Redwood Region Forest Management and Market Opportunities

New Developments in geospatial informatics at UC: tools and resources for landowners and resource professionals

Maggi Kelly

March 6 2013

University of California
Agriculture and Natural Resources

Image credit: William Bowen

Mapping for a Changing California


GEOSPATIAL
INNOVATION
FACILITY
Cutting-Edge Mapping Technology at UC Berkeley
http://gif.berkeley.edu

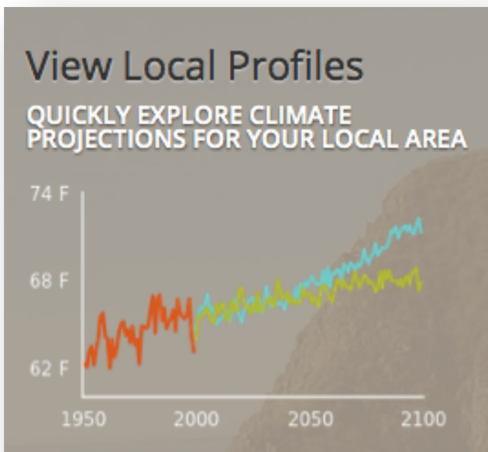
Mapping for a Changing California

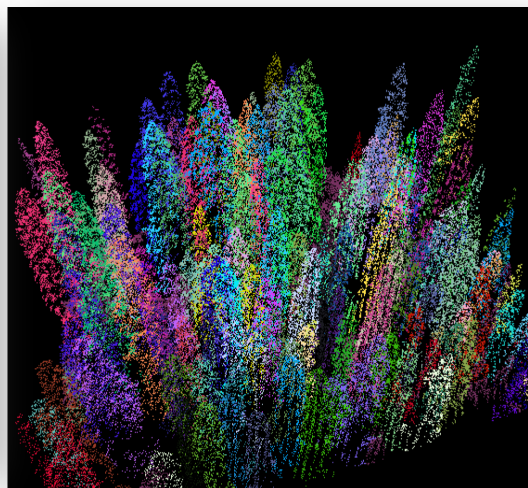
The themes I will cover today include:

- Data Sharing, especially over the web…
- Visualizations
- New Tools
- Networking

I will show examples from 2 projects:

- Cal-Adapt.org
- Lidar and forests





Where to find more information

GEOSPATIAL INNOVATION FACILITY

Cutting-Edge Mapping Technology at UC Berkeley

Providing access to training, services, and a community that focus on cutting-edge geospatial technology in support of the environmental sciences, in both natural and social systems.

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cal-adapt

Bringing Global Climate Change to Local Applications

Mission: Develop an innovative web based platform to increase access to the wealth of climate change research and data being produced by the scientific community in California.

Kevin Koy, Brian Galey, Maggi Kelly

Geospatial Innovation Facility
College of Natural Resources
UC Berkeley

PUBLIC INTEREST ENERGY RESEARCH
"Research Powers the Future"

GEOSPATIAL INNOVATION FACILITY
Cutting-Edge Mapping Technology at UC Berkeley

A product of the
Public Interest Energy Research (PIER) program

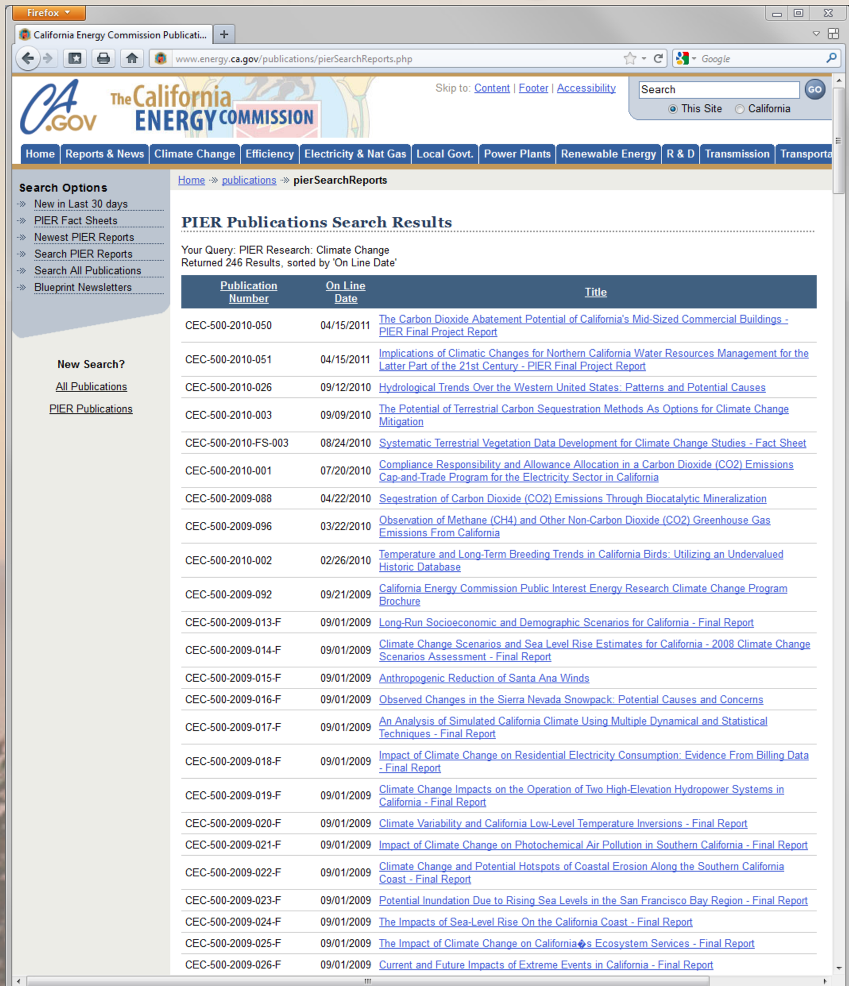
Public Interest Energy Research

PIER — PUBLIC INTEREST ENERGY RESEARCH — "Research Powers the Future"

California Energy Commission (CEC) program informs decision makers through:

- Climate Monitoring, Analysis, and Modeling
- Greenhouse gas Inventory Methods
- Options to Reduce GHG Emissions
- Impact and Adaptation

What is the challenge?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PIER Publications Search Results

Your Query: PIER Research: Climate Change
Returned 246 Results, sorted by 'On Line Date'

Publication Number	On Line Date	Title
CEC-500-2010-050	04/15/2011	The Carbon Dioxide Abatement Potential of California's Mid-Sized Commercial Buildings - PIER Final Project Report
CEC-500-2010-051	04/15/2011	Implications of Climatic Changes for Northern California Water Resources Management for the Latter Part of the 21st Century - PIER Final Project Report
CEC-500-2010-026	09/12/2010	Hydrological Trends Over the Western United States: Patterns and Potential Causes
CEC-500-2010-003	09/09/2010	The Potential of Terrestrial Carbon Sequestration Methods As Options for Climate Change Mitigation
CEC-500-2010-FS-003	08/24/2010	Systematic Terrestrial Vegetation Data Development for Climate Change Studies - Fact Sheet
CEC-500-2010-001	07/20/2010	Compliance Responsibility and Allowance Allocation in a Carbon Dioxide (CO2) Emissions Cap-and-Trade Program for the Electricity Sector in California
CEC-500-2009-088	04/22/2010	Segestration of Carbon Dioxide (CO2) Emissions Through Biocatalytic Mineralization
CEC-500-2009-096	03/22/2010	Observation of Methane (CH4) and Other Non-Carbon Dioxide (CO2) Greenhouse Gas Emissions From California
CEC-500-2010-002	02/26/2010	Temperature and Long-Term Breeding Trends in California Birds: Utilizing an Undervalued Historic Database
CEC-500-2009-092	09/21/2009	California Energy Commission Public Interest Energy Research Climate Change Program Brochure
CEC-500-2009-013-F	09/01/2009	Long-Run Socioeconomic and Demographic Scenarios for California - Final Report
CEC-500-2009-014-F	09/01/2009	Climate Change Scenarios and Sea Level Rise Estimates for California - 2008 Climate Change Scenarios Assessment - Final Report
CEC-500-2009-015-F	09/01/2009	Anthropogenic Reduction of Santa Ana Winds
CEC-500-2009-016-F	09/01/2009	Observed Changes in the Sierra Nevada Snowpack: Potential Causes and Concerns
CEC-500-2009-017-F	09/01/2009	An Analysis of Simulated California Climate Using Multiple Dynamical and Statistical Techniques - Final Report
CEC-500-2009-018-F	09/01/2009	Impact of Climate Change on Residential Electricity Consumption: Evidence From Billing Data - Final Report
CEC-500-2009-019-F	09/01/2009	Climate Change Impacts on the Operation of Two High-Elevation Hydropower Systems in California - Final Report
CEC-500-2009-020-F	09/01/2009	Climate Variability and California Low-Level Temperature Inversions - Final Report
CEC-500-2009-021-F	09/01/2009	Impact of Climate Change on Photochemical Air Pollution in Southern California - Final Report
CEC-500-2009-022-F	09/01/2009	Climate Change and Potential Hotspots of Coastal Erosion Along the Southern California Coast - Final Report
CEC-500-2009-023-F	09/01/2009	Potential Inundation Due to Rising Sea Levels in the San Francisco Bay Region - Final Report
CEC-500-2009-024-F	09/01/2009	The Impacts of Sea-Level Rise On the California Coast - Final Report
CEC-500-2009-025-F	09/01/2009	The Impact of Climate Change on California�s Ecosystem Services - Final Report
CEC-500-2009-026-F	09/01/2009	Current and Future Impacts of Extreme Events in California - Final Report

- More than 150 peer reviewed reports on climate change
- Dozens of researchers and organizations
- Thousands of statewide data layers

What is the need?

- Relevant information presented in easy to understand themes and topics
- Interactive maps and charts providing a variety of approaches to explore different aspects of climate change
- Improved access to primary climate change data in GIS and tabular formats

Target Audiences

- General Public
  Learn about climate change data relevant to their area
- Local planners and technicians
  Obtain meaningful information and data to help guide locally relevant climate action plans and adaptation strategies
- Scientific community
  Access primary data relevant to an area of interest

The Climate Modeling Context

- 2 Climate Scenarios
  - **B1** - The lower emissions scenario
  - **A2** - The medium-high emissions scenario

- 4 Models
  - **NCAR** - National Center for Atmospheric Research Parallel Climate Model (PCM1)
  - **CCSM** - Community Climate System Model Version 3.0 (CCSM3)
  - **GFDL** - Geophysical Fluids Dynamic Laboratory (GFDL) CM2.1
  - **CNRM** - Centre National de Recherches Météorologiques

Data

Each variable = 14,400 GIS layers

* 150 years
* 12 months
* 4 Models
* 2 Scenarios

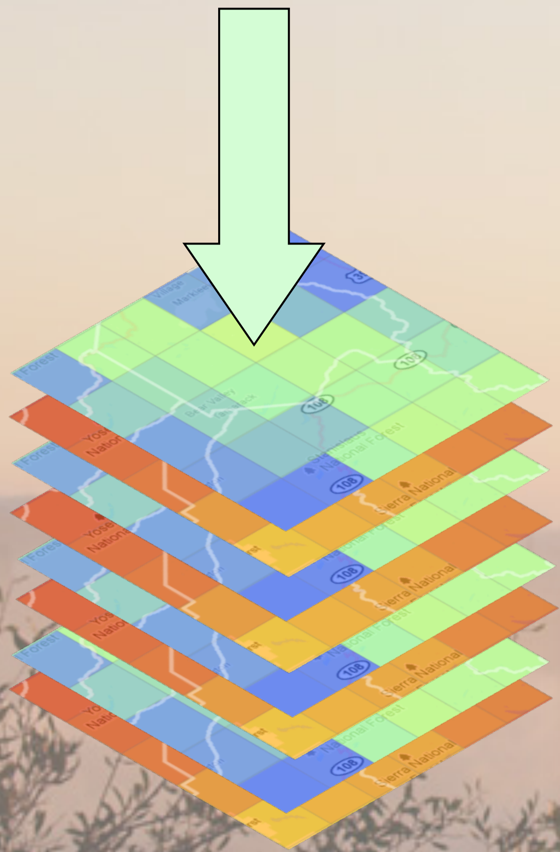
Over 230,000 GIS layers total

Monthly layers 1950-2099

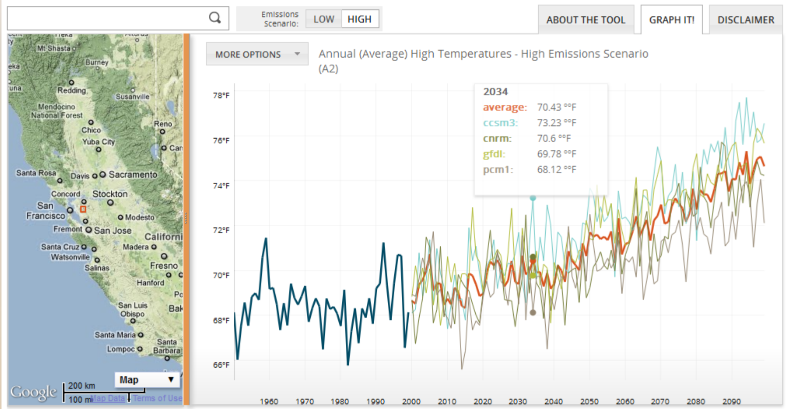
- Actual evapotranspiration
- **Average temperature**
- Baseflow
- **Fire**
- Fractional moisture in the entire soil column
- **Maximum temperature**
- **Minimum temperature**
- Net surface radiation
- **Precipitation**
- Relative humidity
- Runoff
- **Snow water equivalent**
- Soil moisture at bottom layer
- Soil moisture at middle layer
- Soil moisture at top layer
- Wind

How does Cal-Adapt work?

Cal-Adapt analysis platform is an open source, web-based GIS and visualization project



Baselayers



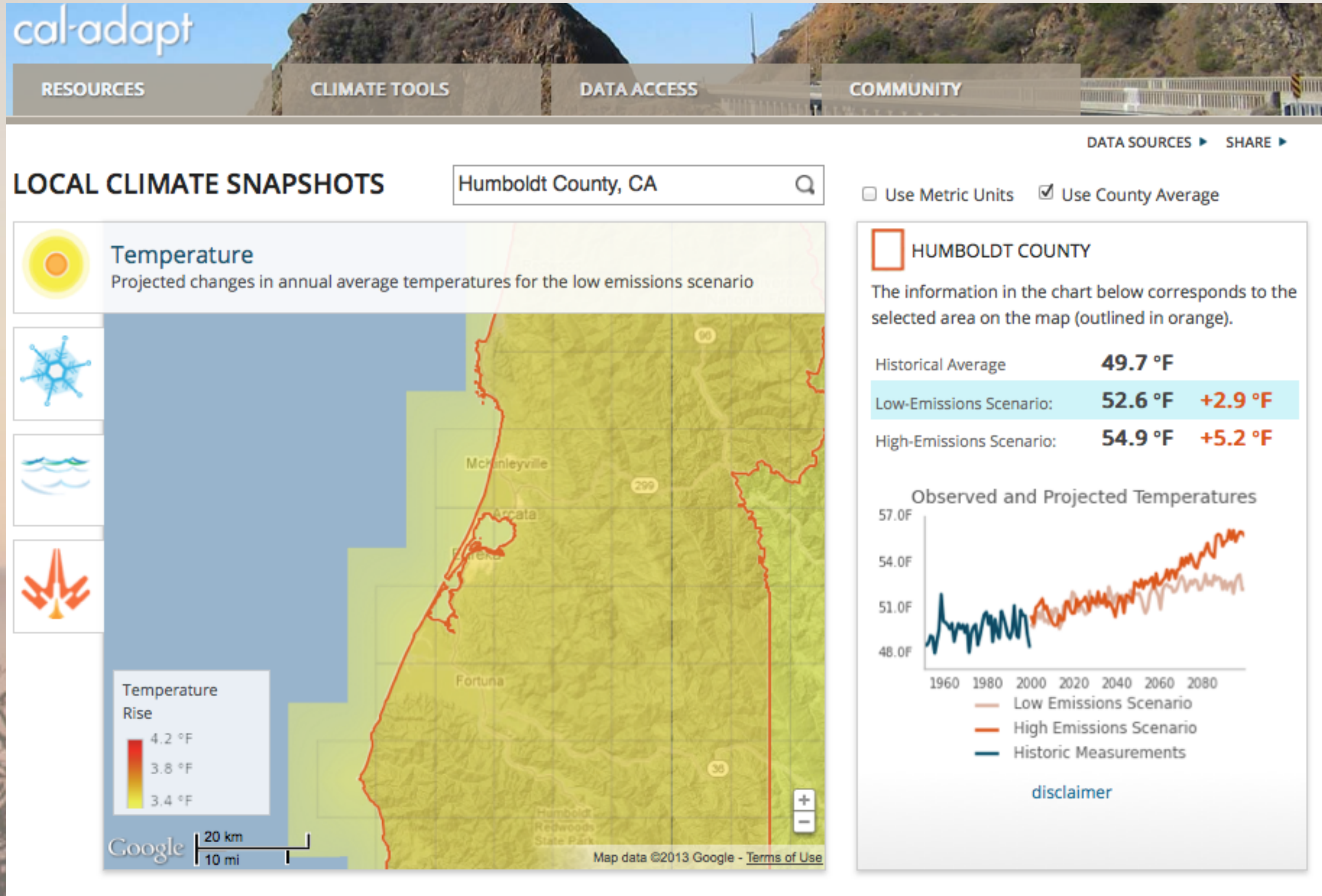
Rapid production of interactive outputs

date	observed	average	ccsm3	cnrm	gfdl	pcm1
Jan 2000		57.75°F	57.40°F	57.25°F	58.35°F	57.99°F
Jan 2001		57.47°F	57.32°F	56.59°F	58.73°F	57.24°F
Jan 2002		58.63°F	59.99°F	56.80°F	58.96°F	58.76°F
Jan 2003		58.50°F	58.41°F	58.11°F	58.04°F	59.43°F
Jan 2004		58.89°F	58.41°F	60.63°F	57.78°F	58.72°F
Jan 2005		59.40°F	60.13°F	59.70°F	58.88°F	58.90°F

