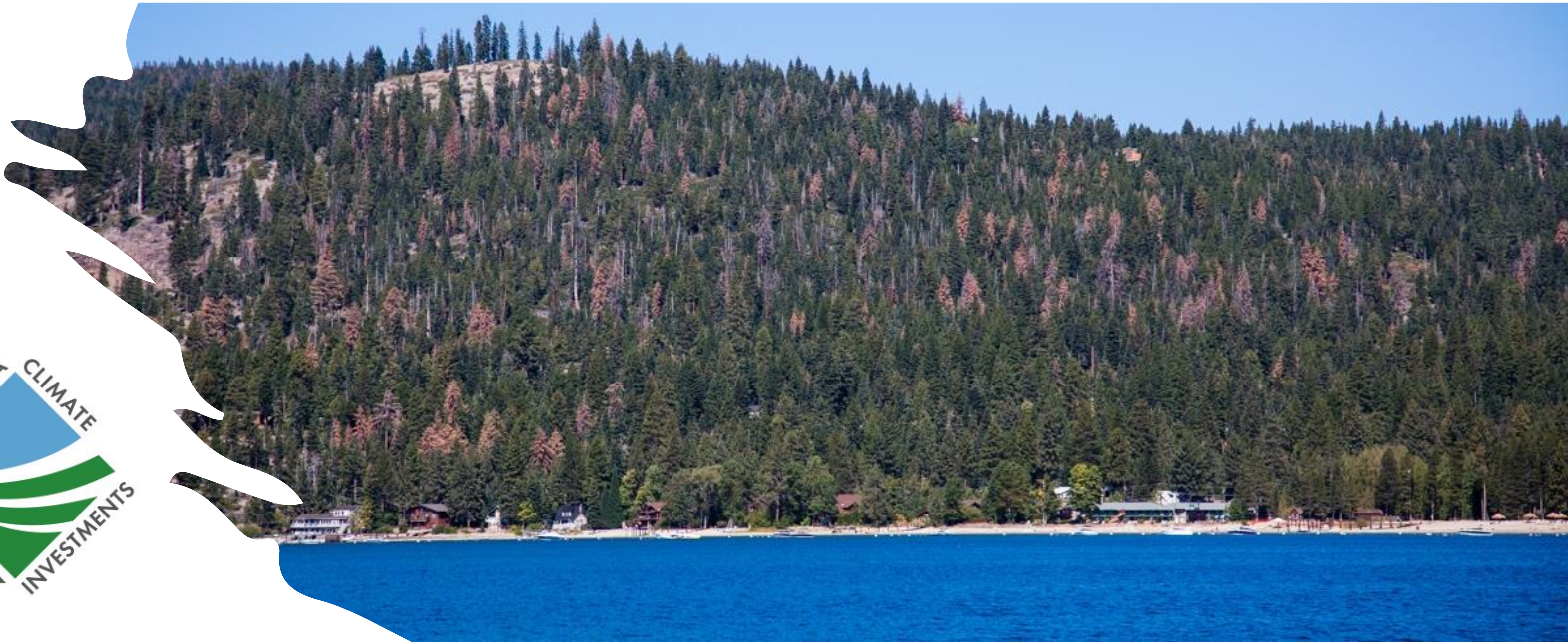
IUFRO FOREST ENVIRONMENT DIV8
CONFERENCE 2023
OCTOBER 24TH – 27TH, 2023,
ÉVORA, PORTUGAL

Climate Resilient Forest Restoration

Patricia Maloney



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CALIFORNIA CLIMATE INVESTMENTS
Cap and Trade
Dollars at Work

