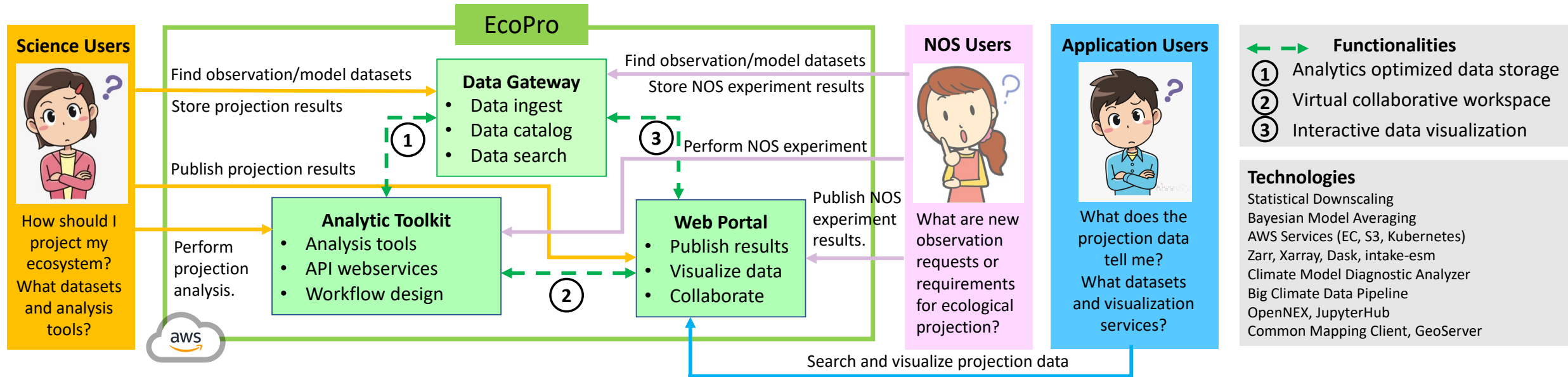
2023 Earth Science Technology Forum

EcoPro: What is it?



EcoPro is an analytic collaborative framework to

- Perform scientific studies for ecological projection;
- Generate and visualize application-usable datasets for ecosystem conservation;
- Conduct experimental studies for New Observing Strategies (NOS) development.



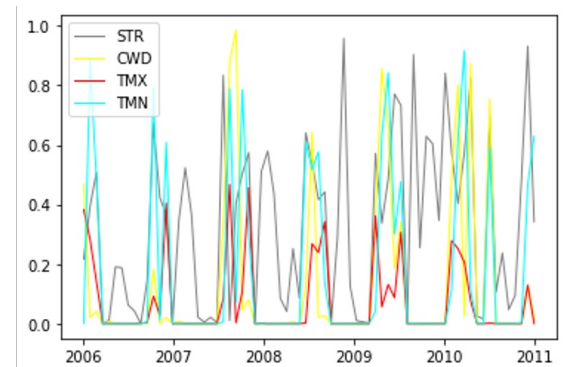
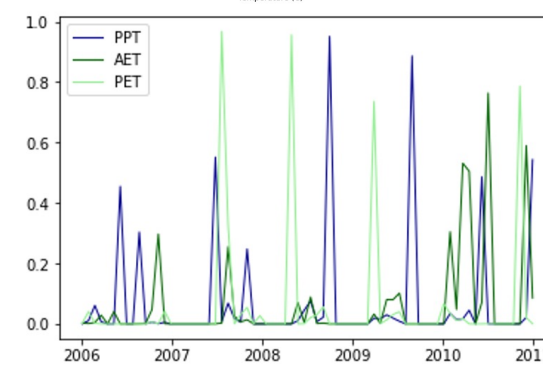
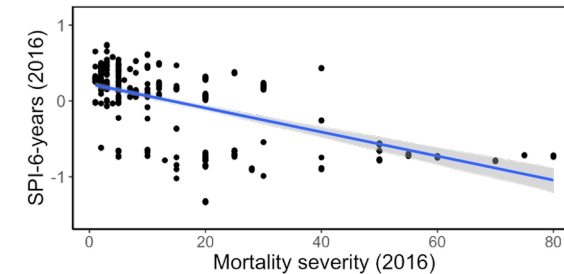
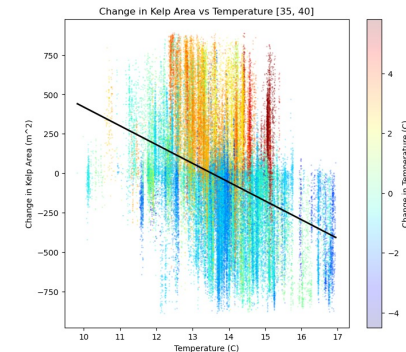
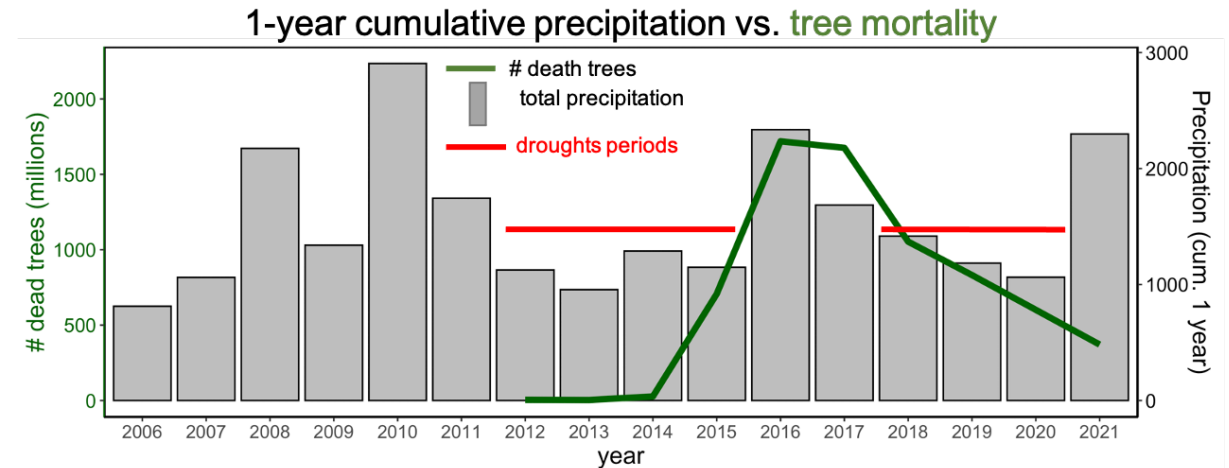
EcoPro: Why are we building it?