cal-adapt

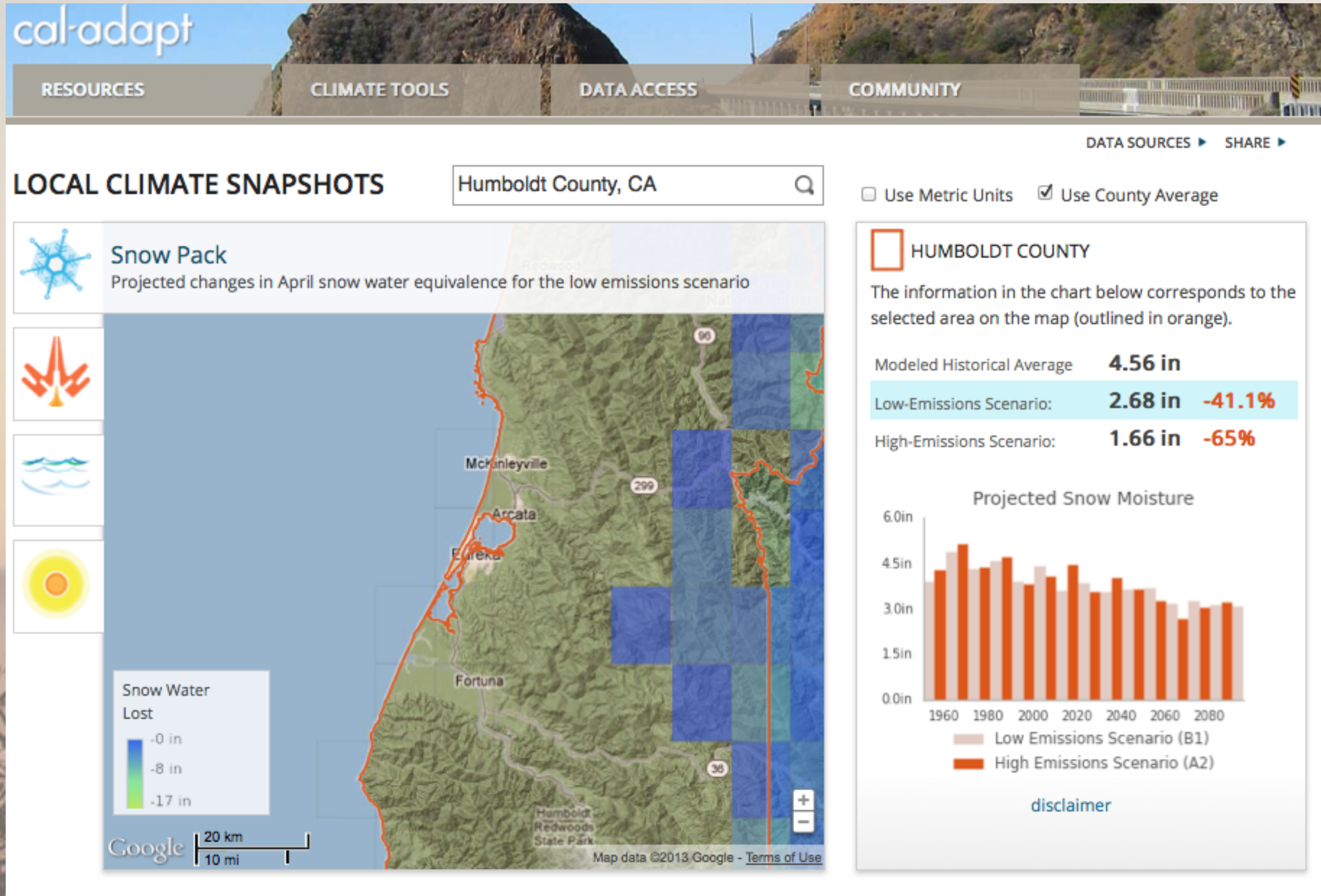
http://cal-adapt.org

Cal-adapt example for Eureka



cal-adapt http://cal-adapt.org

Cal-adapt example for Eureka



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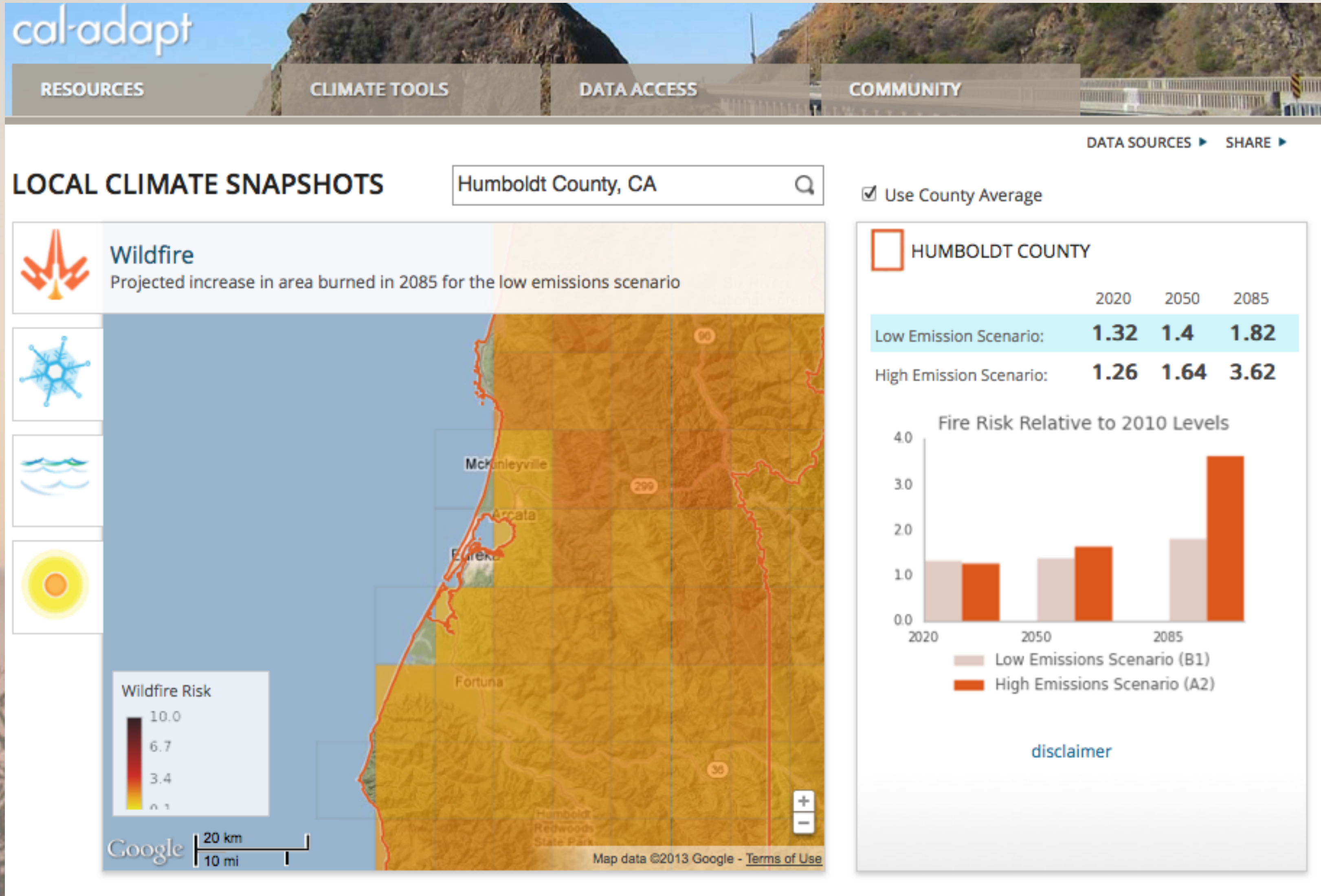

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Cal-adapt example for Eureka

cal-adapt

RESOURCES | CLIMATE TOOLS | DATA ACCESS | COMMUNITY

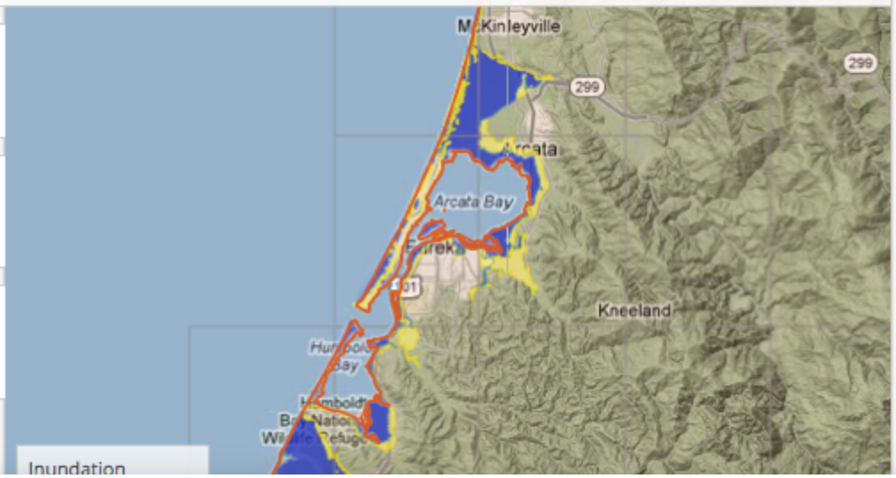
DATA SOURCES ▸ SHARE ▸

LOCAL CLIMATE SNAPSHOTS

eureka

☐ Use Metric Units

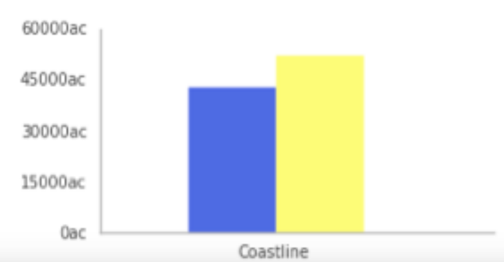
Sea Level Rise
Areas vulnerable to a 100-year flood event as sea level rises



5TH & H STREETS AREA

Land Vulnerable to a 100-Year Flood Event

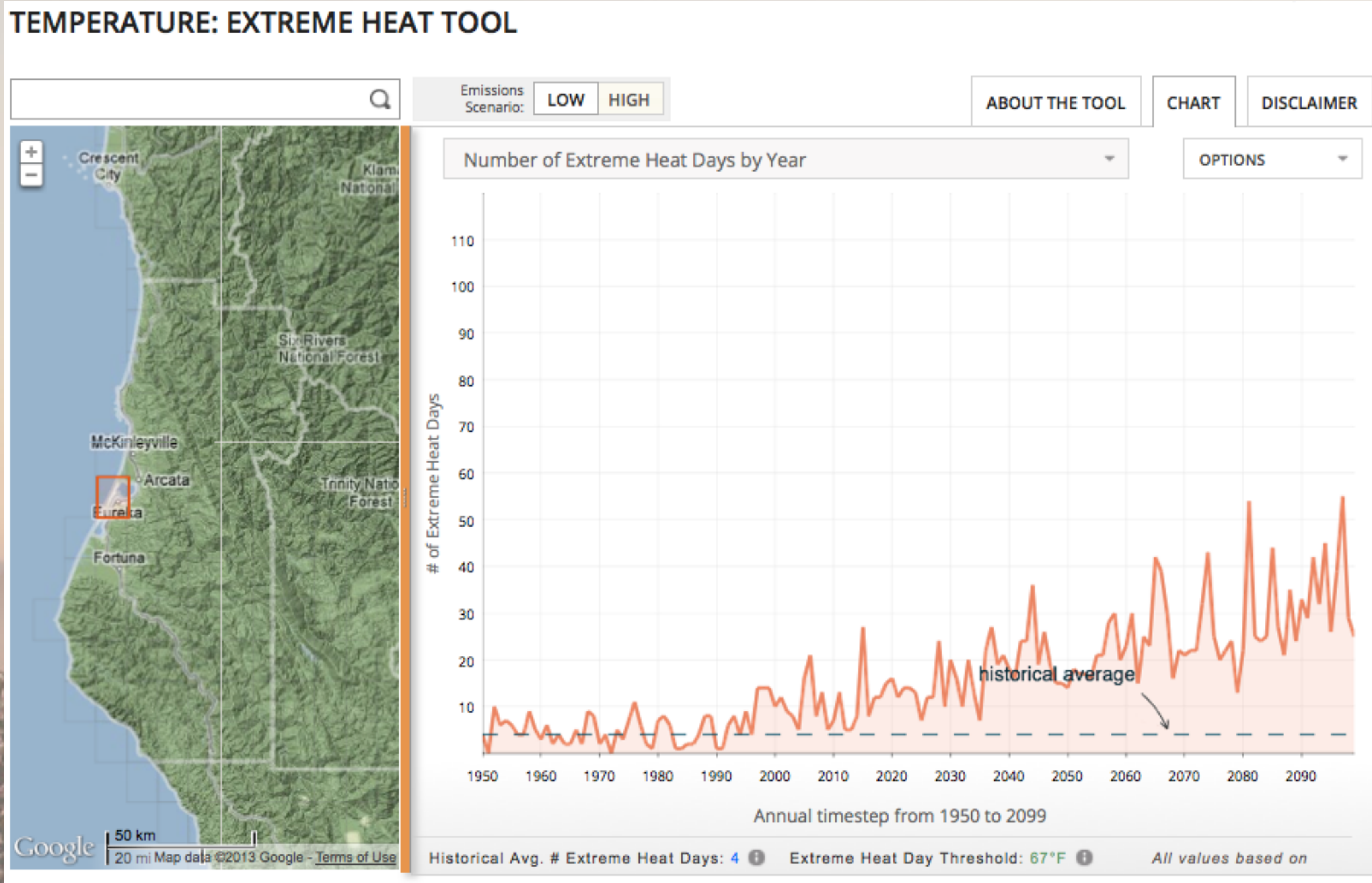
	Estimated Acreage in 2000	Estimated Acreage in 2100	Percent Change
Coast:	43,070	52,610	+18%