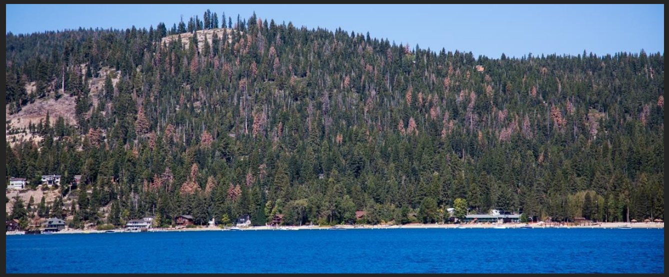
Genetics

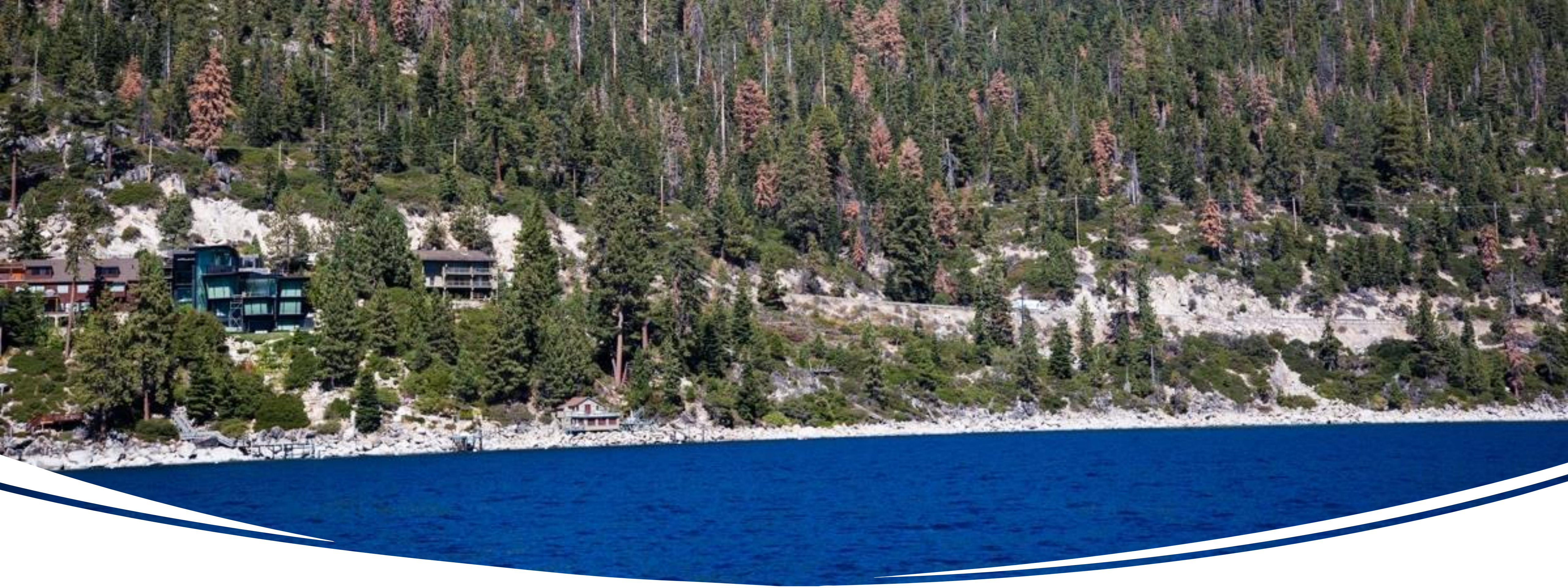
Climate resilient approaches need to integrate:

1. Genetic information

2. Comprehensive characterization of the environment using remote sensing, and geospatial datasets

Environment





GENETICS

Climate change induced drought

From 2012 to 2016 drought and bark beetles killed more than 126 million trees in California and 72,000 in the Lake Tahoe Basin.

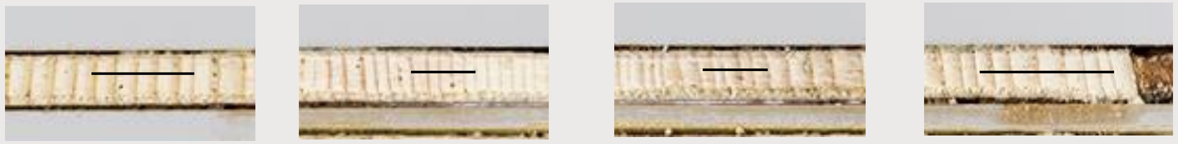
GENETICS

Bark beetles, such as mountain pine beetle (MPB), are known to preferentially attack drought-stressed trees.

Trees have a physical-based defense by producing resin (>90% MPB-killed trees showed no pitch tubes).

Host chemistry can either defend against bark beetle attack or aid in locating a suitable host.

GENETICS – Water use efficiency



Retrospectively analyzed water-use efficiency over the last 90 years

In 2016 we cored from 100 live and 100 mountain pine beetle-killed sugar pine trees to analyze tree rings.

Sugar pine trees that were more water-use efficient, and better adapted to drought, survived the 2012-2016 MPB outbreak.

In contrast those sugar pines killed by MPB utilized water less efficiently and were most susceptible to MPB attack.

GENETICS –

Collections from 100 local drought "survivors"

Amplifying sugar pines resilience to drought

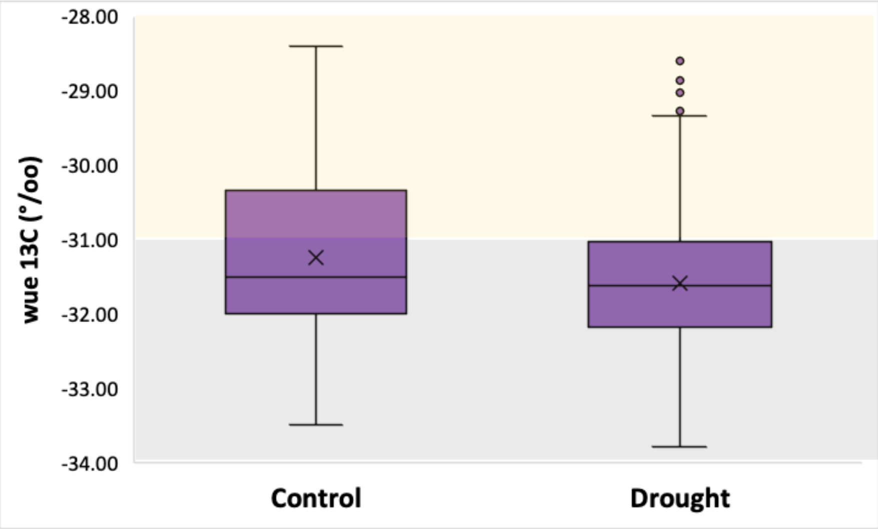
GENETICS

In 2021 established a common garden of the 100 source families that survived the 2012-2016 drought & MPB

Evaluated important adaptive traits

Set up a drought experiment to determine the relationship and changes in WUE and host defense chemistry