- In this time of global heating and rapid climate change, Earth's ecosystems are under great stress for their survival and Earth's biodiversity is being rapidly reduced.
- Despite the importance of biodiversity for humanity and the imminent nature of the threat, efforts to project these losses over the coming decades remain crude.
- As a discipline, ecological projection is still in its early stage and will become increasingly important as stress drivers increase and losses mount.
- EcoPro will advance the ecological projection discipline by using cutting-edge data science methodologies to more optimally extract information from remote-sensing data, in-situ data, and ESM projections and by providing a framework to collaborate and generate application-ready datasets.

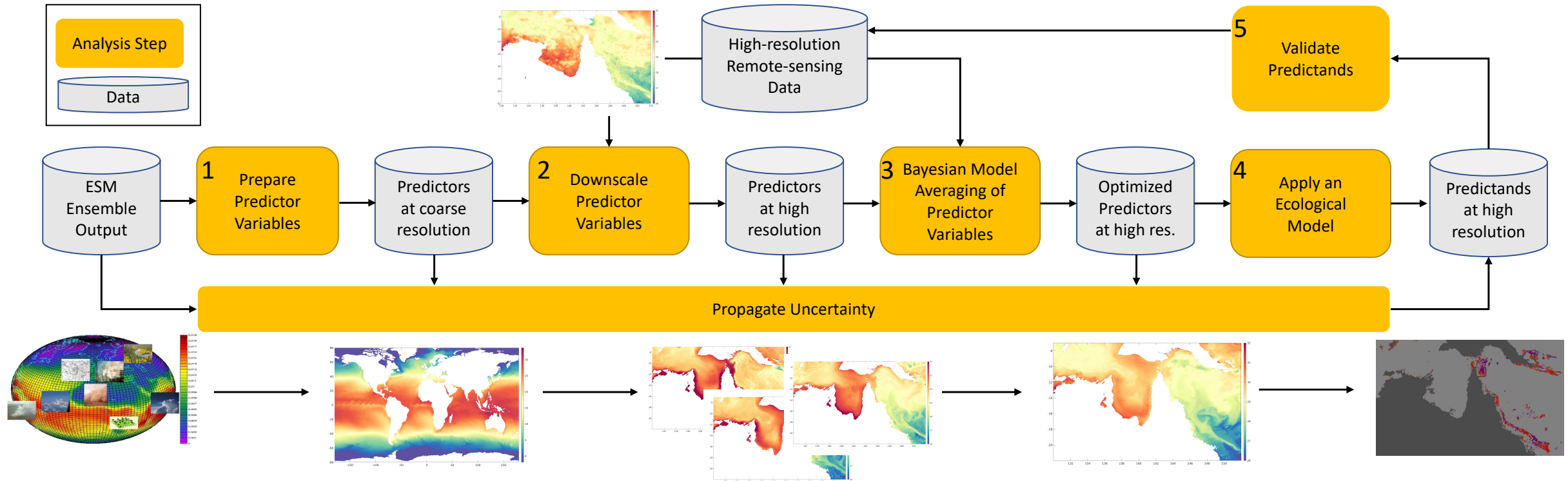


EcoPro: Ecological Model Development

- Find the relationship between predictors and predictands.
- Explore potential predictor/stressor variables (e.g., individual climate variables, multivariable-driven climate indices).
- Quantify their relative importance/contribution to the predictand (e.g. the ecological system health/mortality).
- Explore time-dependent correlations between the predictor and predictand variables (e.g. instantaneous response, time-delayed response, or time-cumulative response).
- Use a regression method to build an ecological model based on the results.