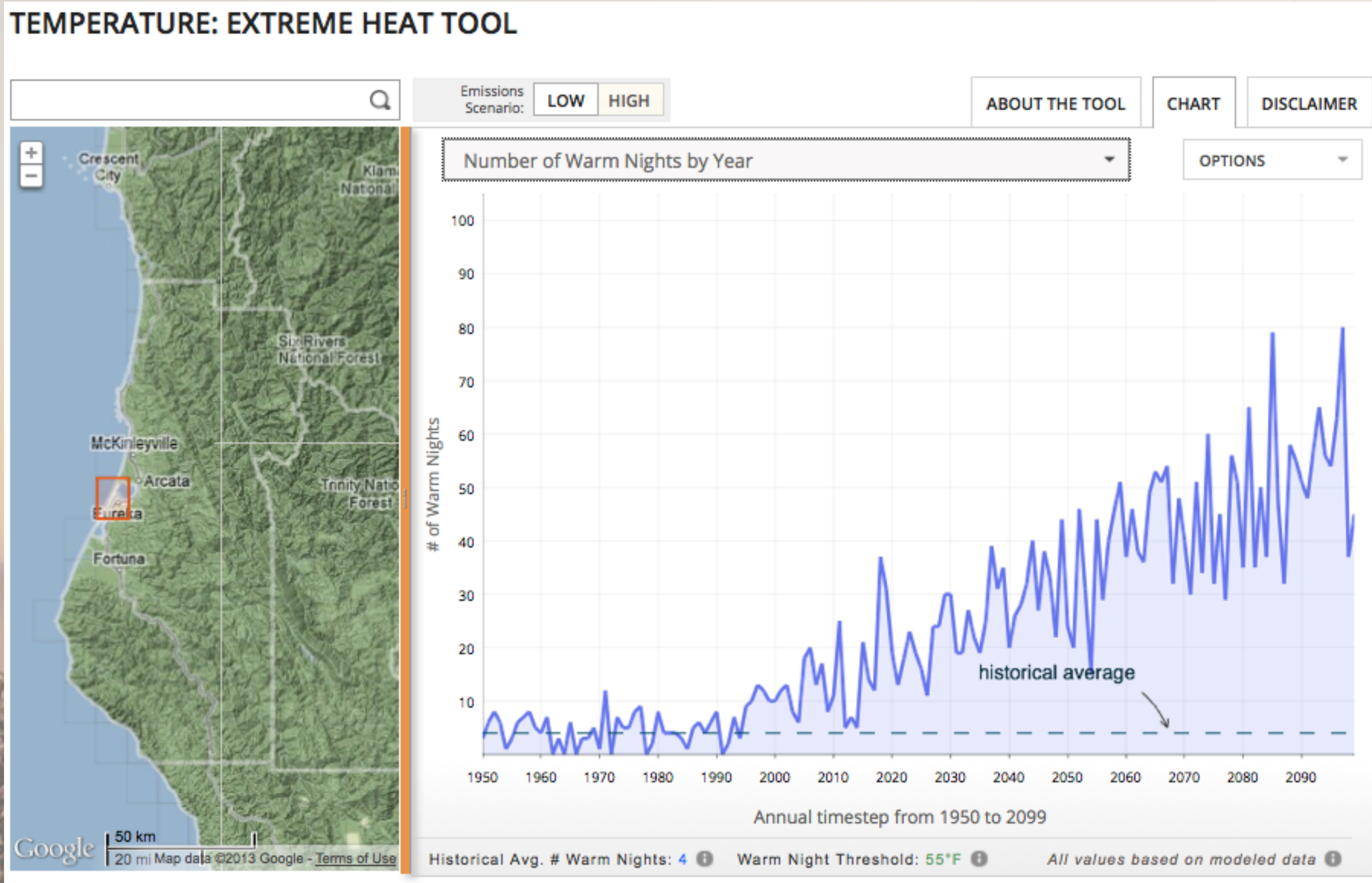
SEA LEVEL RISE

- Pacific Institute Coastal Data
  Source: Pacific Institute
  These data include areas inundated by 100-year unimpeded Pacific coastal flooding under baseline (year 2000) conditions for the California Coastline, as well as areas inundated by 100-year unimpeded Pacific coastal flooding under a scenario of 1.4-meter (55-inch) sea-level rise. These data are available for download via the Pacific Institute.

Cal-adapt example for Eureka



Cal-adapt example for Eureka



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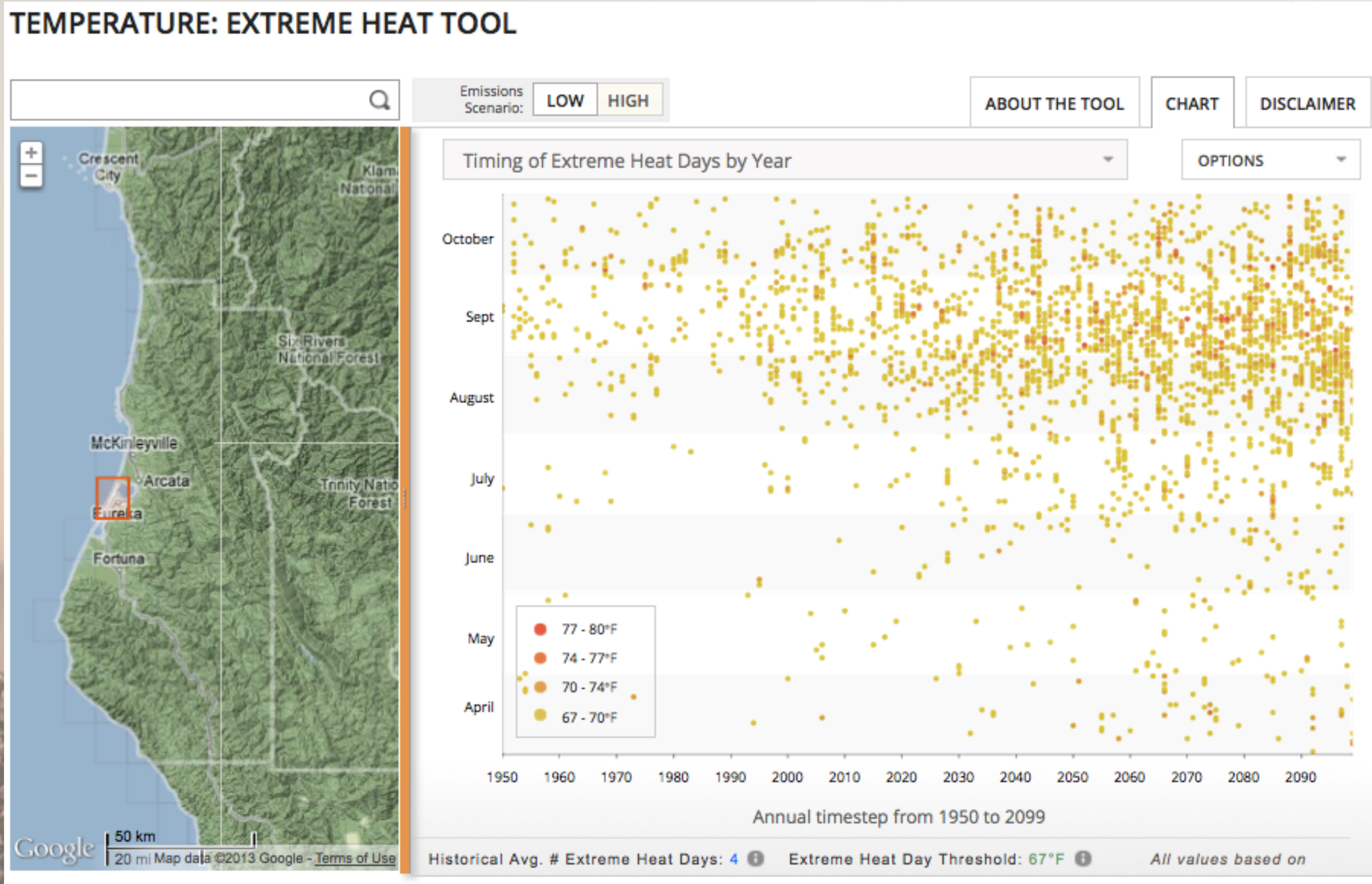
Cal-adapt example for Eureka



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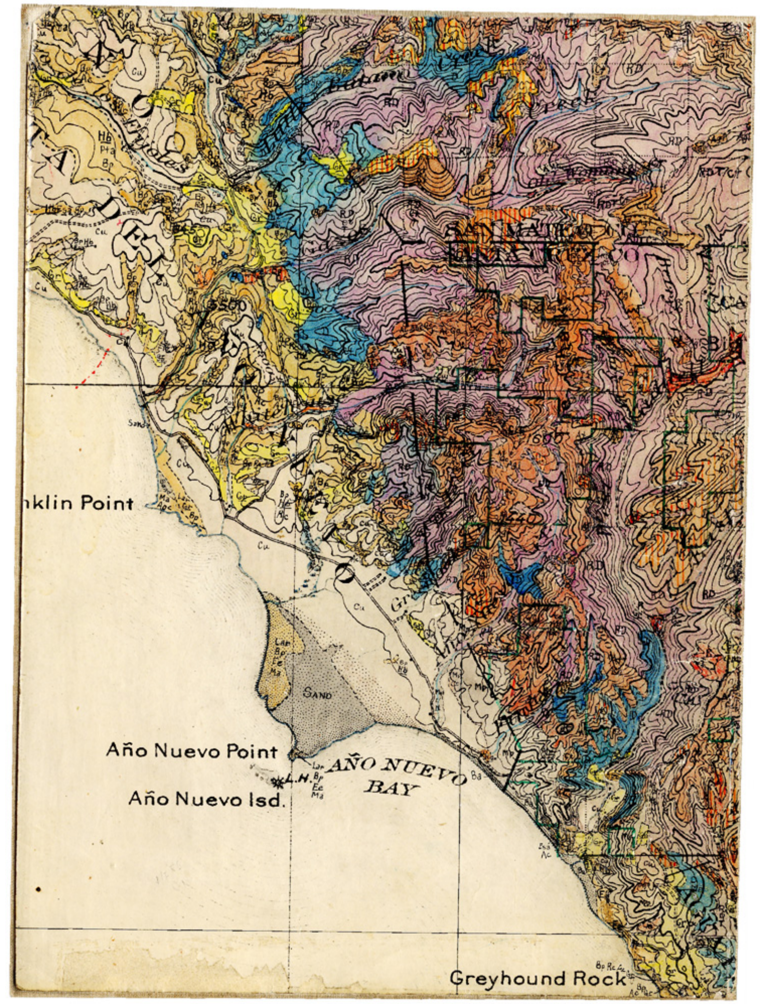
Wieslander Vegetation Survey

- **USGS effort 1928–42**
- **Detailed vegetation maps**
  - **Drawn by hand**



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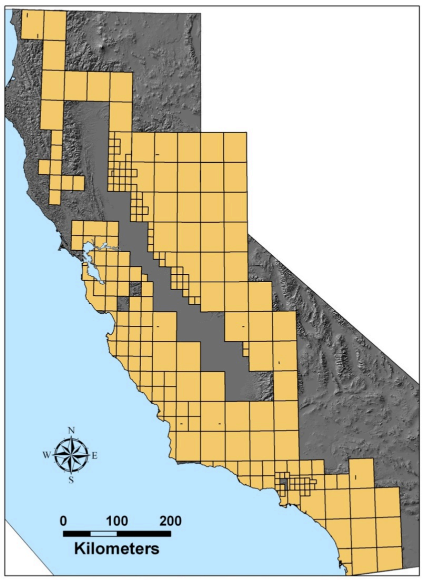
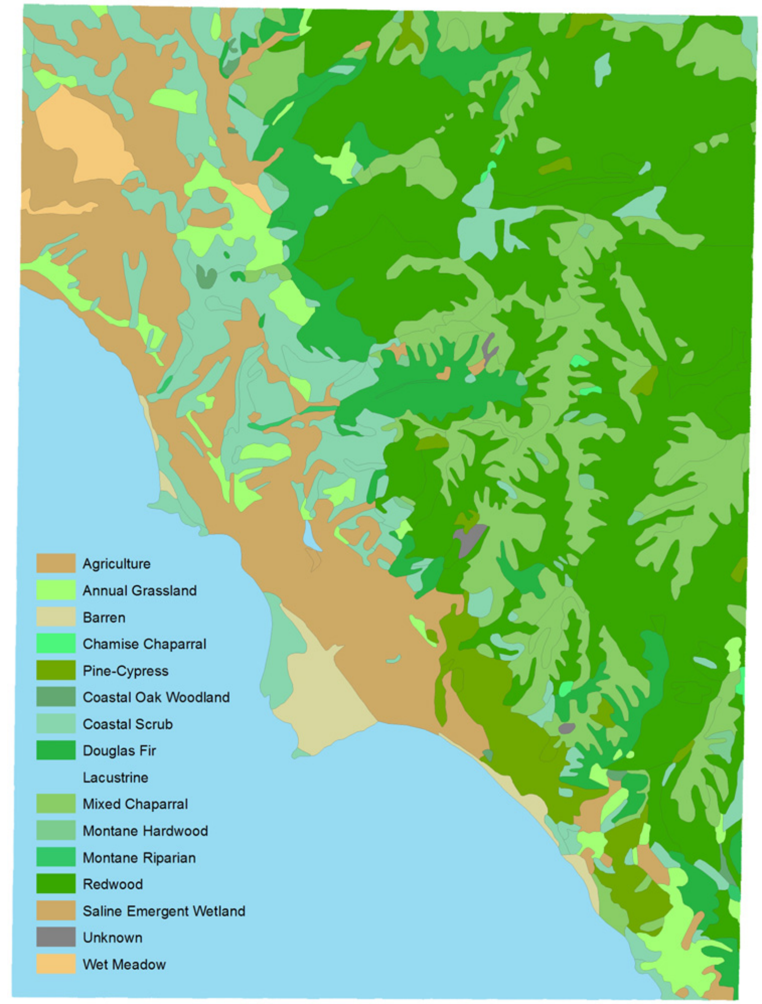
Wieslander Vegetation Survey

- **247,848 polygons digitized by UC Davis**





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Wieslander Vegetation Survey

- **3,000+ geolocated photos**

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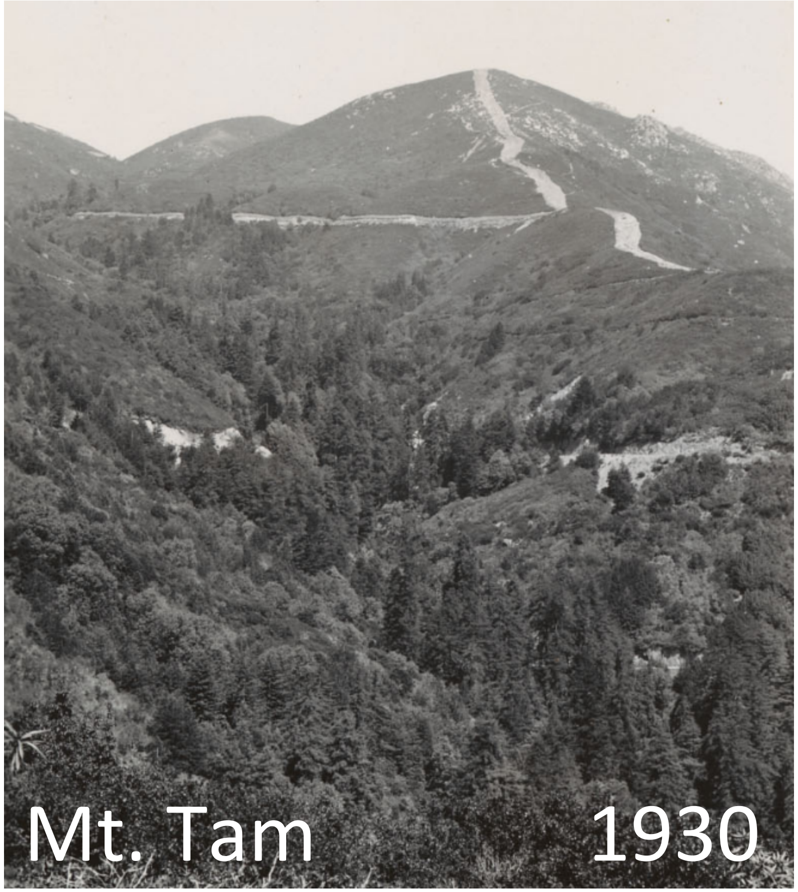
EcoHackSF: Photo Resurvey

- Photo geocache
- Find points
- Incentivize important locations
- Line up photos
- Visualize 3D Overlays
- Submit new shots



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EcoHackSF: Photo Resurvey

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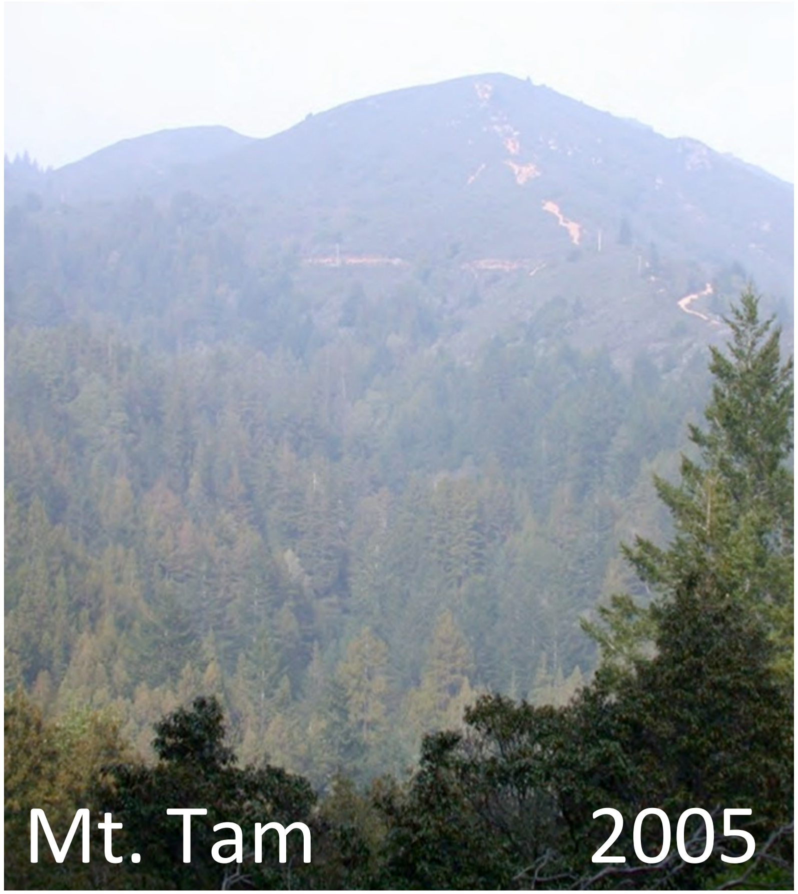