GENETICS

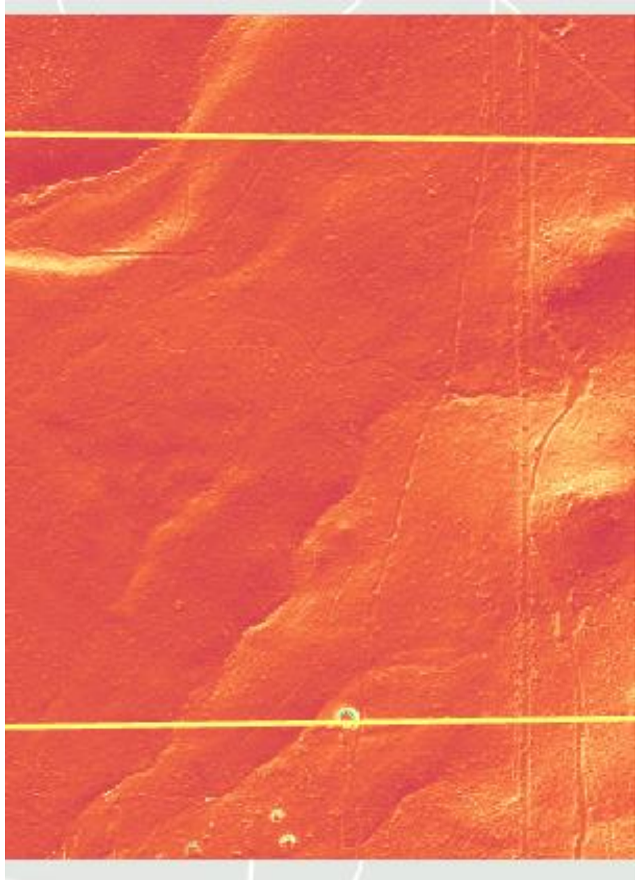


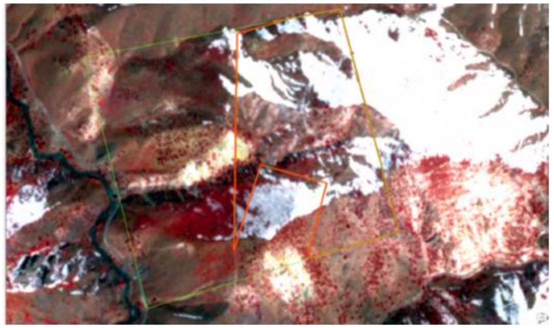
Monoterpene	Match score	Mean control (SD)	Mean drought (SD)
Alpha-pinene *	0.89	0.274 (0.114)	0.636 (0.263)
Beta-pinene *	0.92	0.460 (0.193)	1.103 (0.523)
Myrcene *	0.80	0.017 (0.011)	0.043 (0.023)
Alpha-phellandrene *	0.80	0.032 (0.023)	0.089 (0.072)
Total Monoterpenes		**0.783**	**1.871**

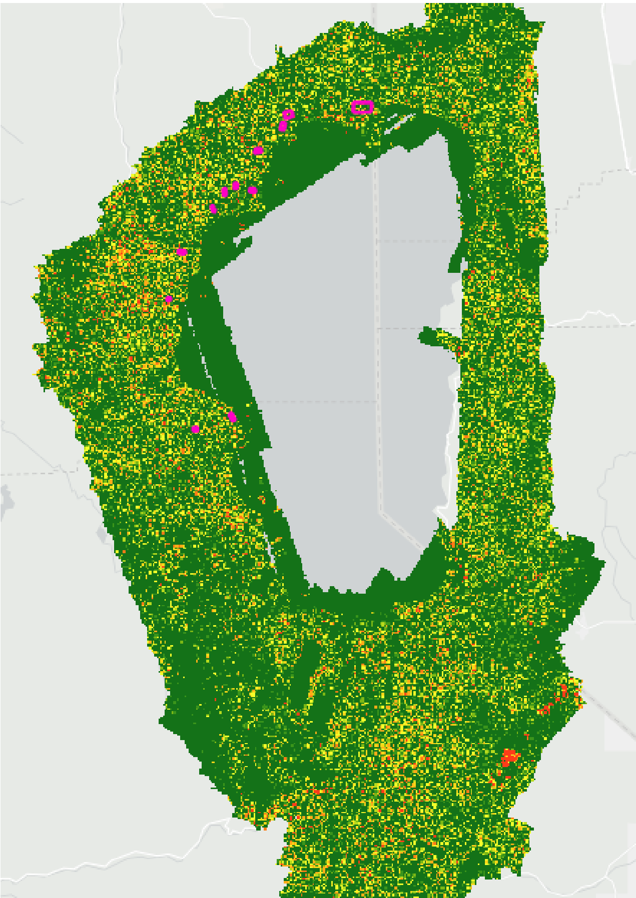
ENVIRONMENT

- Use remote sensing (RS) imagery and other geospatial datasets (e.g., soils, drainage patterns, LiDAR) to develop GIS algorithms that identify site conditions (e.g., presence of late-lying snow patches, soil properties, canopy water status) to select appropriate microsites for planting locally sourced and diverse seed material

- Deploy an unmanned aerial vehicle UAV in select locations to generate high-resolution microtopographic maps