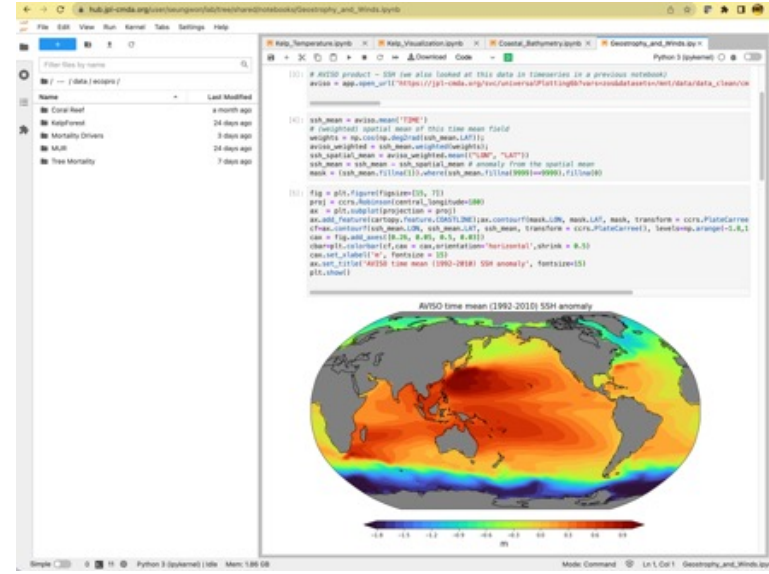
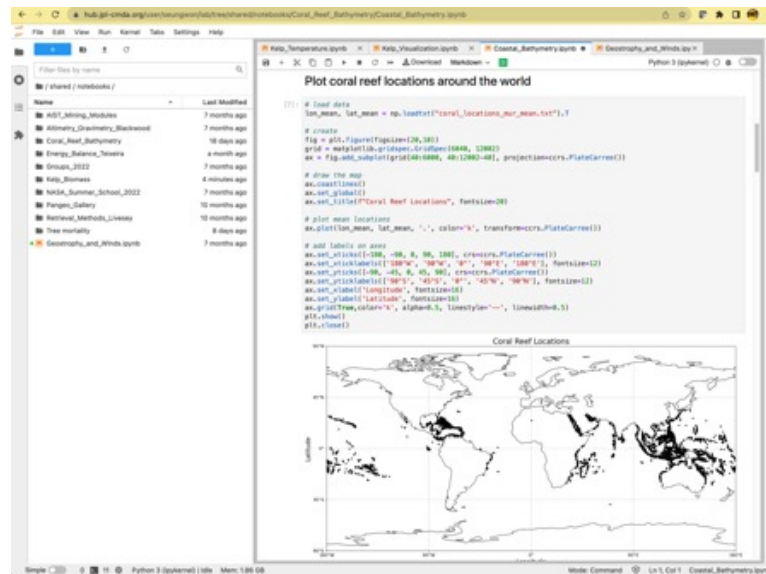
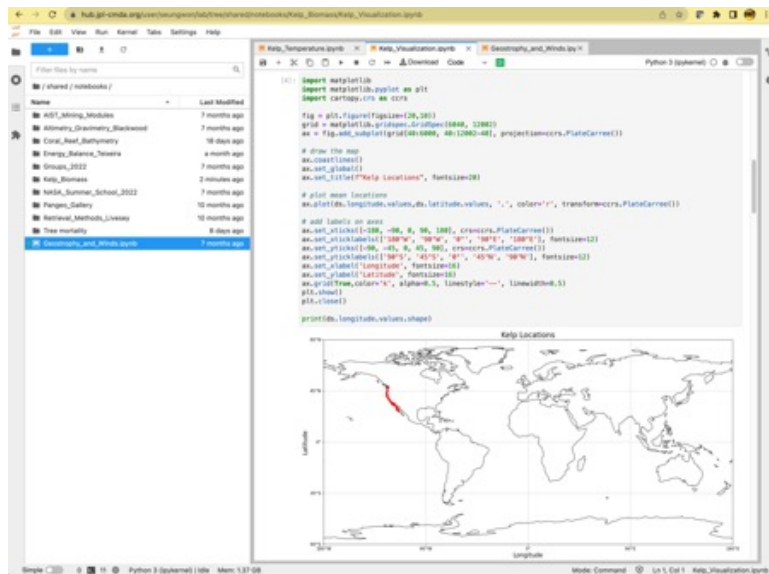


EcoPro: Ecological Projection Methodology



1. Collect, collate, and re-grid the ESM predictor variables;
2. Downscale the predictor variables using geostatistical inference and high-resolution remote sensing observations;
3. Skill-weight the ESM predictor variables against observations;
4. Apply the ecological model to perform the ecological projection and quantify the uncertainty of the projection;
5. Validate the ecological projections.