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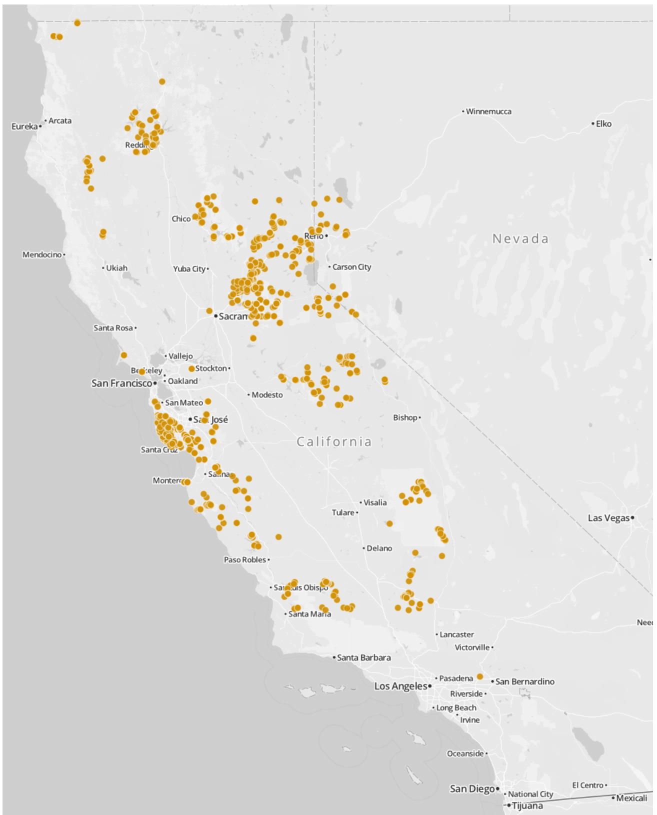
EcoHackSF: Photo Resurvey



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EcoHackSF: Photo Resurvey

Understand change in:

- Land Use
- Vegetation composition
- Stand age and health
- And more…

Photo: Stella Cousins

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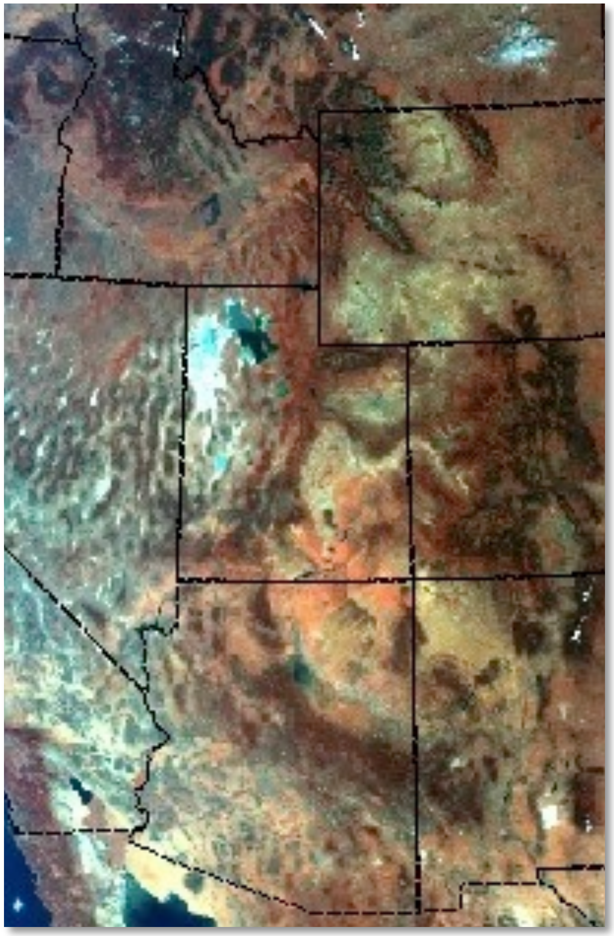
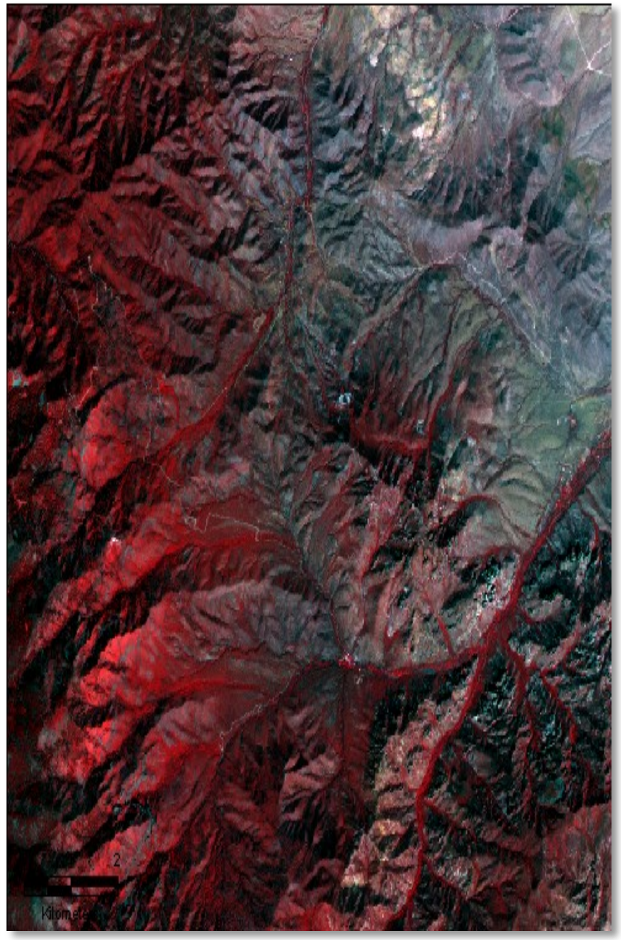
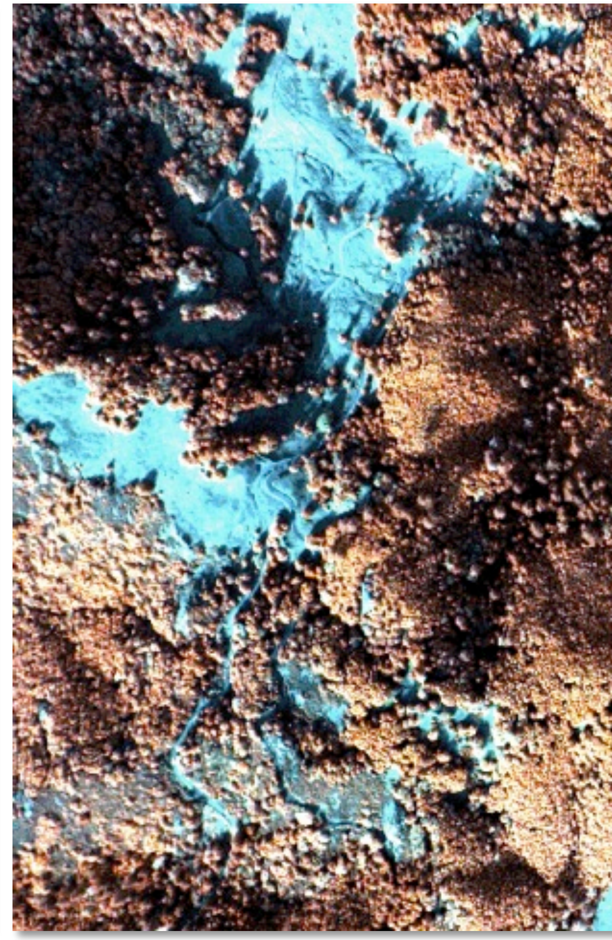
Lidar analysis in support of forest management:
the
Sierra Nevada Adaptive Management Project
SNAMP Spatial Team
Maggi Kelly, Qinghua Guo
Sam Blanchard, Jacob Flanagan,
Marek Jakubowski, Wenkai Li, Feng Zhao

Optical Remote Sensing: the View from Overhead



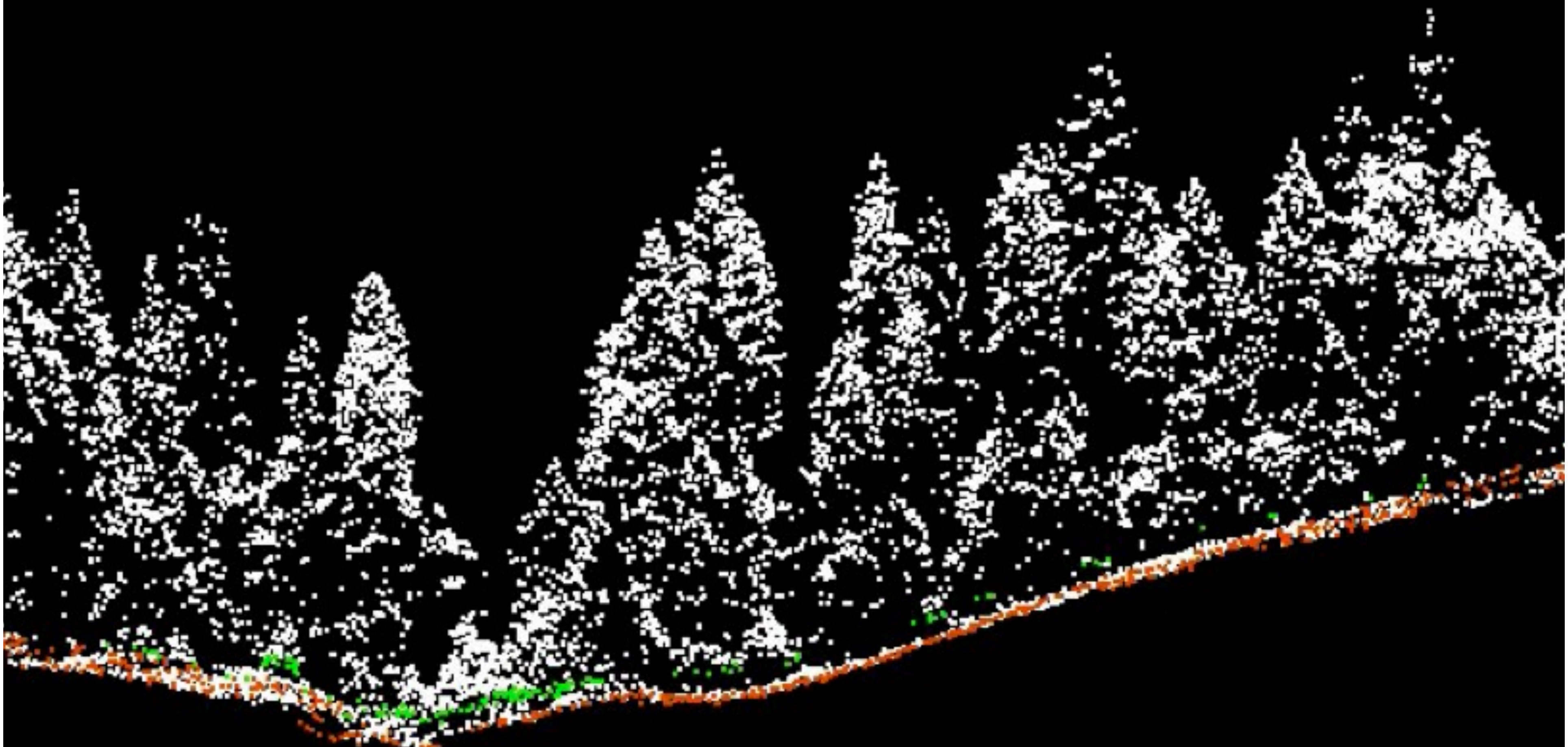




..MODIS Landsat Orthophotography..

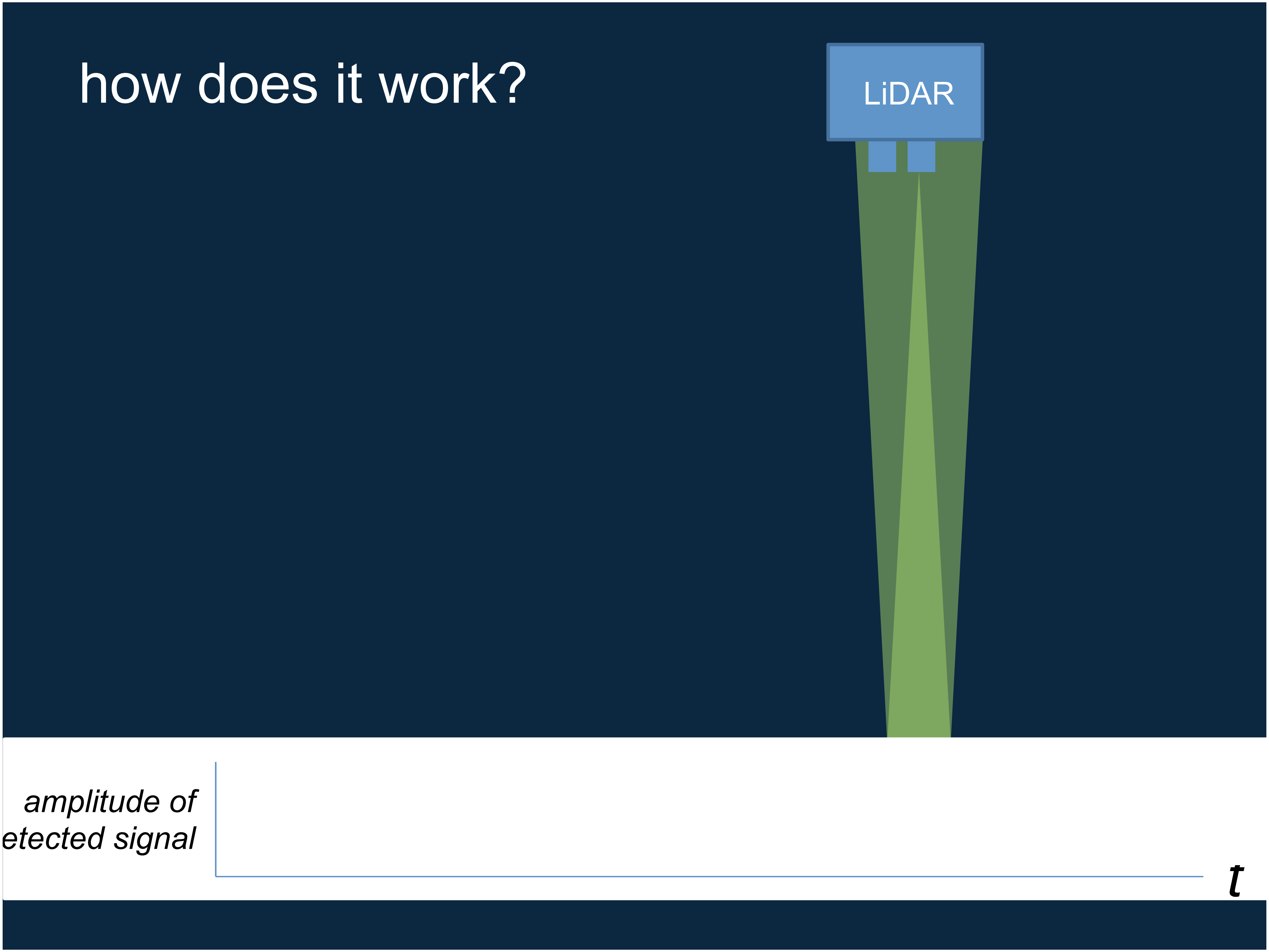
..1km 10m 1m..

Lidar Basics



LiDAR = Light Detection And Ranging

how does it work?