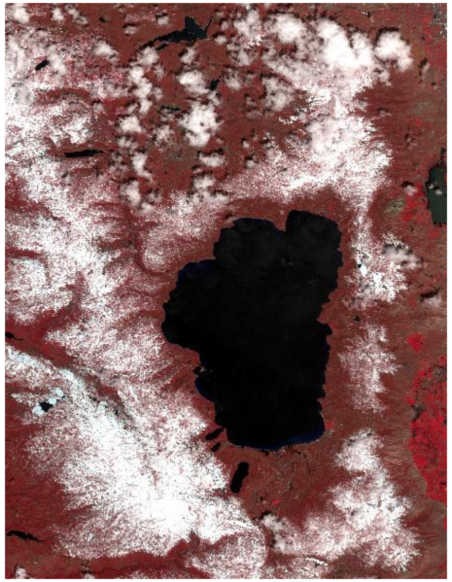






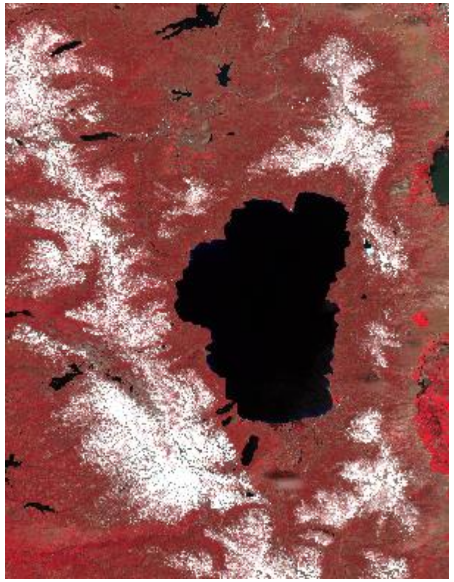
Environment

Late lying snow from Sentinel data – 2017



April 27, 2017

May 17, 2017



June 06, 2017

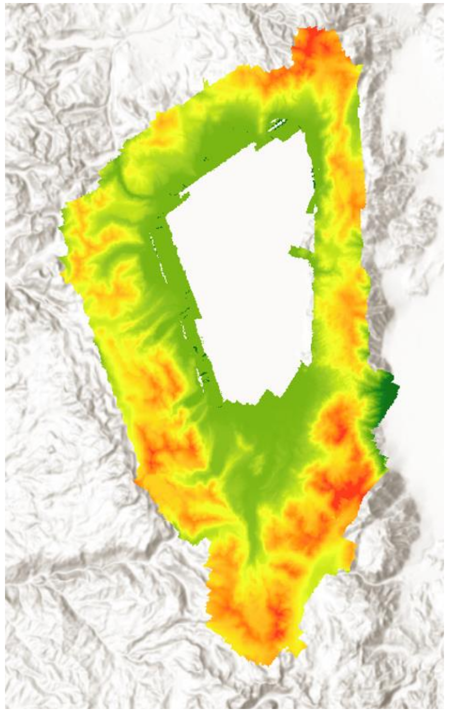
Environment

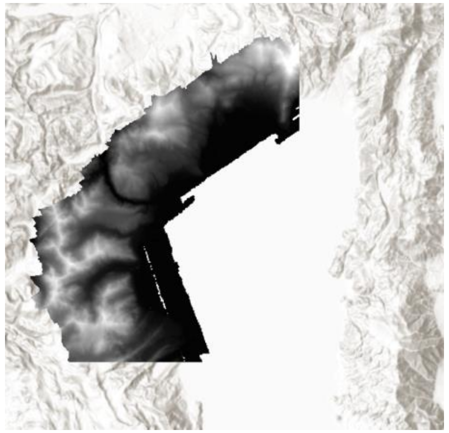
Tahoe Basin Lidar – 0.5m US Forest Service

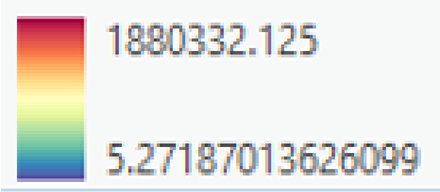
Arcpro 2.9 default settings for area in a year. **WH/m² (watt hours per square meter)**

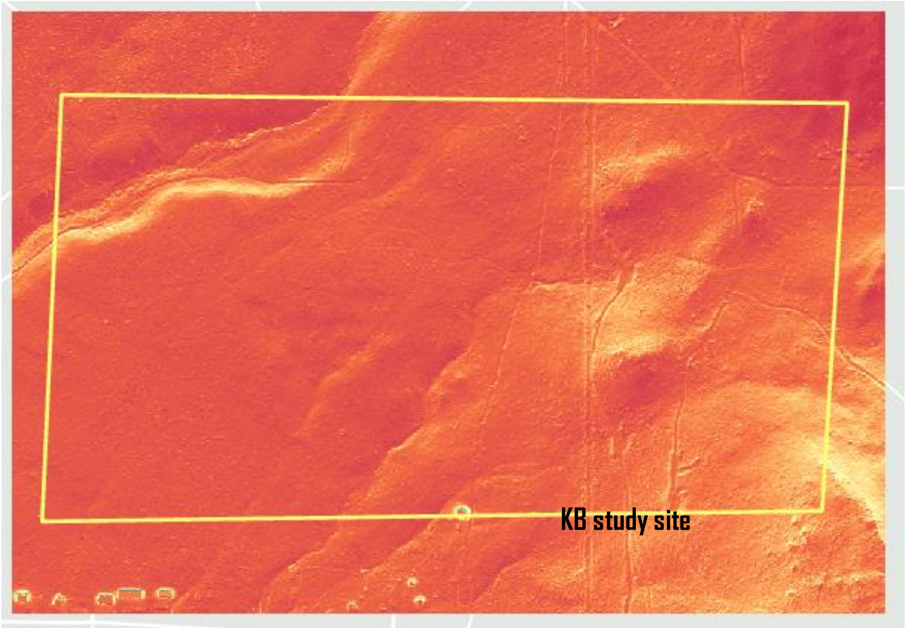
Solar radiation was calculated over large digital elevation model – ran ~90 days