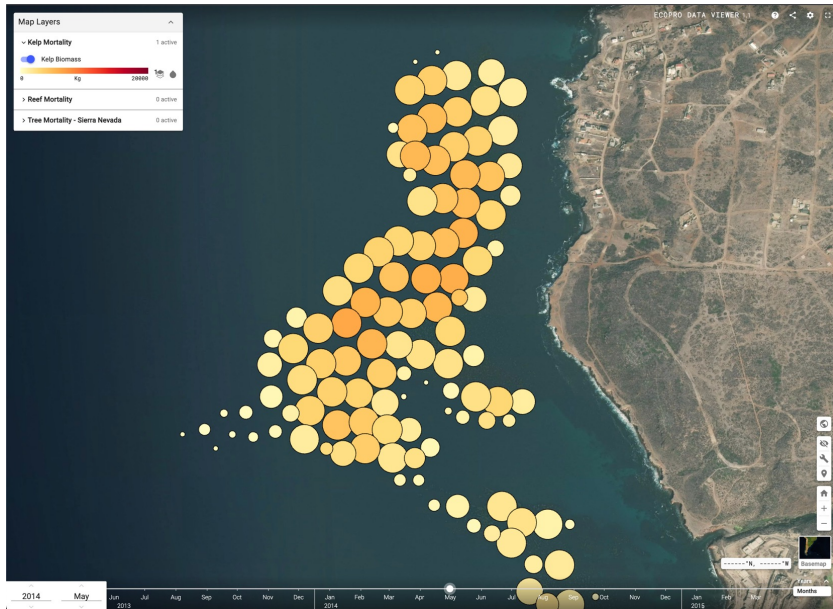
- JupyterHub server running on Amazon Elastic Kubernetes Service
- Data transfer between AWS EC2 instances and S3 bucket data server without requiring access key authentication
- Python and R code development environment
- Reusable routines to build a workflow for ecological projection
- Data cataloguing, search, selection, access, and loading with intake-esm



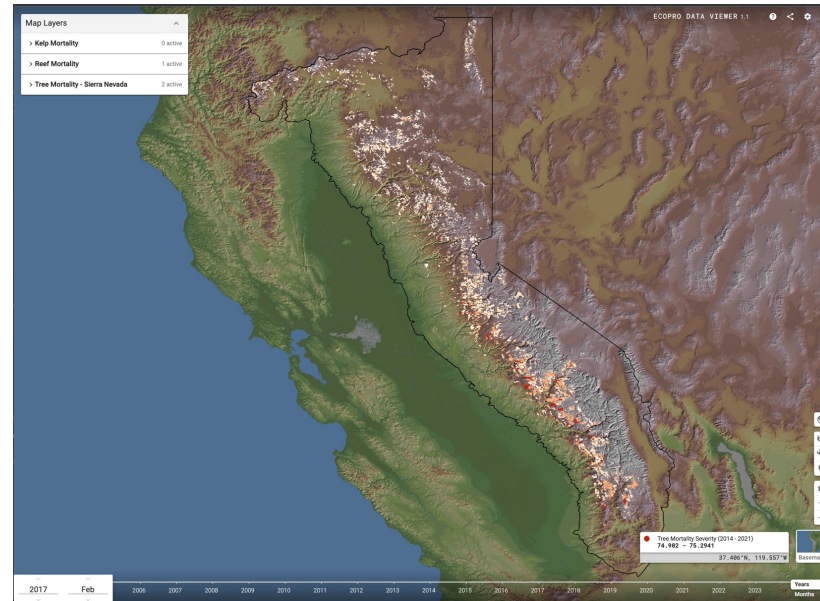
EcoPro Visualization Server



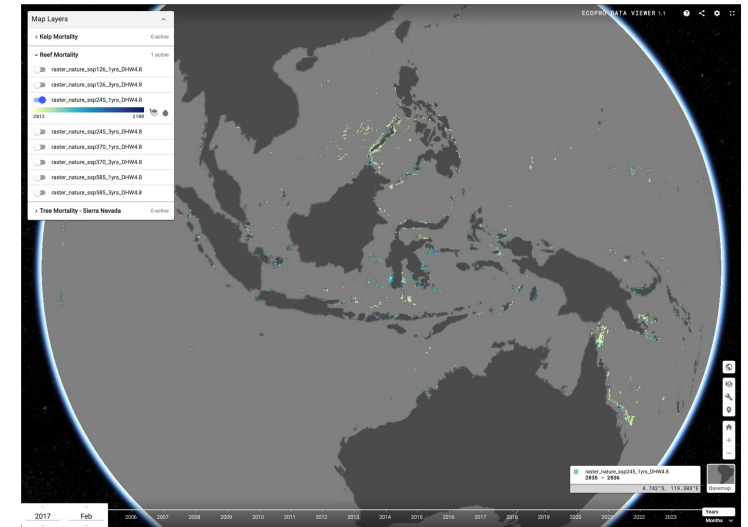
- A frontend and backend application bundle for ingesting, serving, and viewing high-resolution geospatial data
- Common Mapping Client (CMC) base framework
- Support for GeoTIFF, NetCDF, and Shapefiles.
- Dynamic pixel value extrapolation
- Dynamic layer ingestion with minimal configuration
- Multi-layer configuration, Layer sub-grouping
- Fully Dockerized and ready for cloud deployment