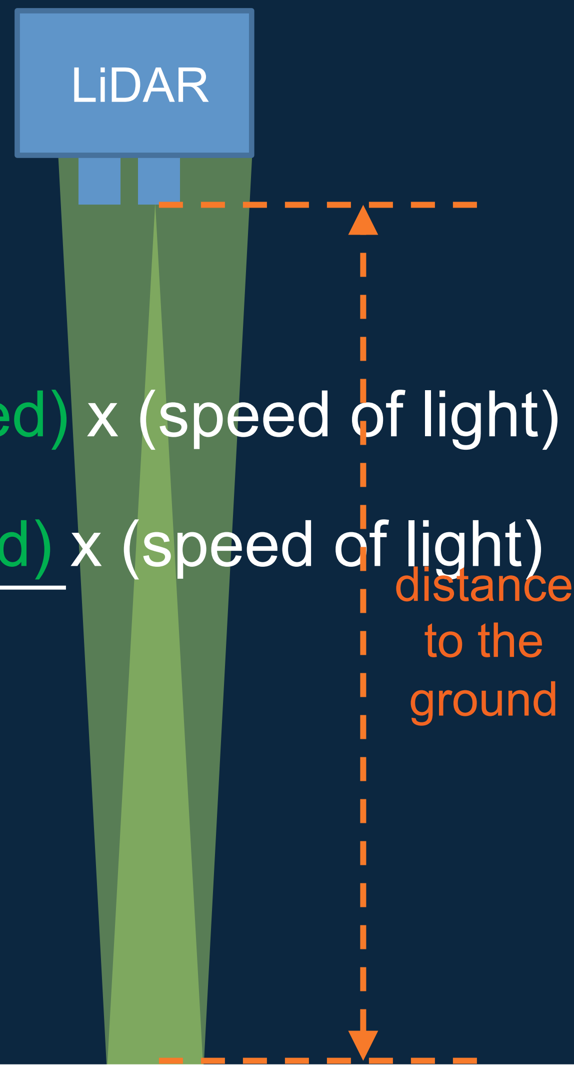

how does it work?
LiDAR
amplitude of
etected signal
t

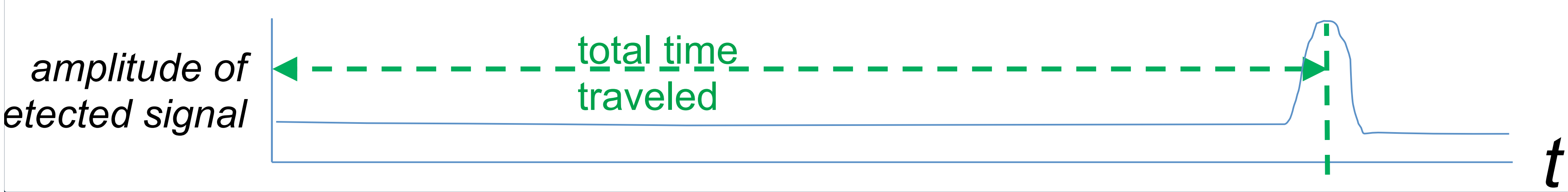
how does it work?

distance = time x speed

total *distance* traveled = (total *time* traveled) x (speed of light)

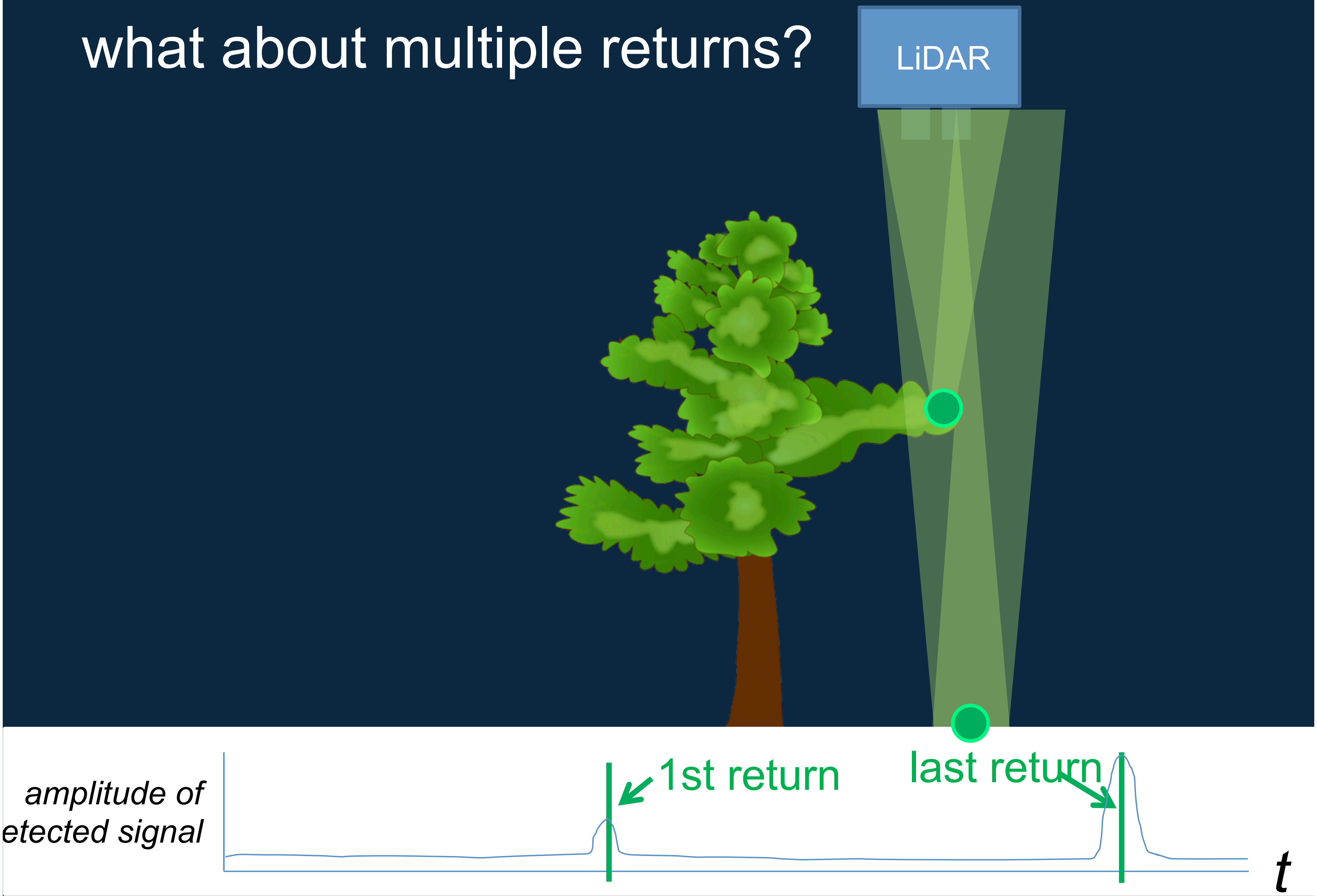
$$\text{distance to the ground} = \frac{(\text{total } \textit{time} \text{ traveled}) \times (\text{speed of light})}{2}$$



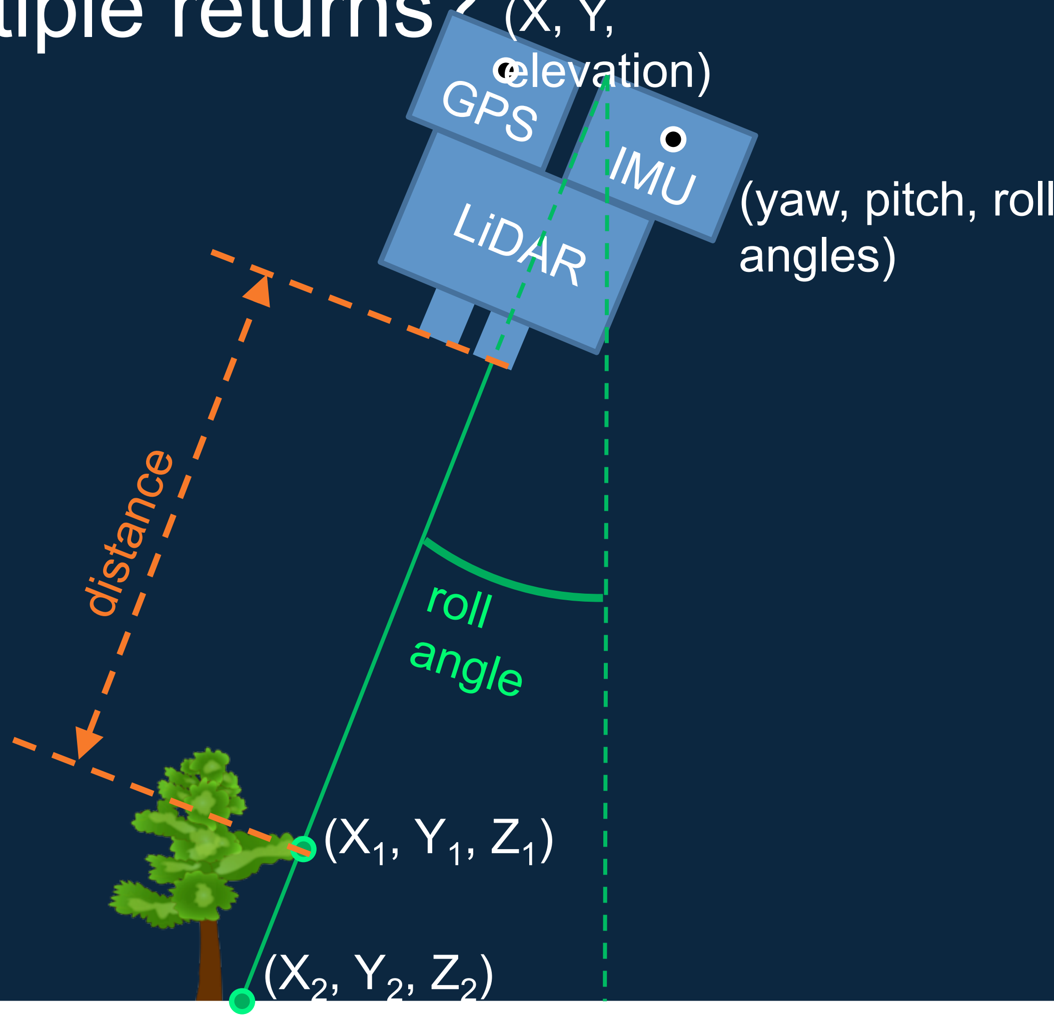


what about multiple returns?

what about multiple returns?



what about multiple returns?

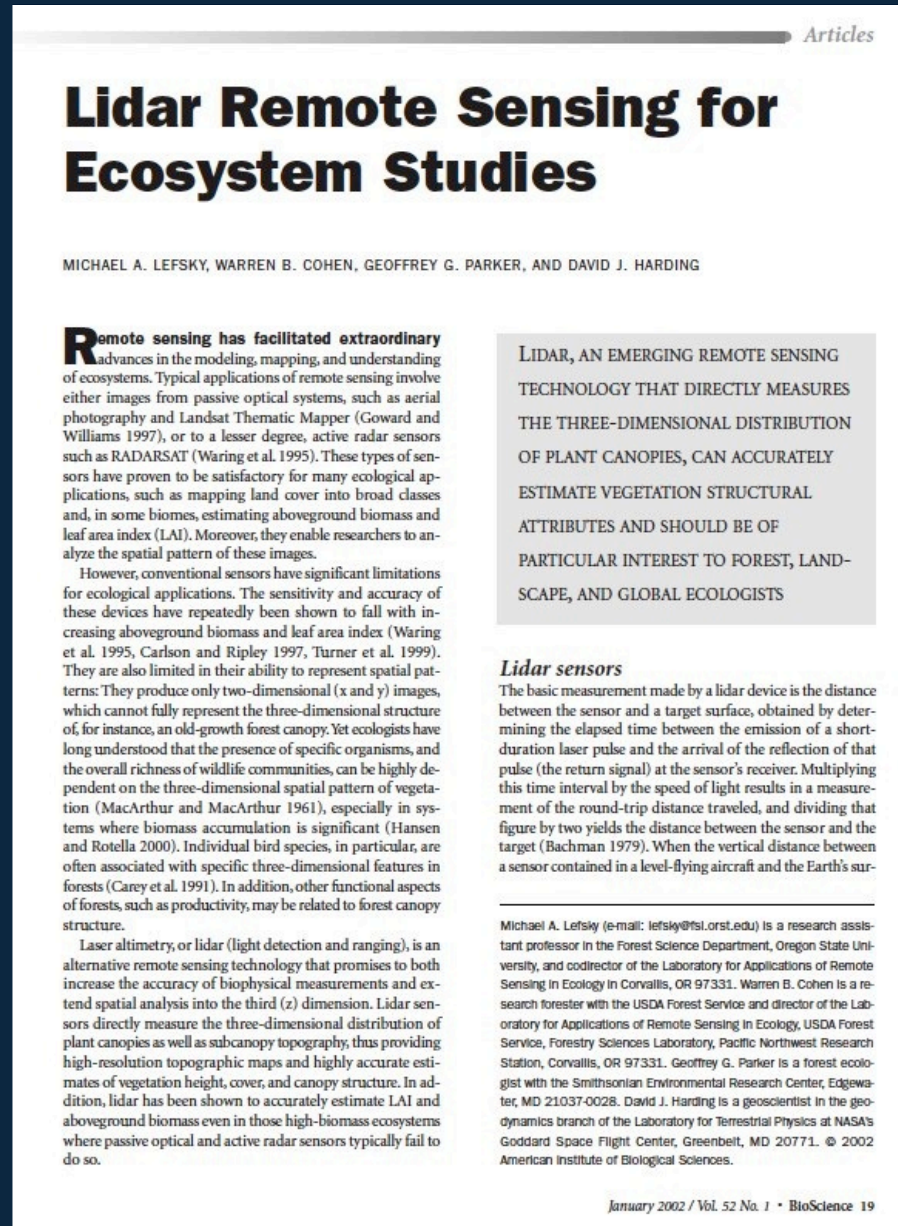


Lidar Applications

In 2002, Lefsky wrote*:*
"Developments in lidar remote sensing are occurring so rapidly that it is difficult to predict which applications will be dominant in 5 years."

Current ecological applications of lidar remote sensing:

- ground topography,
- 3D structure and function of vegetation canopies,
- forest stand structure attributes,
- Carbon, carbon, carbon



Lidar Remote Sensing for Ecosystem Studies

MICHAEL A. LEFSKY, WARREN B. COHEN, GEOFFREY G. PARKER, AND DAVID J. HARDING

Remote sensing has facilitated extraordinary advances in the modeling, mapping, and understanding of ecosystems. Typical applications of remote sensing involve either images from passive optical systems, such as aerial photography and Landsat Thematic Mapper (Goward and Williams 1997), or to a lesser degree, active radar sensors such as RADARSAT (Waring et al. 1995). These types of sensors have proven to be satisfactory for many ecological applications, such as mapping land cover into broad classes and, in some biomes, estimating aboveground biomass and leaf area index (LAI). Moreover, they enable researchers to analyze the spatial pattern of these images.

However, conventional sensors have significant limitations for ecological applications. The sensitivity and accuracy of these devices have repeatedly been shown to fall with increasing aboveground biomass and leaf area index (Waring et al. 1995, Carlson and Ripley 1997, Turner et al. 1999). They are also limited in their ability to represent spatial patterns: They produce only two-dimensional (x and y) images, which cannot fully represent the three-dimensional structure of, for instance, an old-growth forest canopy. Yet ecologists have long understood that the presence of specific organisms, and the overall richness of wildlife communities, can be highly dependent on the three-dimensional spatial pattern of vegetation (MacArthur and MacArthur 1961), especially in systems where biomass accumulation is significant (Hansen and Rotella 2000). Individual bird species, in particular, are often associated with specific three-dimensional features in forests (Carey et al. 1991). In addition, other functional aspects of forests, such as productivity, may be related to forest canopy structure.