Solar radiation

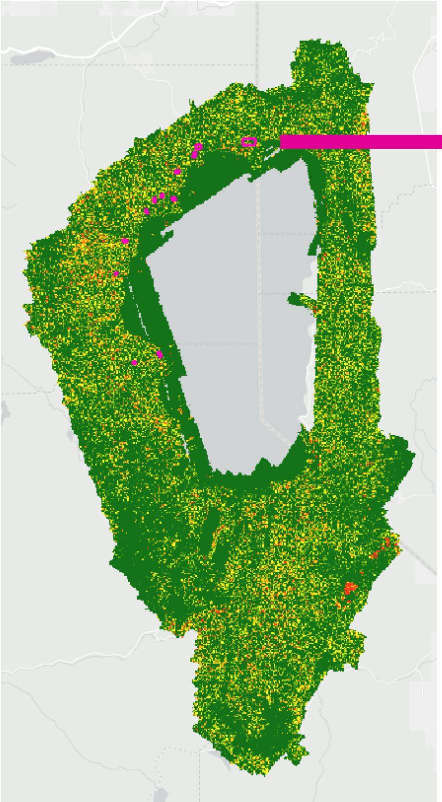








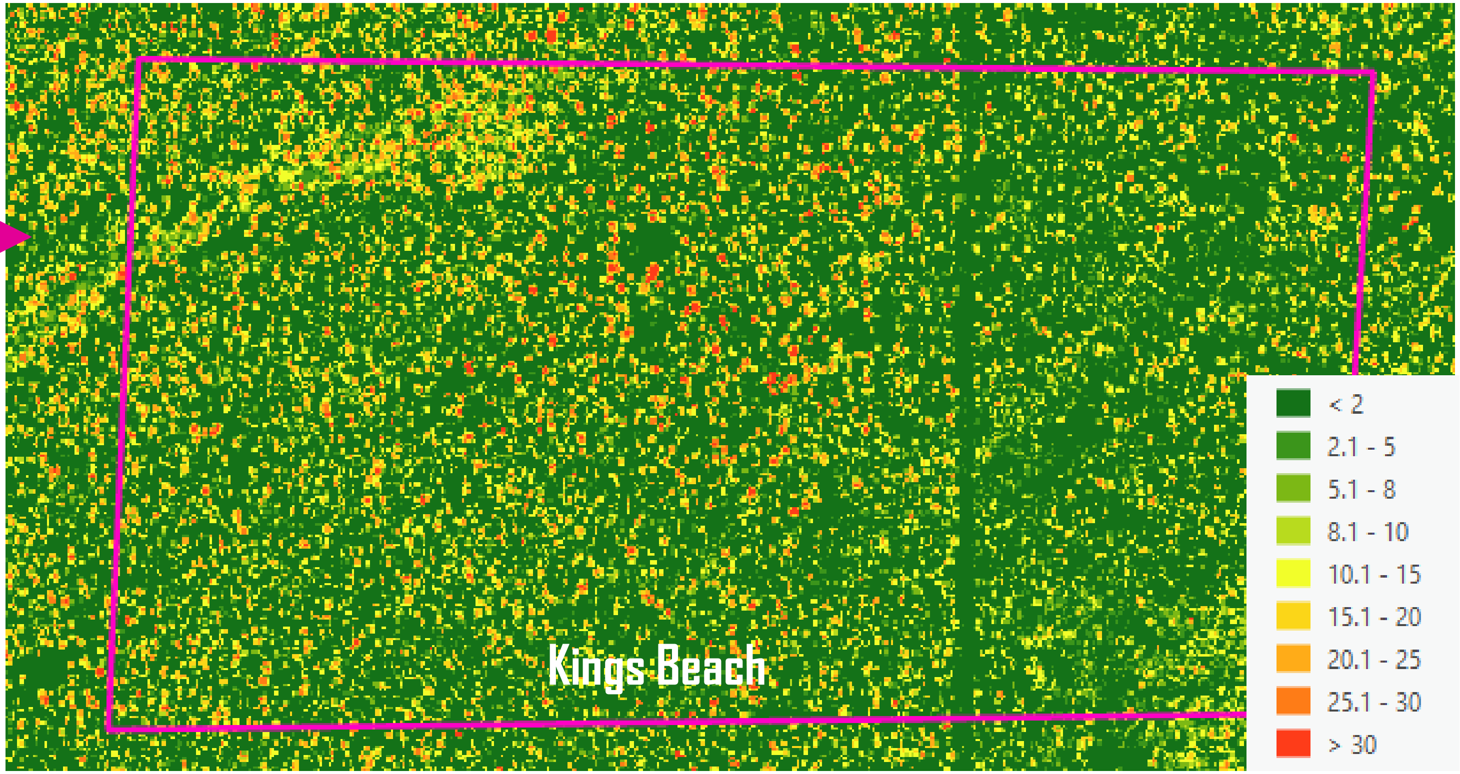
Environment

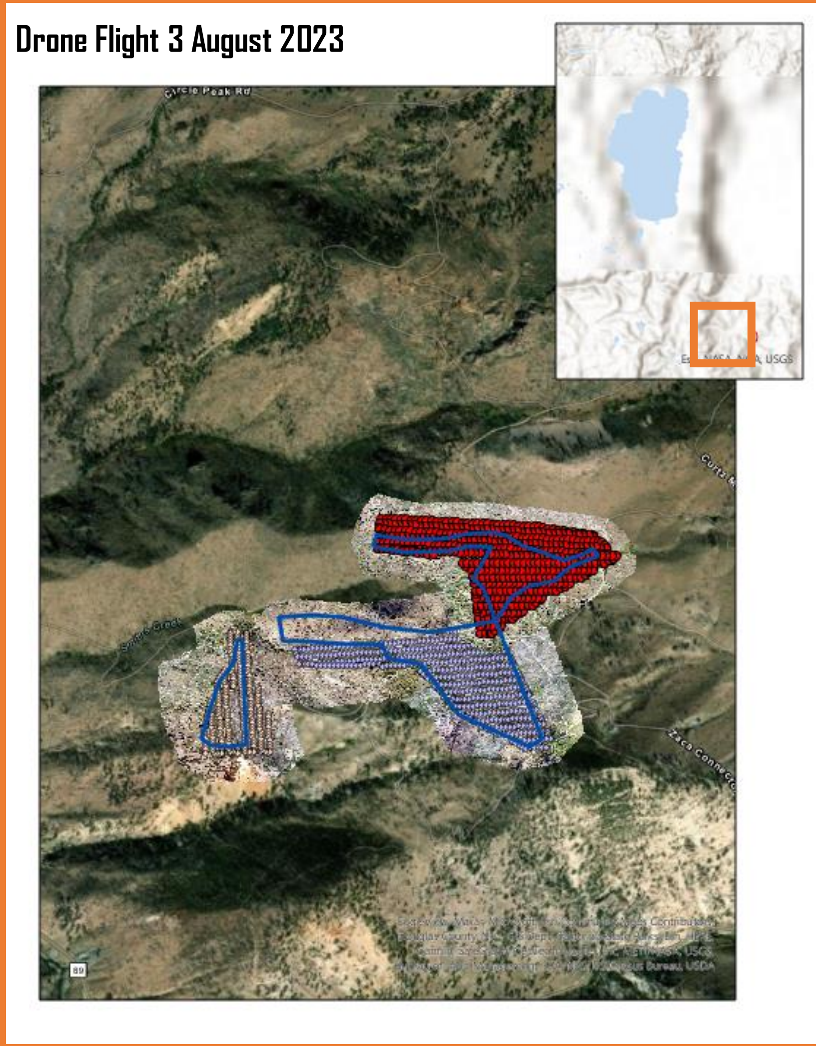


Canopy height

< 2 meters = ground cover, forbs, shrubs