Kelp Area



Tree Mortality



Coral Reef Mortality

EcoPro Collaboration Server



- Web-based collaboration portal: <http://smudsi.org>
- Deployed to an AWS instance
- Functionalities supported:
 - User access control and profile management
 - Project publication
 - Team communication through comment board
 - Email notification for new comments in the project comment board

List of Comments Registered of Project				
Comment Board				
Showing results: 1 to 4 of 4				
Sort By: Comments ID				
Id	Comment	Publisher	Date	File
43	I'm uploading the slides presented in the EcoPro m...	Ferraz Antonio	Wed Jun 14 05:04:26 UTC 2023	Check File
22	I am uploading the random forest analysis using 10...	Chakraborty Sudip	Thu May 11 06:26:51 UTC 2023	Check File
12	sounds good (test)	Ferraz Antonio	Wed May 03 06:38:13 UTC 2023	-
11	Idea: We have the data. Now we can begin with ra...	Chakraborty Sudip	Wed May 03 06:36:41 UTC 2023	-

NASA EcoPro Collaboration Server

A Virtual Collaborative Work Space for High-resolution Datasets.

Projects	NASA Researchers	My Dashboard	Collaboration Server
Default Project: EcoPro	NASA Researchers	My Followers	Visual tutorials
Projects List	Technologies	My followees	About NASA
Users List	Find researchers	My network	NASA EcoPro Collaboration Server

EcoPro - Tree Mortality

Goals
Study the climate drivers of tree mortality in Sierra Nevada (CA)

Description
We will model tree mortality in Sierra Nevada using annual tree mortality maps (2012-2021) and a time series of potential mortality drivers (climate, environmental, geology and biota). We will test the predictive power of the mortality drivers using Generalized Linear Models (GLM) with LASSO regularization and Machine Learning models (e.g., Random Forest).

Technologies Used
hub server, analytic tool, web portal, phyton, R

Project Member

Email	First name	Last Name
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EcoPro: Tree Mortality Use Case

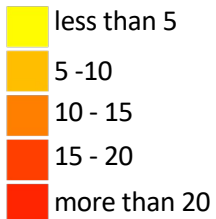
- Model tree mortality from environmental data (climate, soil moisture, topography), enabling predictions of tree mortality under future climate scenarios.
- Harmonized the USFS tree mortality time series geodatabases to produce time series (2012-2021).
- Processed historical and future monthly climate products and developed drought indices from the monthly climate products.

Tree mortality time series

2012-2014

2012-2016

dead trees per acre



Drought indices

2012

2014

2016

Standardized
Precipitation Index

drier than 50-year average

wetter than 50-year average

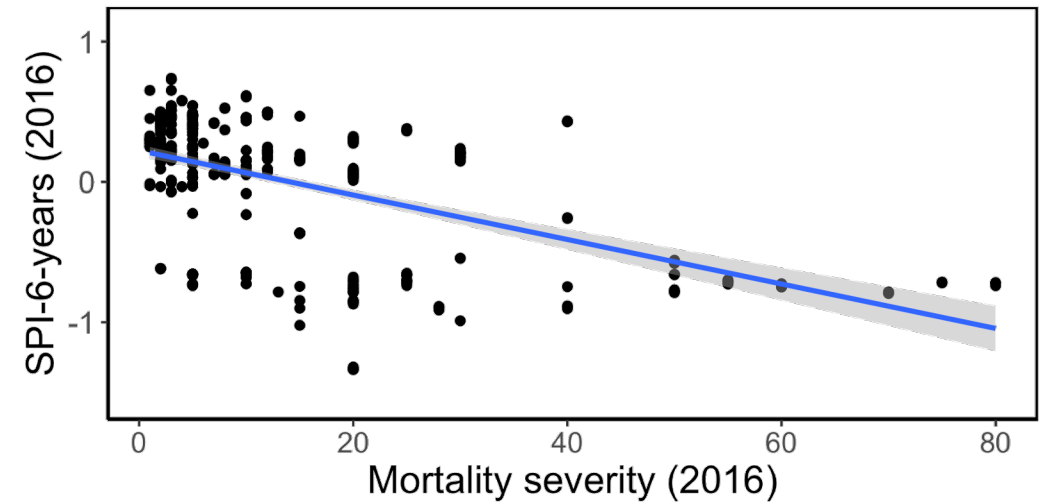
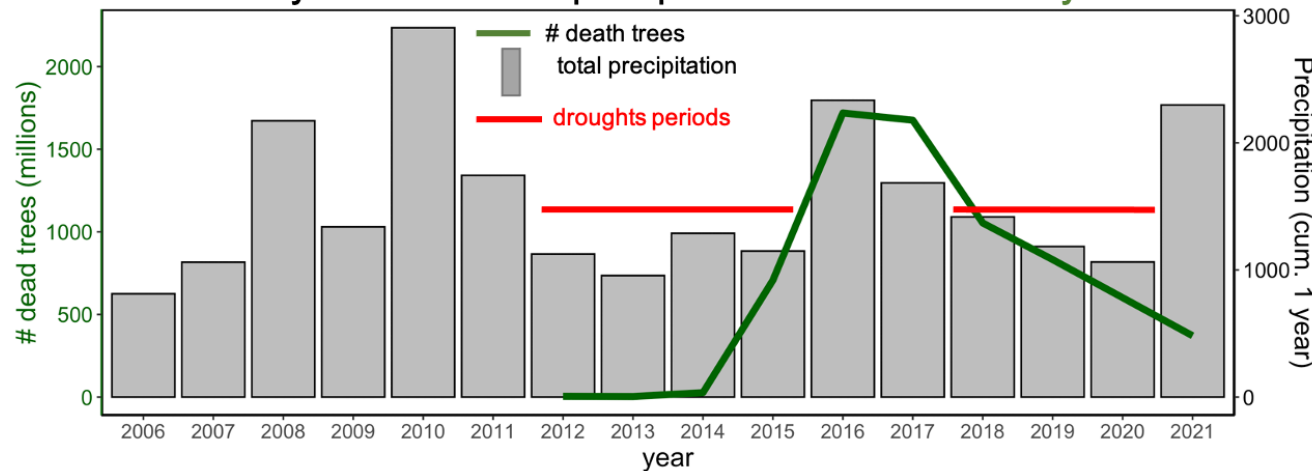