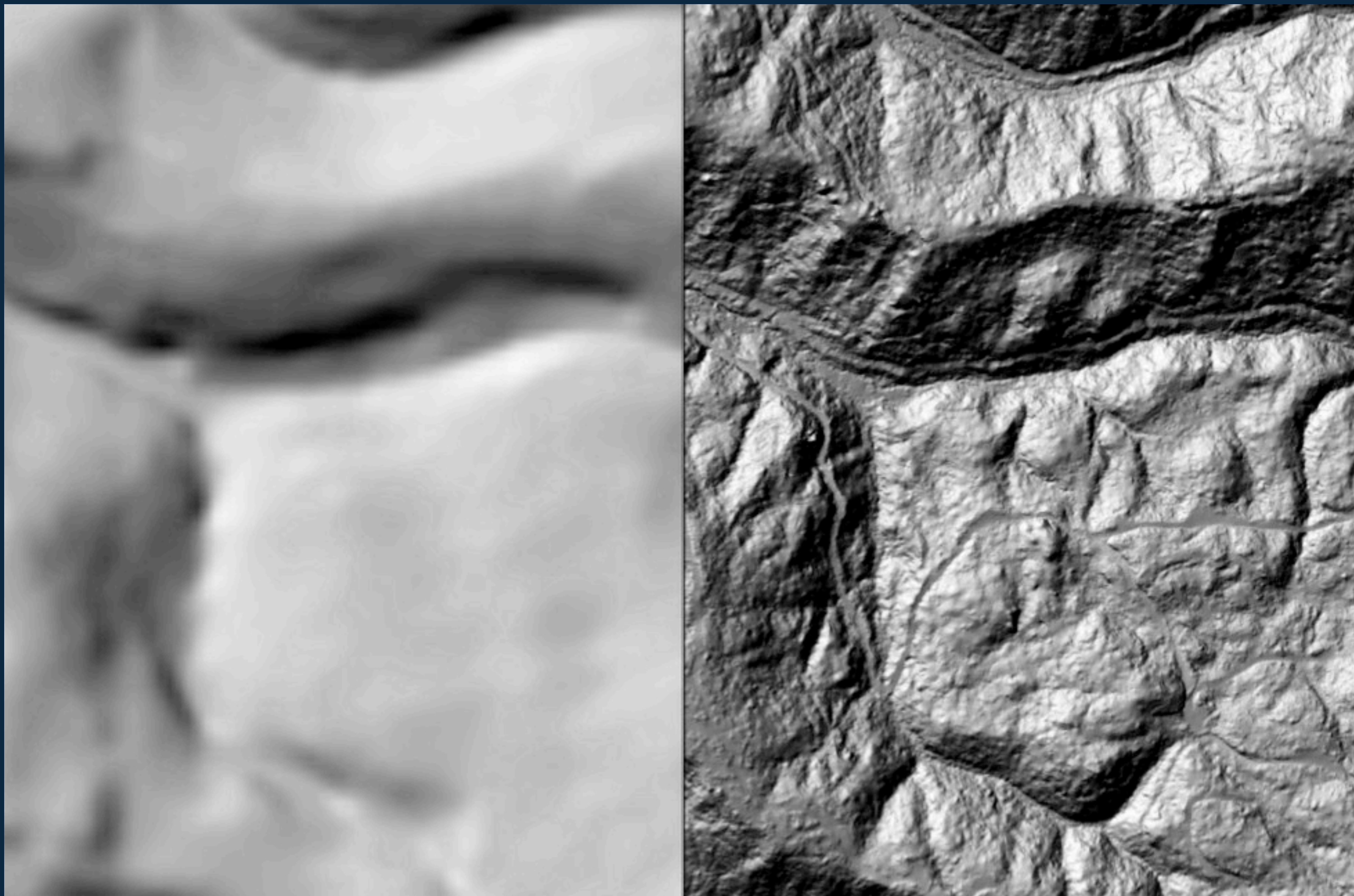
Laser altimetry, or lidar (light detection and ranging), is an alternative remote sensing technology that promises to both increase the accuracy of biophysical measurements and extend spatial analysis into the third (z) dimension. Lidar sensors directly measure the three-dimensional distribution of plant canopies as well as subcanopy topography, thus providing high-resolution topographic maps and highly accurate estimates of vegetation height, cover, and canopy structure. In addition, lidar has been shown to accurately estimate LAI and aboveground biomass even in those high-biomass ecosystems where passive optical and active radar sensors typically fail to do so.

LIDAR, AN EMERGING REMOTE SENSING TECHNOLOGY THAT DIRECTLY MEASURES THE THREE-DIMENSIONAL DISTRIBUTION OF PLANT CANOPIES, CAN ACCURATELY ESTIMATE VEGETATION STRUCTURAL ATTRIBUTES AND SHOULD BE OF PARTICULAR INTEREST TO FOREST, LANDSCAPE, AND GLOBAL ECOLOGISTS

Lidar sensors

The basic measurement made by a lidar device is the distance between the sensor and a target surface, obtained by determining the elapsed time between the emission of a short-duration laser pulse and the arrival of the reflection of that pulse (the return signal) at the sensor's receiver. Multiplying this time interval by the speed of light results in a measurement of the round-trip distance traveled, and dividing that figure by two yields the distance between the sensor and the target (Bachman 1979). When the vertical distance between a sensor contained in a level-flying aircraft and the Earth's sur-

Michael A. Lefsky (e-mail: lefsky@fsl.orst.edu) is a research assistant professor in the Forest Science Department, Oregon State University, and codirector of the Laboratory for Applications of Remote Sensing in Ecology in Corvallis, OR 97331. Warren B. Cohen is a research forester with the USDA Forest Service and director of the Laboratory for Applications of Remote Sensing in Ecology, USDA Forest Service, Forestry Sciences Laboratory, Pacific Northwest Research Station, Corvallis, OR 97331. Geoffrey G. Parker is a forest ecologist with the Smithsonian Environmental Research Center, Edgewater, MD 21037-0028. David J. Harding is a geoscientist in the geodynamics branch of the Laboratory for Terrestrial Physics at NASA's Goddard Space Flight Center, Greenbelt, MD 20771.

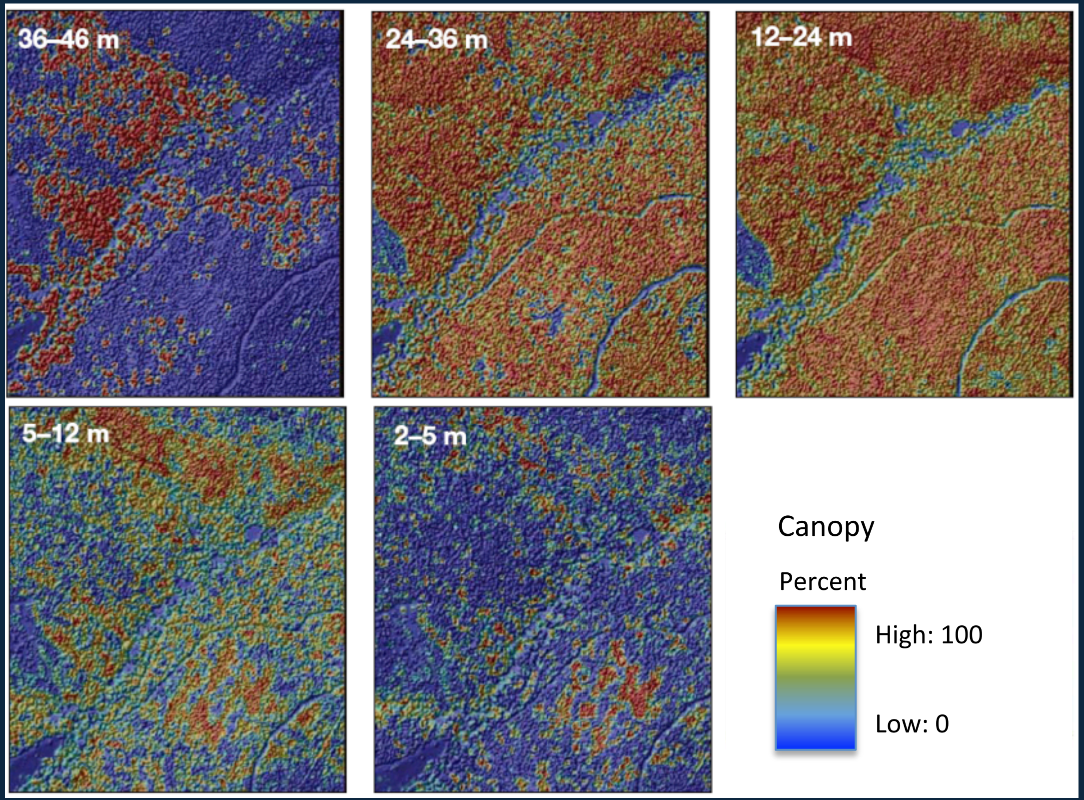


National Elevation Dataset (NED) vs lidar-derived DEM

Lidar Applications: Vegetation Canopies and Habitat

From Vierling et al. 2008. *Lidar: shedding new light on habitat characterization and modeling*. Frontiers in Ecology and Environment.

Lidar can provide fine-grained information about the 3-D structure of ecosystems across broad spatial extents.

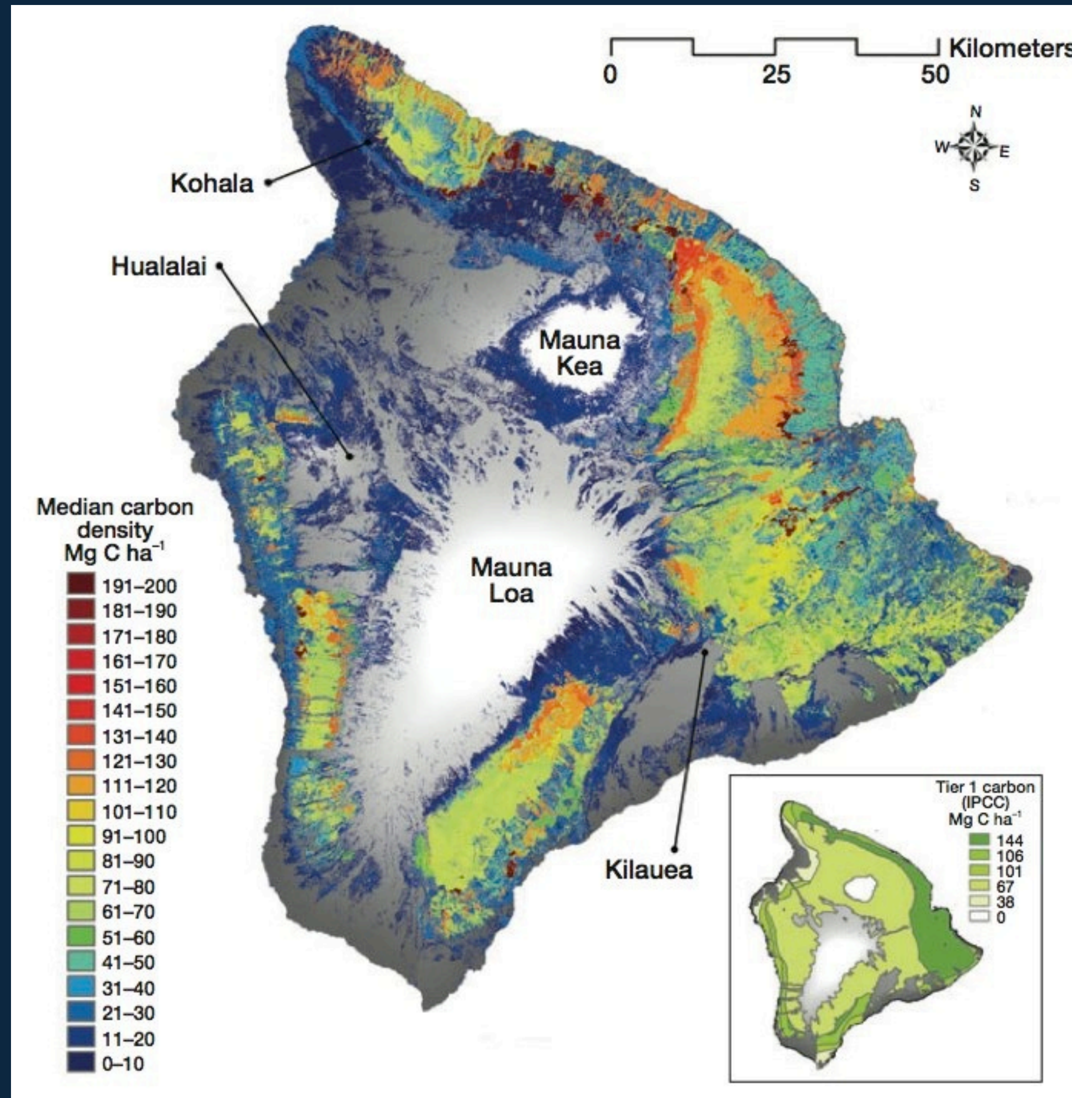


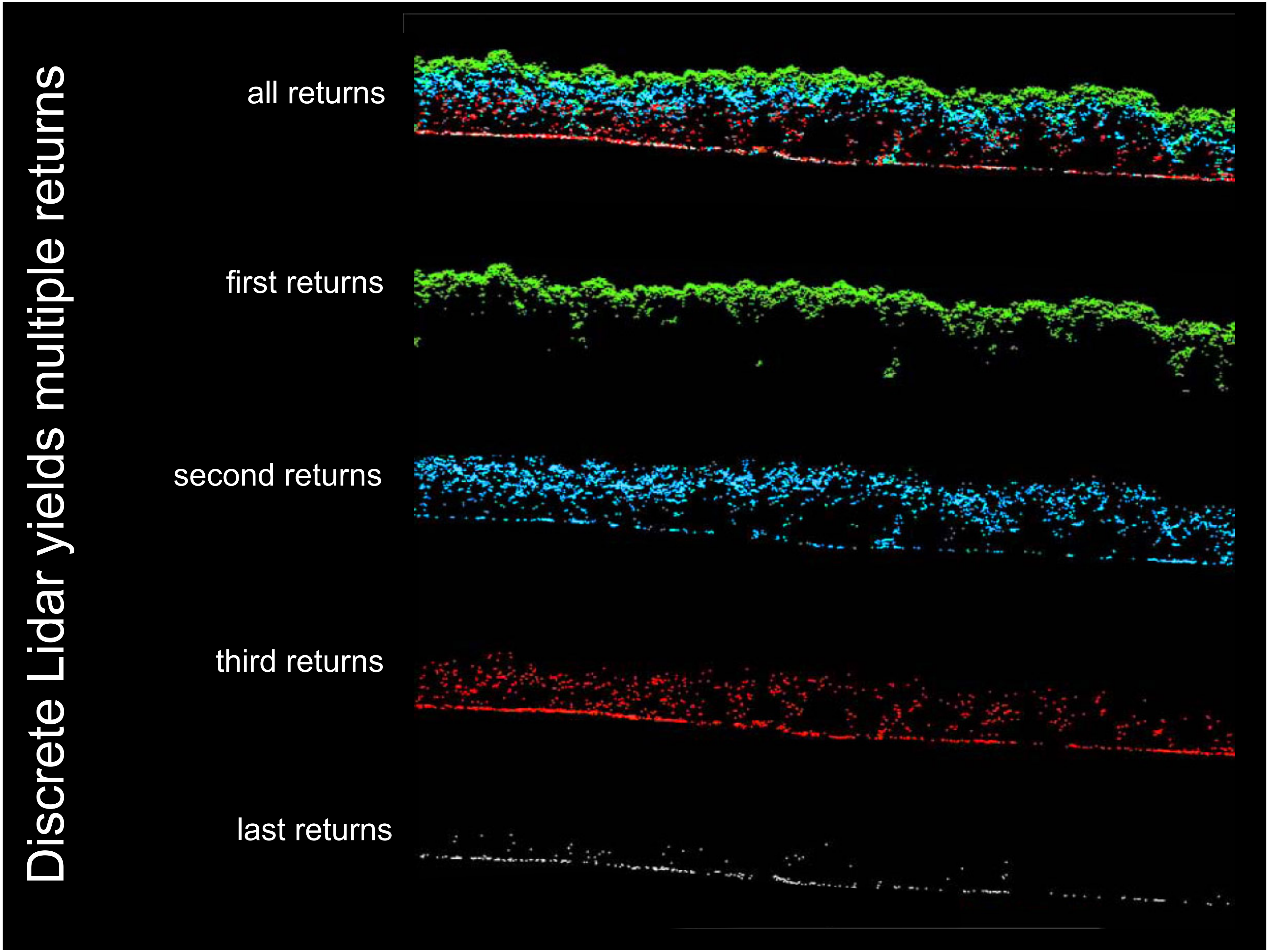
Lidar-derived vertical distribution plots showing the percentage of laser pulse hits that occurred within a particular height classification.
This kind of analysis helps us more fully understand the 3-D structure of vegetation.