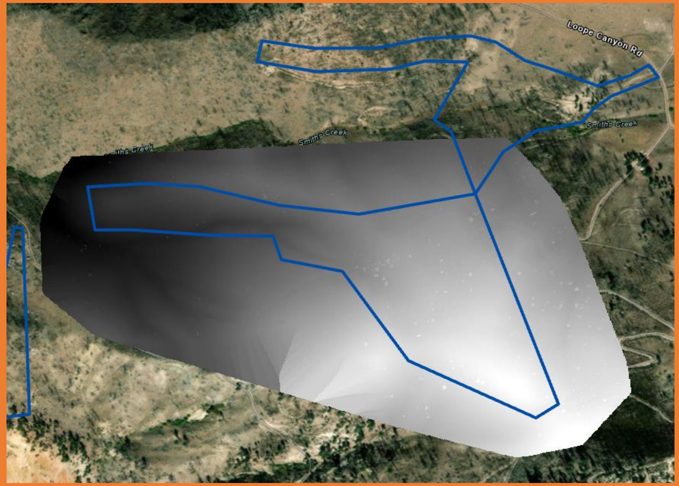
> 2 meters = individual trees





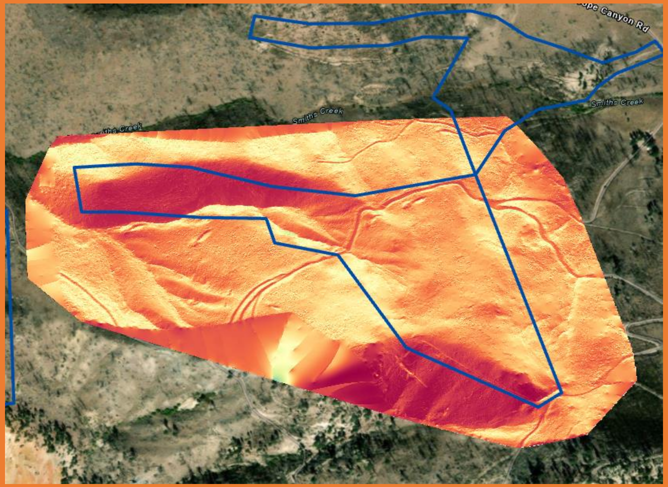
Environment

Natural color image ~ 3 cm pixel



Digital surface model

Digital terrain model

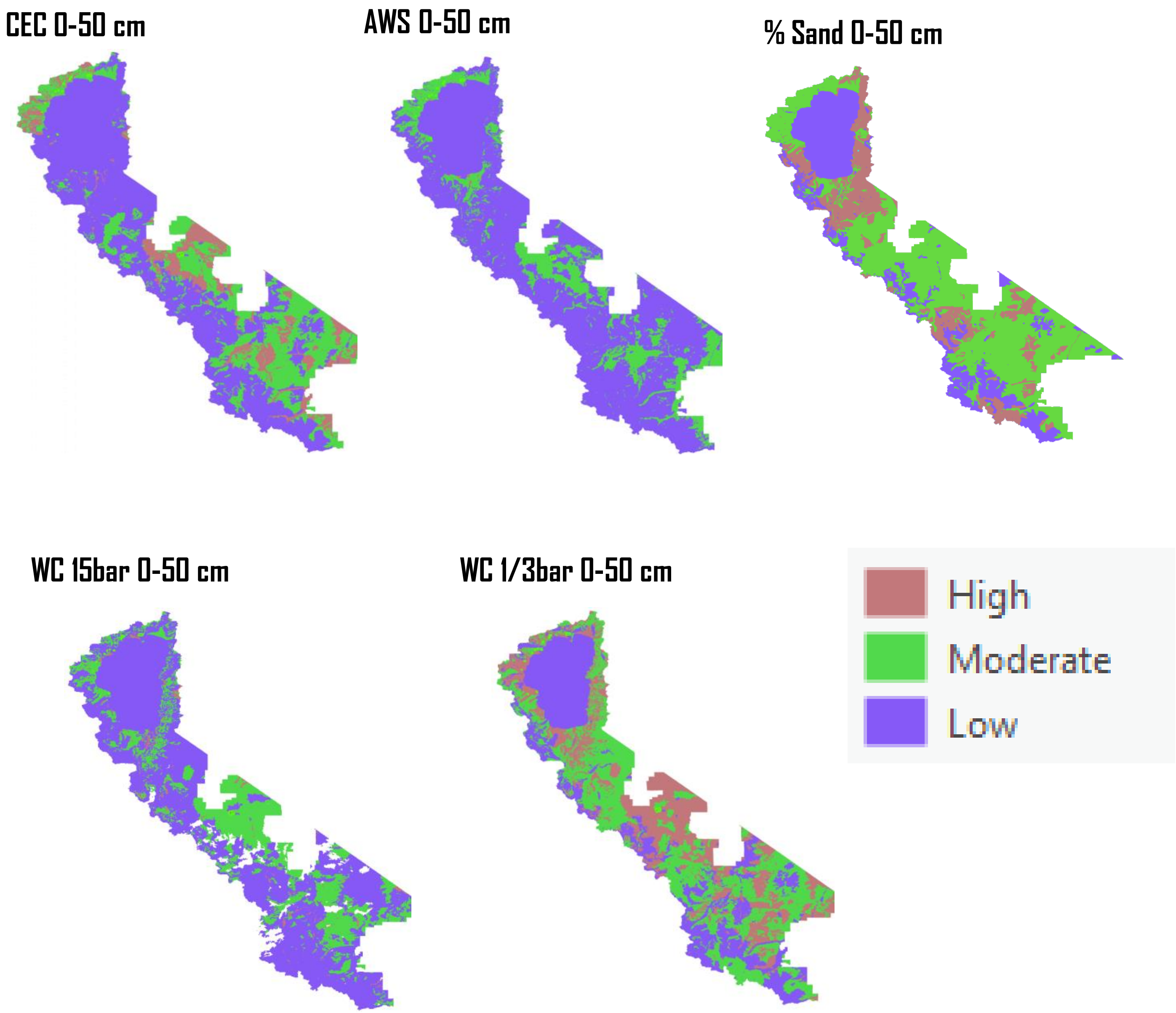


Solar radiation for the year using drone digital terrain model

Environment

Environment

Soil properties: cation exchange capacity, available water supply, %sand, water content 15 bar, water content 1/3rd bar