EcoPro: Tree Mortality Use Case



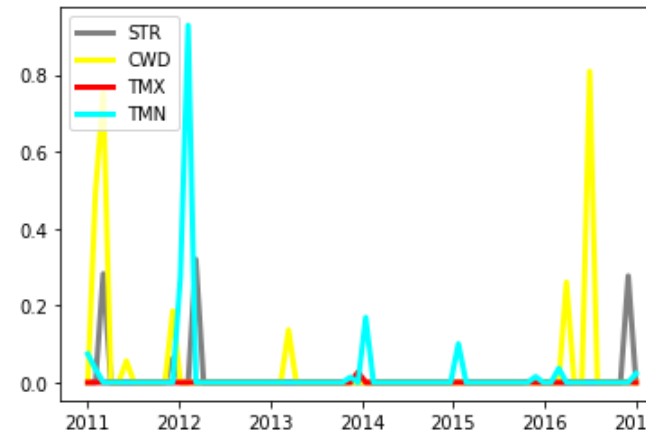
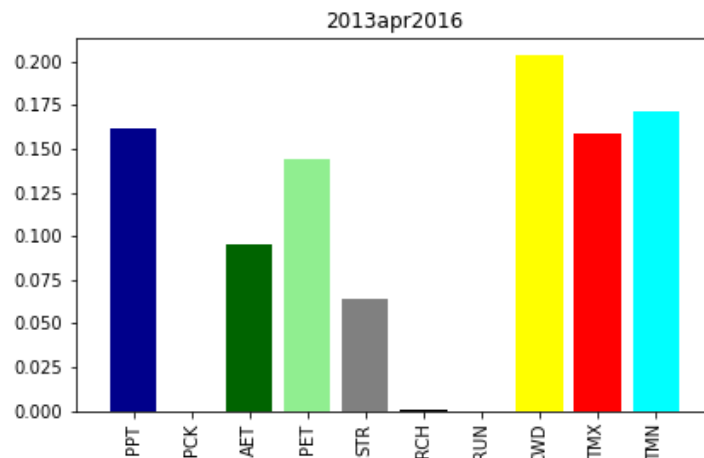
- Time series analyses show that tree mortality manifested massively after 3 to 4 consecutive years of drought.
- A single drought index (Standardized Precipitation Index) with respect to 6 years average is well correlated with severe tree mortality.