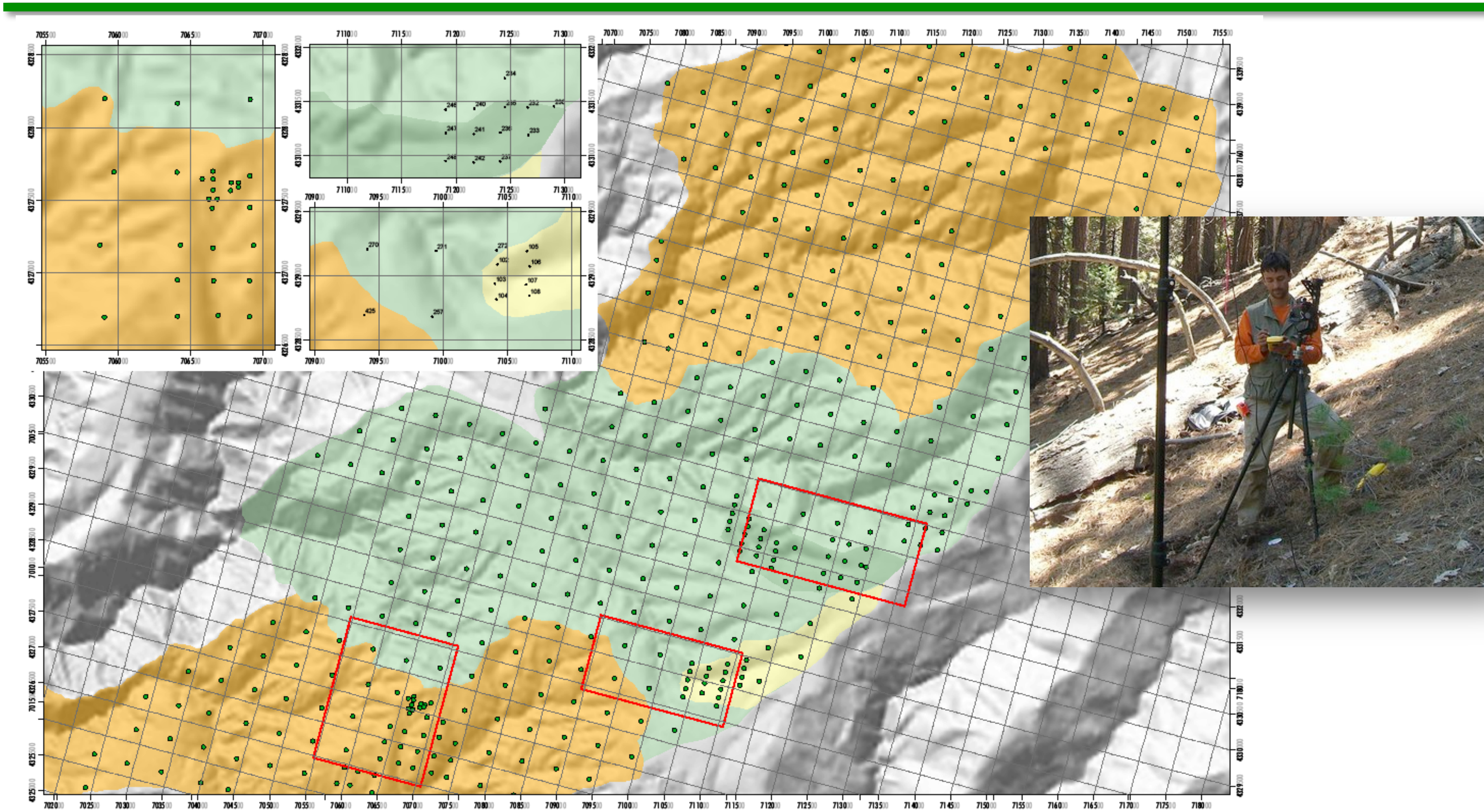
Mapping carbon

Combining field measurements, airborne lidar-based observations, and satellite-based imagery, we developed a 30-meter-resolution map of aboveground C density spanning 40 vegetation types found on the million-hectare Island of Hawaii.

Asner, et al. 2011. High-resolution carbon mapping on the million-hectare Island of Hawaii. Frontiers in Ecology and the Environment 9, 434-439.




Discrete Lidar yields multiple returns
all returns
first returns
second returns
third returns
last returns



SNAMP Field Data

Height, DBH, Species, Vigor (class), Crown class, HTLCB; Shrub Species, % cover, Height; Fuel: 1-, 10-, 100-, 1000-hour fuels, Litter, Duff layer. Other: LAI, Canopy cover (tube sightings), Coarse woody debris, Ladder fuel measurements

Lidar Data Products

Individual Trees

- Isolated from the point cloud, containing location, height, diameter

CHM – Canopy Height Model

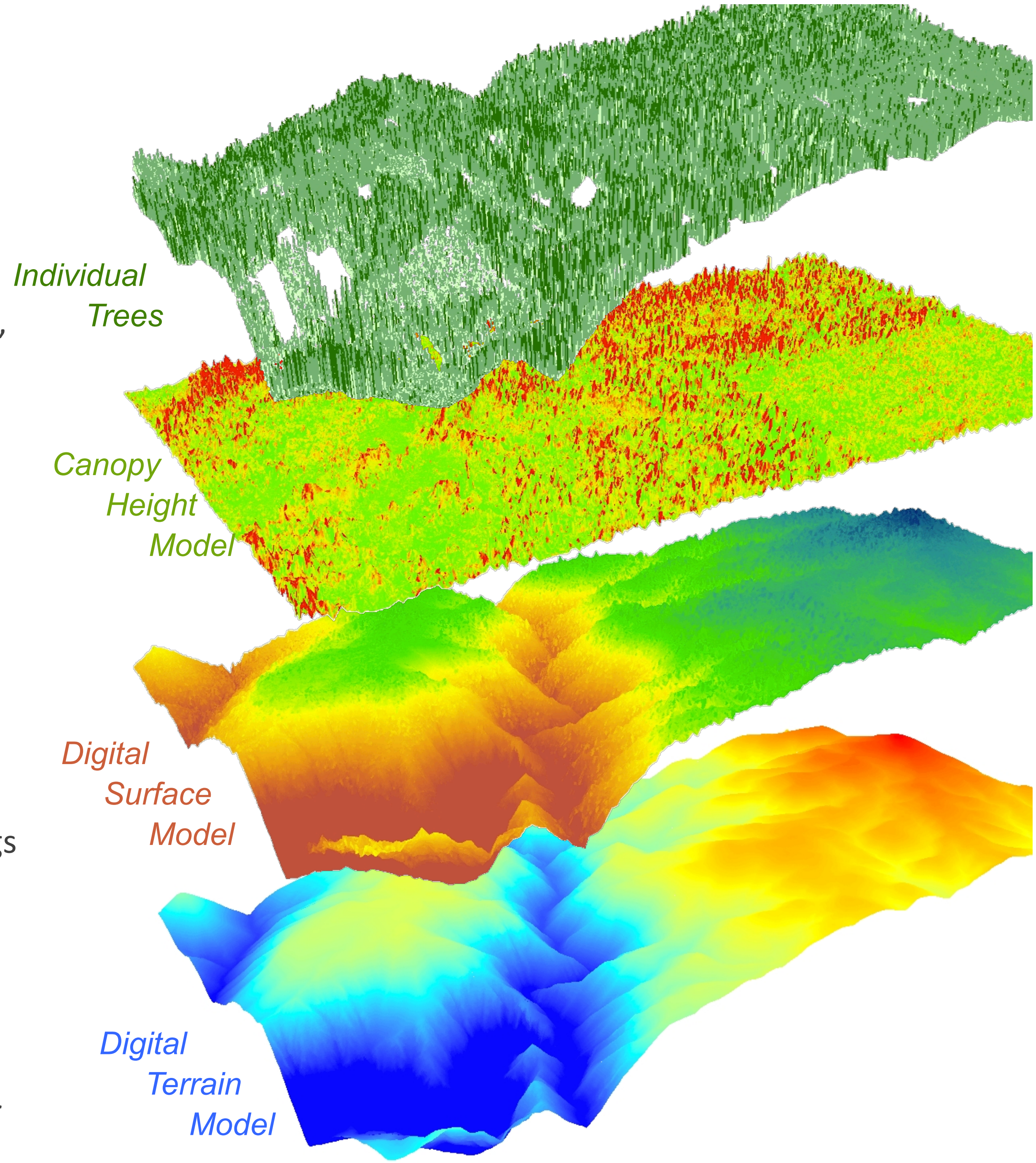
- Height information about vegetation *features with elevation removed*

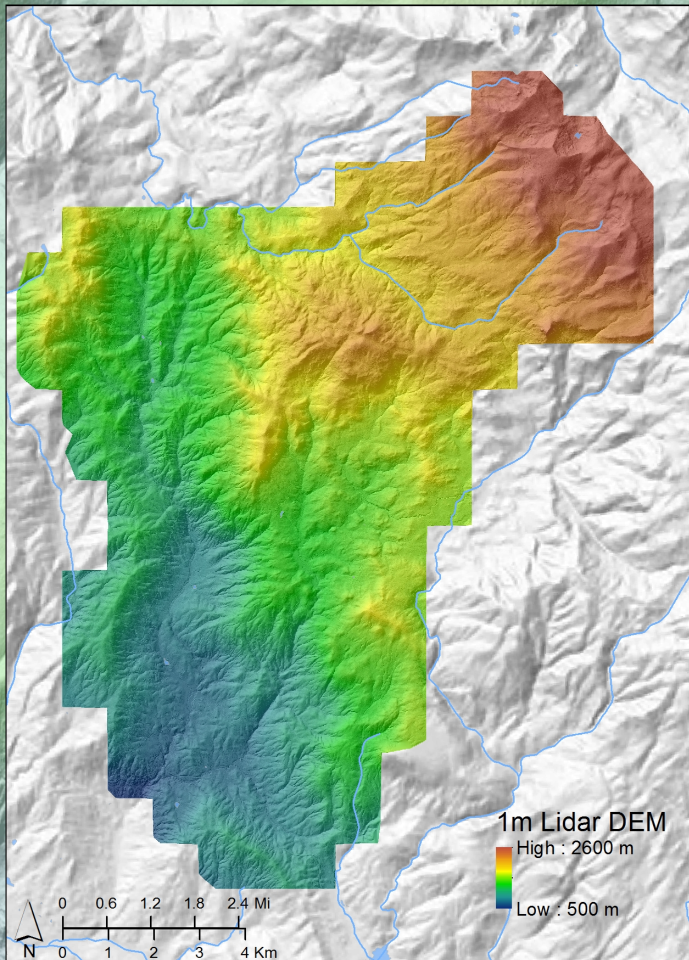
DSM – Digital Surface Model

- Elevation information about *all features* in the landscape, including vegetation, buildings and other structures

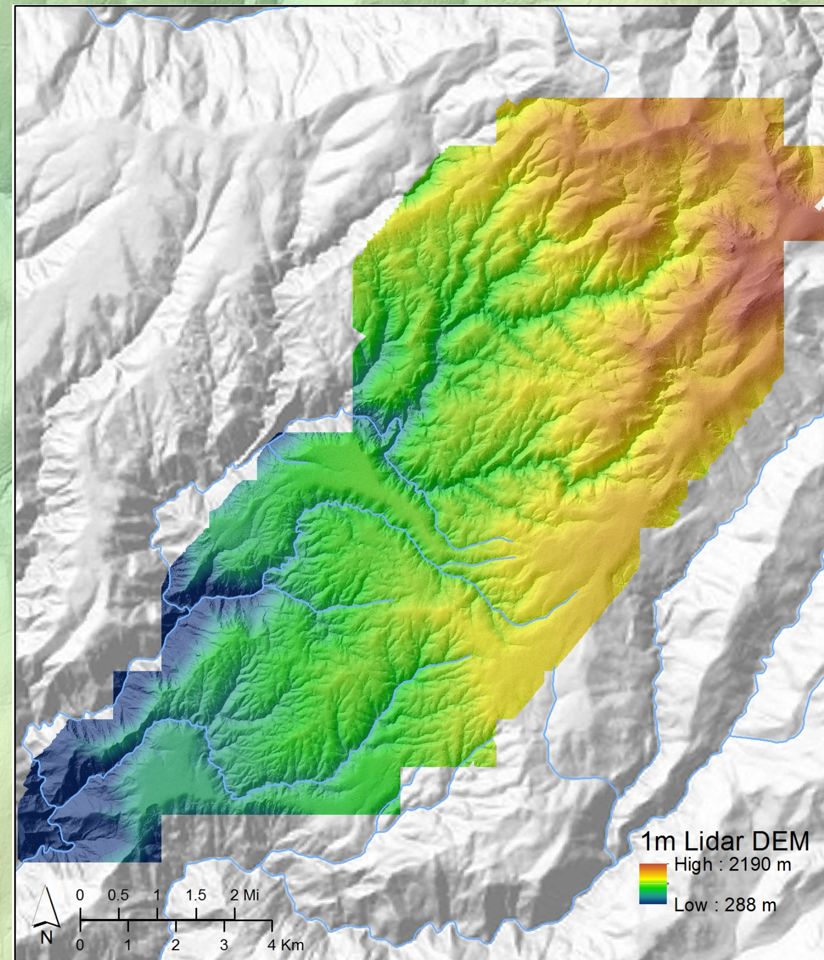
DTM – Digital Terrain Model

- Elevation information about bare-earth surface *without the influence of vegetation or man-made features*





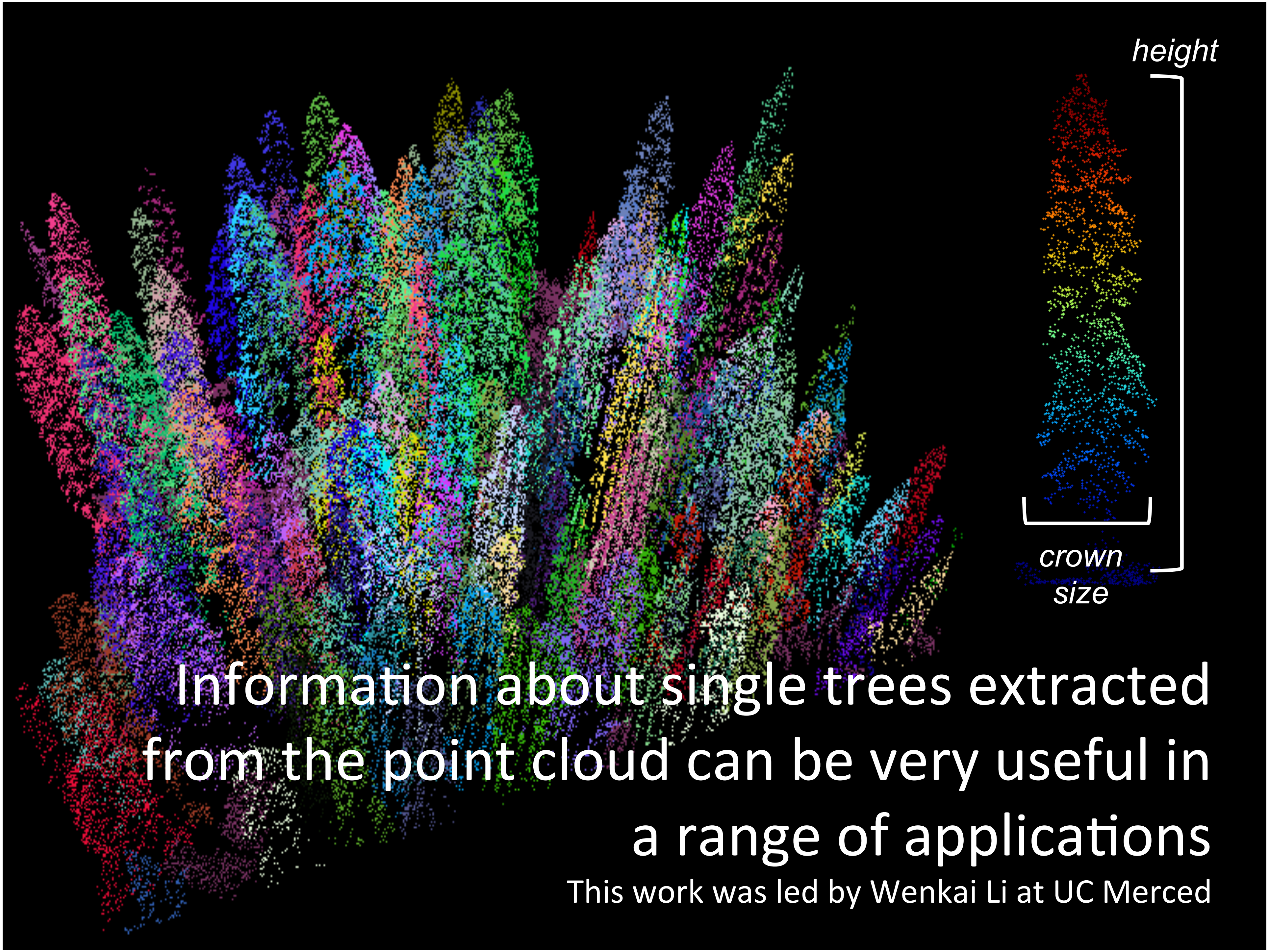
Sugar Pine



Last Chance

DEM products

DEM completed for both sites: Publication looking at methodology for DEM creation (Guo et al, 2010), based on different algorithms, topography, lidar sampling, density, pixel size