Environment

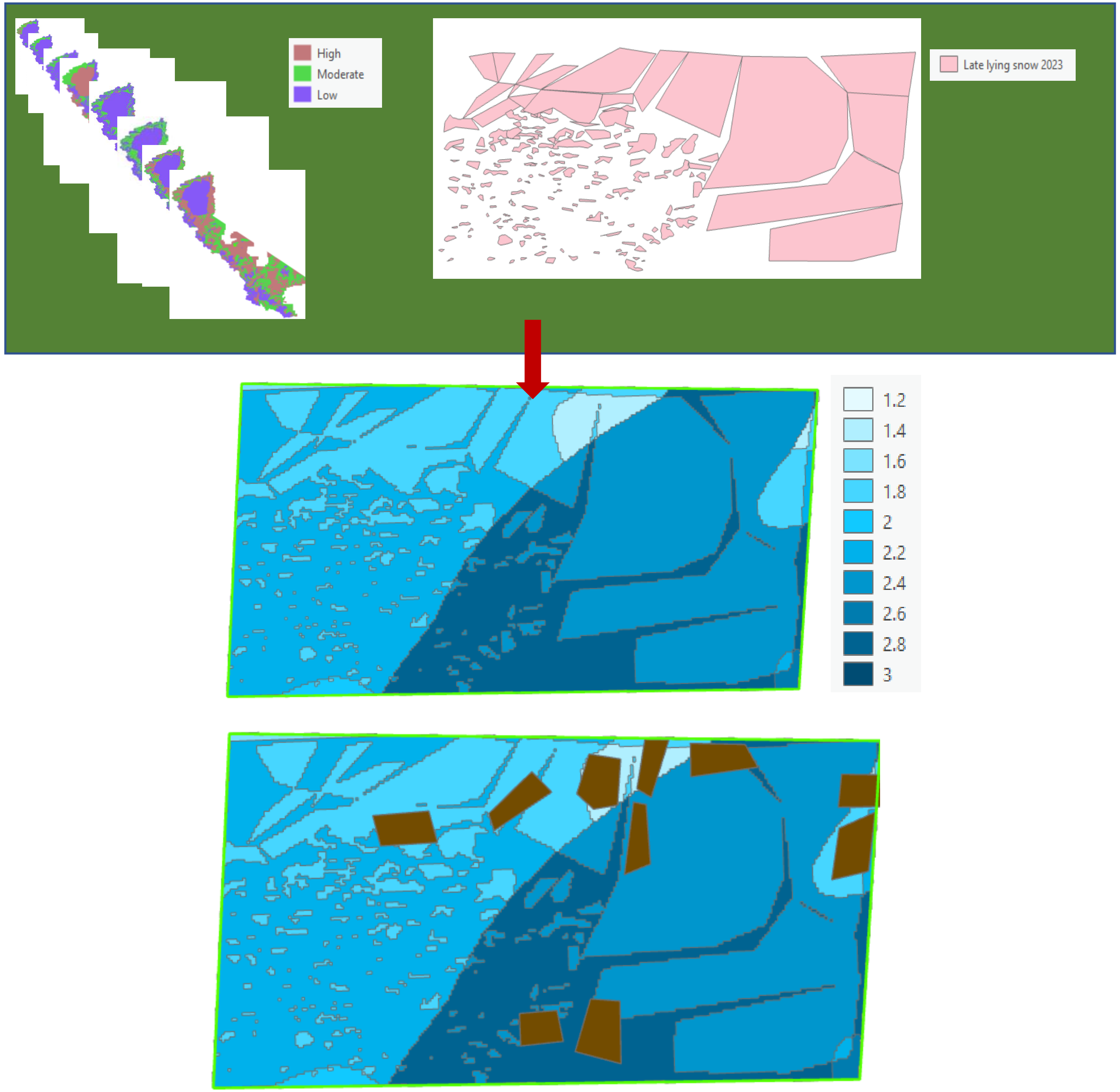
Ranking system was created for each geospatial data layer.

Geospatial data layers (soil properties, late-lying snow, solar radiation, canopy cover, etc.) were combined into one composite layer that shows a gradient of planting conditions from most to least desirable

Example – Kings Beach (lower 2 panels) Ranking system of "best" to "worst" from from composite maps (soil, LLS, solar radiation, etc.)

1 = optimal planting site
2 = moderate planting site
3 = low quality planting site

Brown polygons are selected planting locations for Kings Beach on composite maps and ranking



Conclusions

Genetics & Environment

- Scientifically study the survivors / "winners"
- Out-plant progeny of drought "survivors"
- Use remote sensing technologies, geospatial datasets, and high resolution microtopographic maps to improve microsite selection for restoration plantings and increase seedling survivorship
- Monitor seedling survival as well as track the fate of all known genetic individuals

Trends in Ecology & Evolution

CellPress

Opinion

Who Should Pick the Winners of Climate Change?

Michael S. Webster,[1,*] Madhavi A. Colton,[1] Emily S. Darling,[2] Jonathan Armstrong,[3] Malin L. Pinsky,[4] Nancy Knowlton,[5] and Daniel E. Schindler[6]

Many conservation strategies identify a narrow subset of genotypes, species, or geographic locations that are predicted to be favored under different scenarios of future climate change. However, a focus on predicted winners, which might not prove to be correct, risks undervaluing the balance of biological diversity from which climate-change winners could otherwise emerge. Drawing on ecology, evolutionary biology, and portfolio theory, we propose a conservation approach designed to promote adaptation that is less dependent on uncertain predictions about the identity of winners and losers. By designing actions to facilitate numerous opportunities for selection across biological and environmental conditions, we can allow nature to pick the winners and increase the probability that ecosystems continue to provide services to humans and other species.

Trends

Predict-and-prescribe management may erode diversity by focusing on 'winners'.

Conservation strategies based on portfolio theory reduce risk by protecting diversity.

Adaptation networks are a new approach to conservation based on portfolio theory.

Diverse, connected, and large adaptation networks maximize the adaptive capacity of species.

Los Angeles Times

Leader of Navy is ousted in clash

A bet on Sierra survivors

In climate race, scientists are propagating trees with staying power

Nunes dodges query about meeting

Forest scientists bet on hardiest trees

Workforce Development with the CCC

- **The goal is to develop a pipeline with the California Conservation Corps (CCC) that recruits and integrates a diverse and equitable workforce into forestry and restoration careers as well as climate change initiatives in California**

- **Train and provide the California Conservation Corp (CCC) with applied experience in STEM (e.g., drone technology, GIS science, plant sciences, and ecosystem restoration)**

Thank You for Your Time

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