1-year cumulative precipitation vs. **tree mortality**



Features

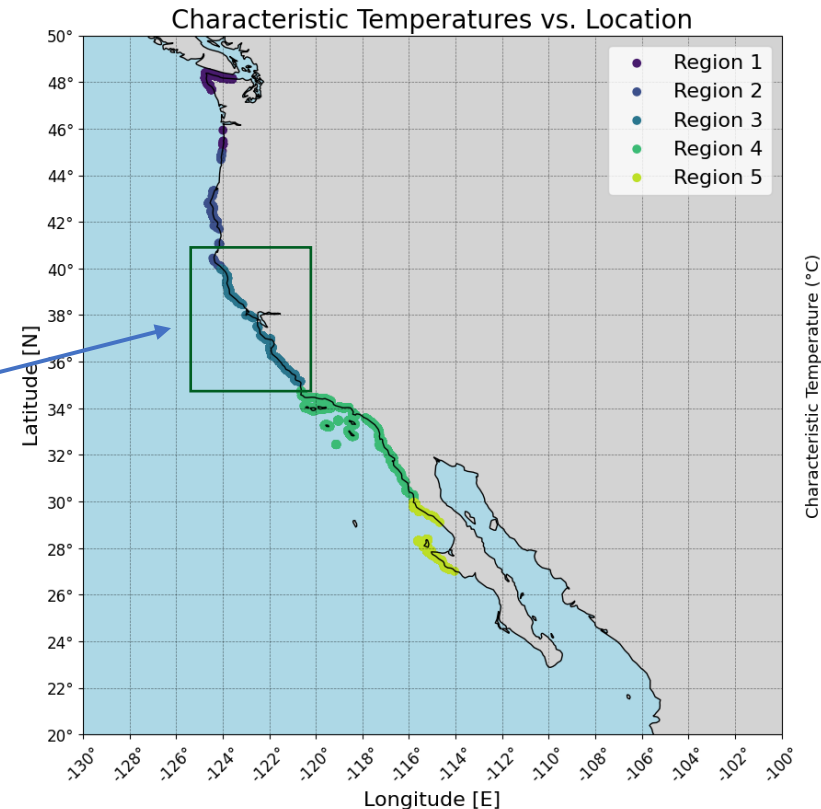
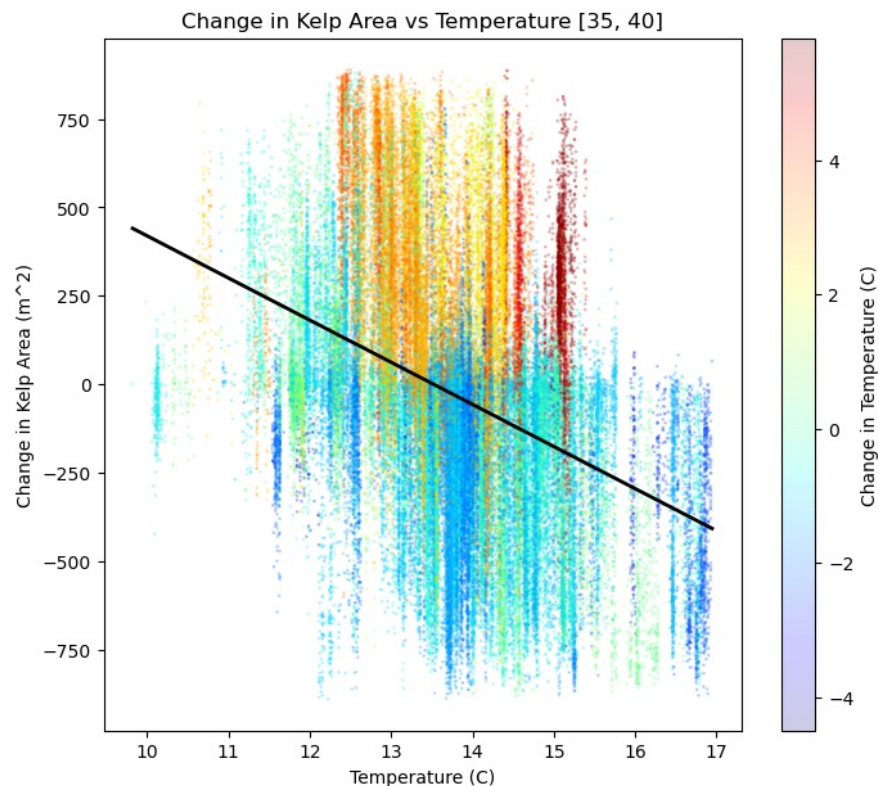
Precipitation (PPT)
Snow water Equivalent (PCK)
Actual ET (AET)
Potential ET (PET)
Soil water storage (STR)
Recharge (RCH)
Runoff (RUN)
Climate water deficit (CWD)
Maximum Temperature (TMX)
Minimum Temperature (TMN)



EcoPro: Kelp Forest Use Case



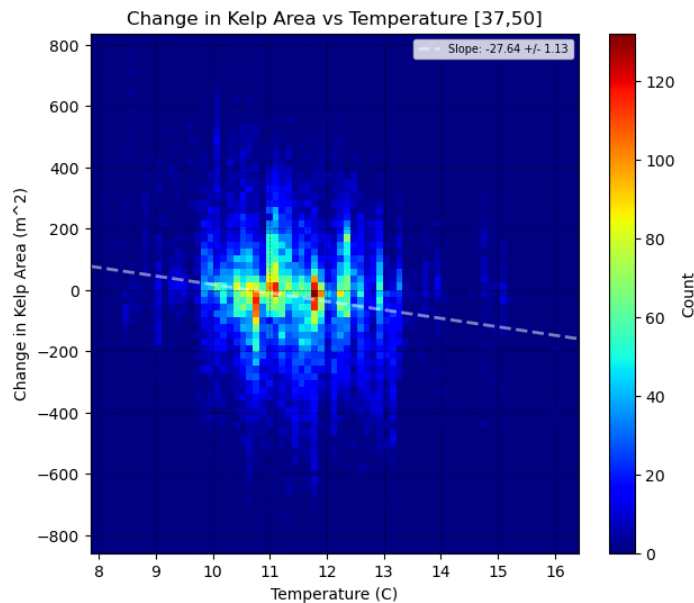
- Model kelp biomass (presence area) with environmental data (sea surface temperature) and predict kelp area under future climate scenarios.
- Found correlations between change in the kelp area and sea surface temperature when grouped the data by regional area with a latitude range.