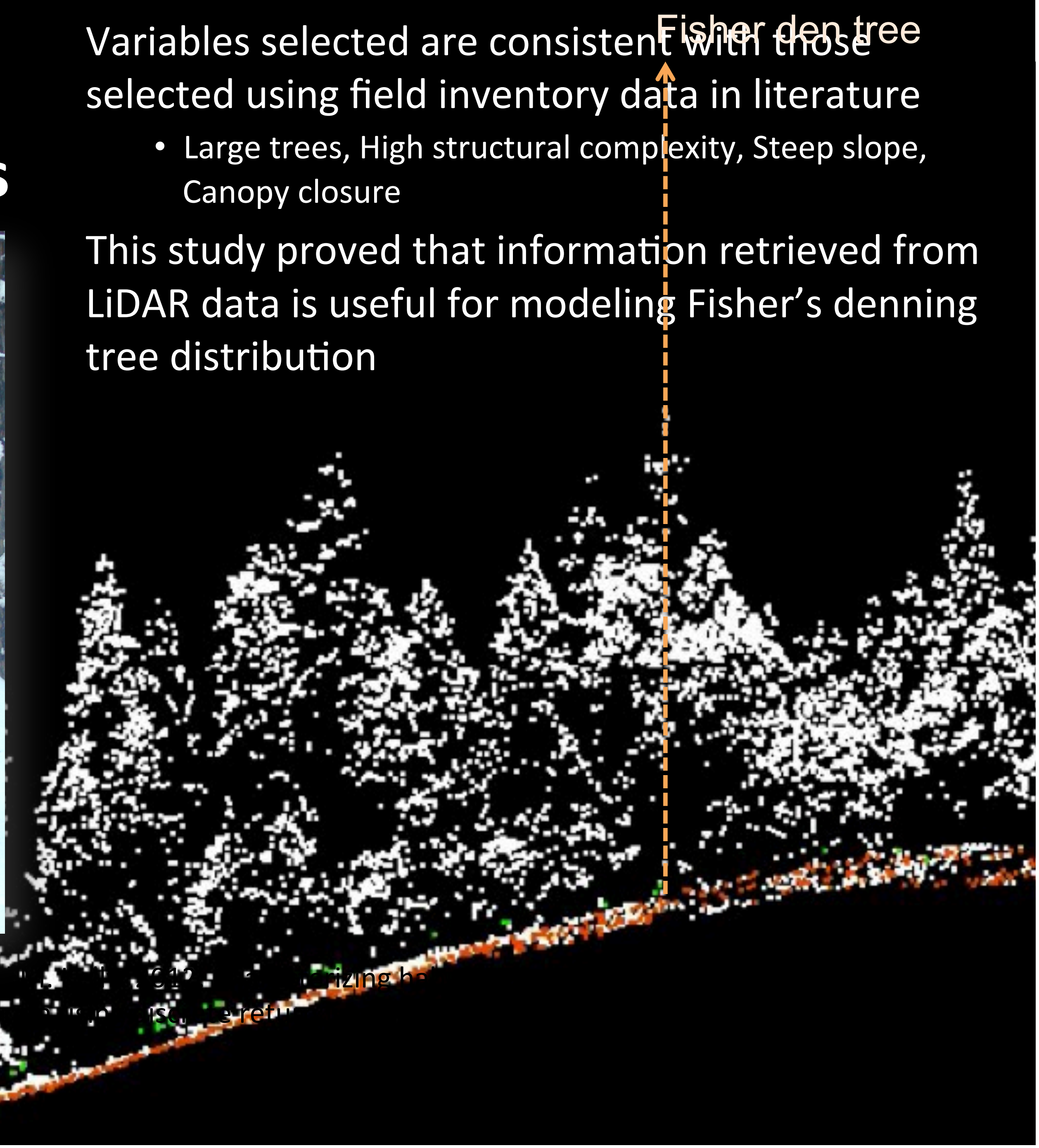

height
crown
size
Information about single trees extracted from the point cloud can be very useful in a range of applications
This work was led by Wenkai Li at UC Merced

Fishers like big trees and complex forests

Variables selected are consistent with those selected using field inventory data in literature

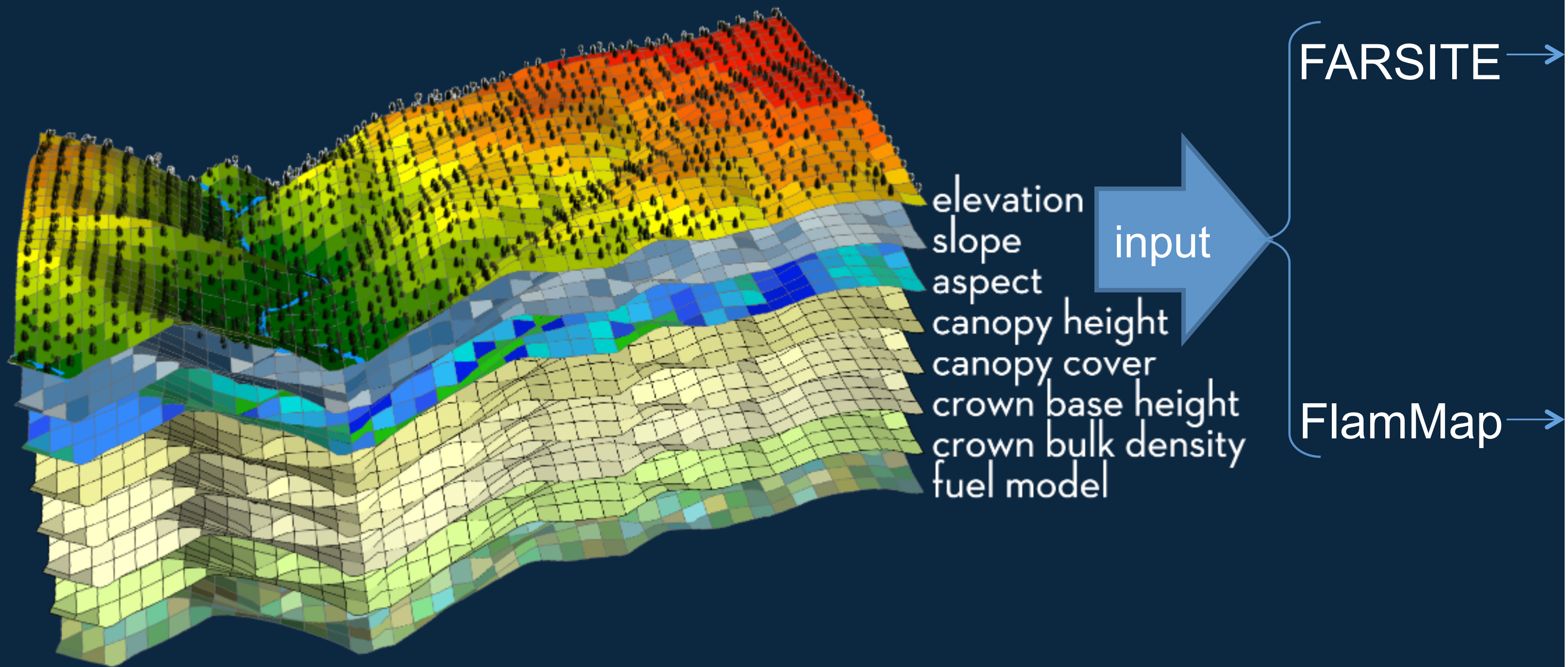
- Large trees, High structural complexity, Steep slope, Canopy closure

This study proved that information retrieved from LiDAR data is useful for modeling Fisher's denning tree distribution



How can we use lidar data for fire modeling?

This work was led by Marek Jakubowski at UC Berkeley



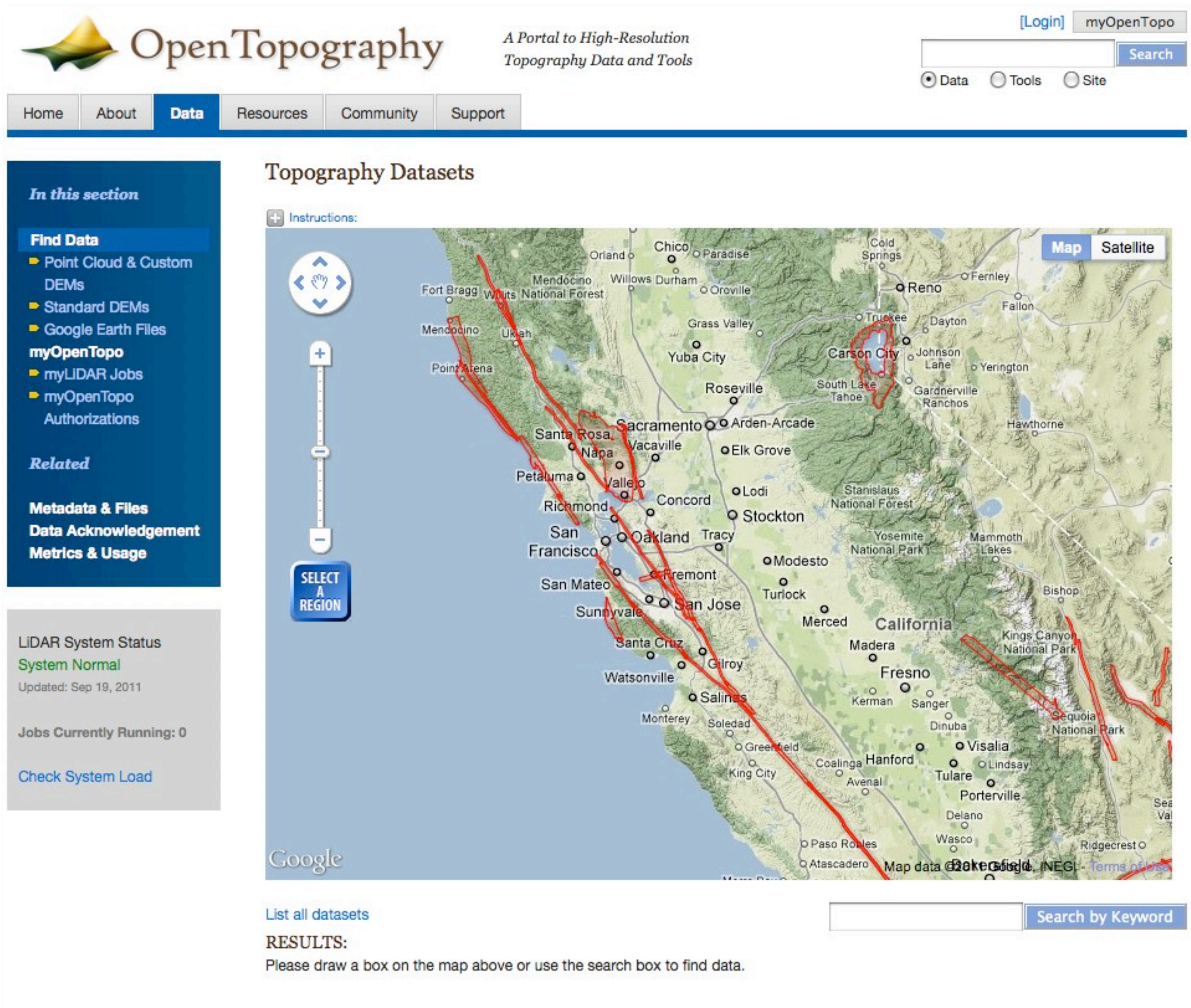
Jakubowski, M. K., Q. Guo, B. Collins, S. Stephens, and M. Kelly. 2013. Predicting surface fuel models and fuel metrics using lidar and CIR imagery in a dense, mountainous forest. In Press in Photogrammetric Engineering and Remote Sensing 79(1):37-49


Viewing a Virtual Scene in 3D


The Virtual Forest

California is a data-rich state

The California Ocean Protection Council has released state-wide high resolution elevation data for coastal California and much of San Francisco Bay. LiDAR data were collected between 2009-2011 and cover nearly 3,800 square miles. Data can be download from NOAA Coastal Services Center's Digital Coast website: http://sc.noaa.gov.



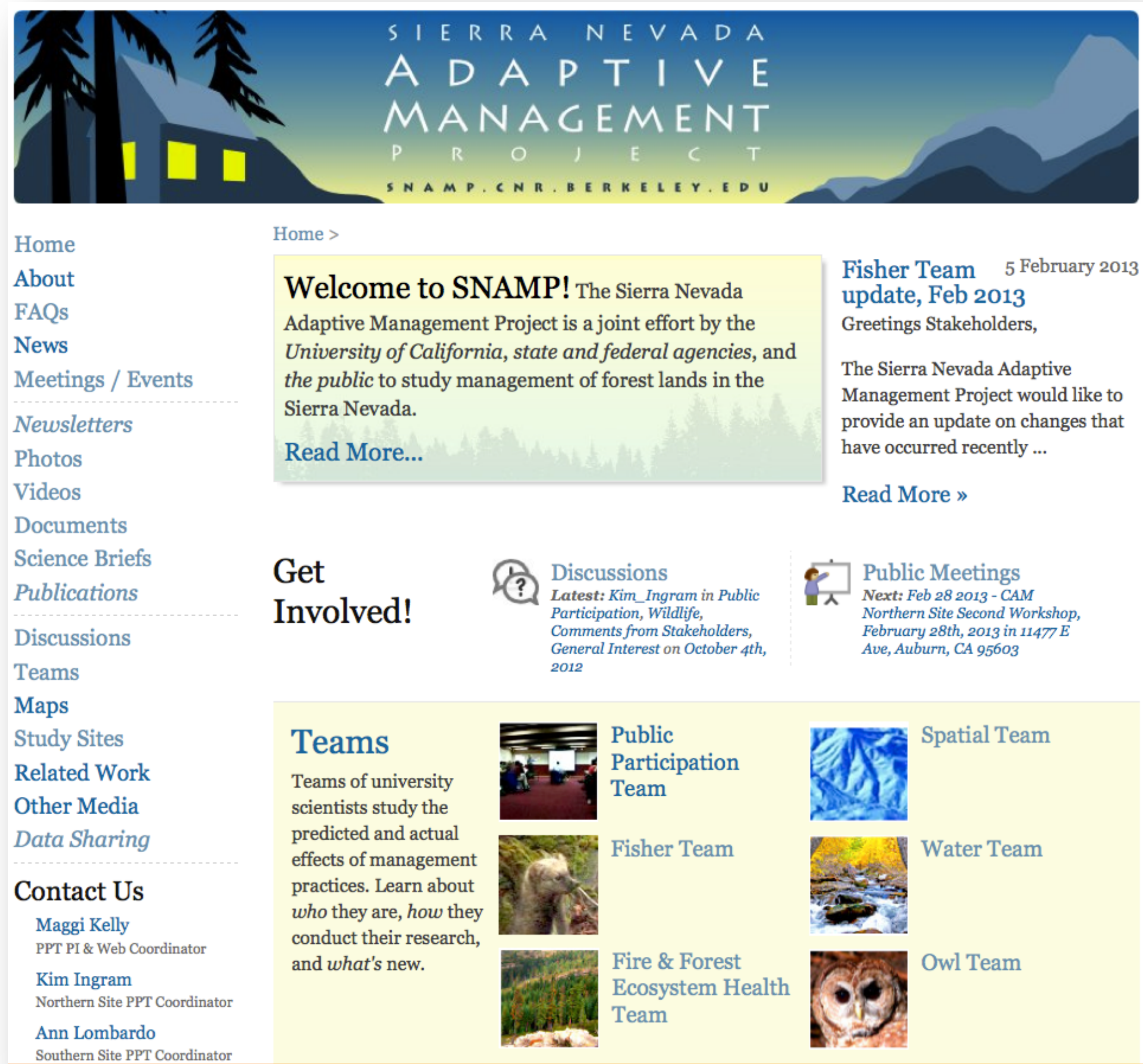
Interaction with the public via the web

The website is our repository for the project.

Shasta Ferranto and Shufei Lei are involved in this effort

All our publications are available on the SNAMP website

http://snamp.cnr.berkeley.edu



Where to find more information

Cal-Adapt website

- http://cal-adapt.org

Statewide Program in Informatics and Geographic Information Systems (IGIS)

- http://ucanr.sites/IGIS

Berkeley's Geospatial Innovation Facility (GIF)

- http://gif.berkeley.edu

Maggi Kelly's website

- http://kellylab.berkeley.edu

Open Topography

- http://opentopography.org

NASA Blue Marble 2.0