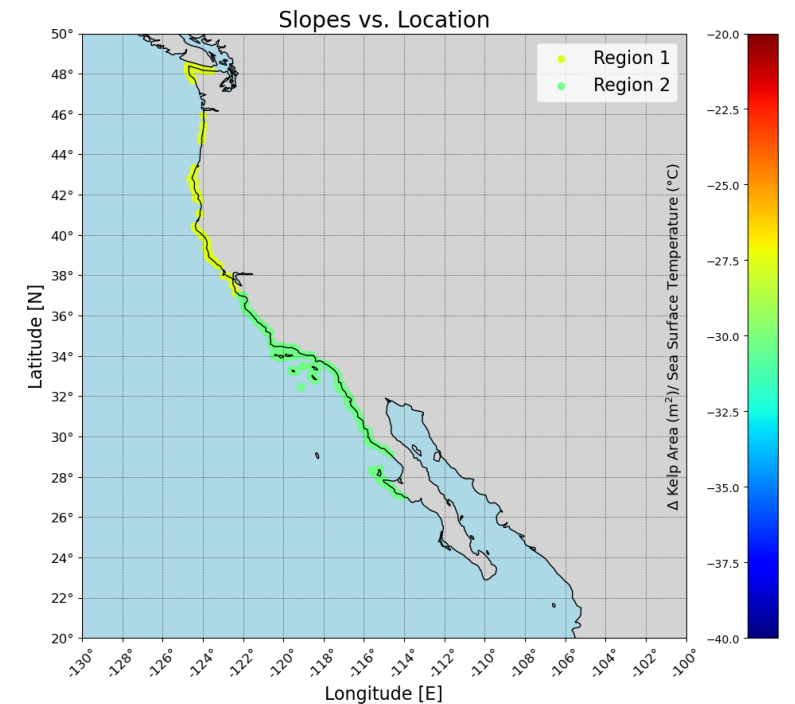
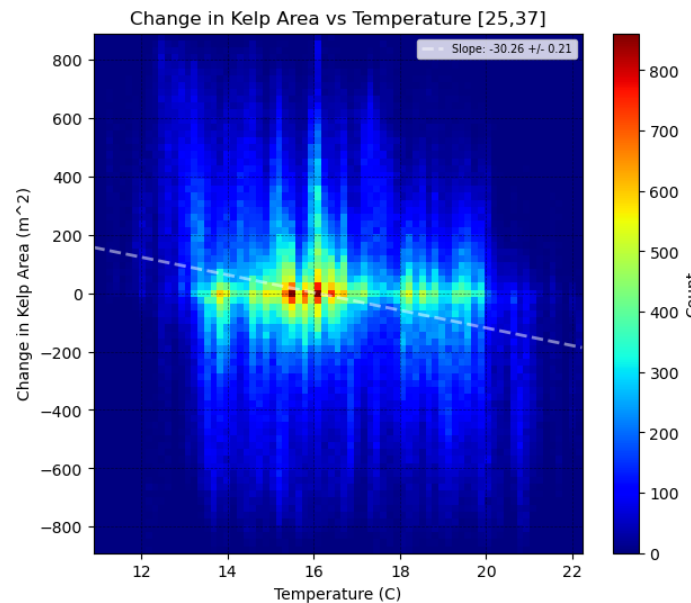
EcoPro: Kelp Forest Use Case

- Estimated transition in kelp species around Half Moon Bay (~37 degrees) from bull kelp to giant kelp
- Northern response (lat > 37 degrees): $-27.6 \pm 1.1 \text{ m}^2/\text{C}$ (bull kelp)
- Southern response (lat < 37 degrees): $-30.3 \pm 0.2 \text{ m}^2/\text{C}$ (giant kelp)

Bull Kelp



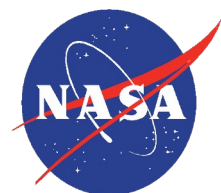
Giant Kelp



Summary



- We are building EcoPro, which is an analytic collaborative framework to support ecological projection science, application, and observation design.
- EcoPro Analytic Server is a JupyterHub server with reusable tools, computing resources, and data storage and access.
- EcoPro Visualization Server is a CMC-based visualization client for viewing high-resolution geospatial data.
- EcoPro Collaboration Server provides a virtual collaboration space for projects.
- With EcoPro, we are developing an ecological model for Sierra Nevada tree mortality and California coast kelp area using observation data and climate model data.
- With EcoPro, we are further developing an ecological projection methodology, which has been tested and applied to coral reef projection (Kalmus et al., Earth's Future, 2021).
- This work is funded by the NASA ROSES AIST-21 program.



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