Ethnography Synthesis

Findings from qualitative research

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Introduction

The California Forest Observatory is a new platform designed to dynamically map forest structure and fuel loads—at the tree level, statewide—using LIDAR, satellite imagery and artificial intelligence. This high resolution, regularly updated forest map will be combined with real-time weather, climate, population, and infrastructure data—the key drivers of wildfire behavior—to better understand wildfire hazards and exposure. Supported by the Gordon and Betty Moore Foundation, the Forest Observatory will provide an unprecedented, continuously updated view of forest health and wildfire risk in California.

The Observatory was designed to support forest restoration and emergency response, enabling federal and state agencies to improve community resilience to wildfire, improve emergency wildfire operations, prioritize, plan, and execute treatments of hazardous fuels, and monitor the short-term impacts and long-term benefits of improving forest resilience to wildfire, disease, and climate change.

In an effort to better understand areas for immediate potential integration, as well as broad blue-sky opportunity spaces, we conducted interviews with advisers and independent stakeholders from a wide range of disciplines. We interviewed experts in land management, emergency services, forest ecology, wildfire, meteorology, hydrology, wildlife biology, user experience, and cartography, who will continuously be engaged to optimize the design and build of the platform. To ensure accuracy and relevance, the beta version of the Forest Observatory will be provided for free to scientists, NGOs, and state and federal agencies.

We employed an approach called mixed-methods: we simultaneously interviewed participants while examining and collecting artifacts related to the domain of investigation. This report summarizes the workflows, tools used, core needs, pain points, and imagined use cases for the Observatory, summarized as representative personas. We've tried to keep the voices and perspectives of the users intact.

Synthesis

The challenges faced by the wildfire community might simply be characterized as a series of small, siloed teams working to understand an increasingly intense and unpredictable ecological process, occurring in ecosystems that have been systematically restructured over the last two centuries. Megafires occur at an intersection: of shifting ignition sources, from lightning and indigenous fires to cigarettes and campfires; of the systematic suppression of fire and other ecological disturbances; of increasing housing density, and housing prices, on the edges of forests; of an ad hoc admixture of federal, private and state responsibilities; of climate change and biodiversity loss.

The community working in this space is larger than we anticipated; the 71 participants interviewed represent just a sample of the perspectives from the hundred-plus organizations involved in managing, monitoring & planning for wildfire. However, each team tends to be small. Science and planning teams often include just two to three researchers. Wildfire response is often coordinated by few to tens of people. And each team has its own tools and datasets they use to make decisions. A shared understanding of the status of fires, fuels and weather is lacking, as is the capacity to share this understanding.

While this document covers a wide range of experiences expressed by this diverse community, we identified consistent feedback patterns across wildfire personas:

Pain points

- Attention and resources are focused on disasters, not long-term resilience
- There are skill and time gaps, characterized by limited access to resources—people, servers, skills, and funding—to work with the data available today
- The planning horizon is too long. Restoration projects are out of date before they begin. How do we get projects done in 3-5 years, not 8-15?
- Current approaches to characterizing surface fuels—the key driver of fire behavior and emissions—is labor-intensive, inconsistent, slow and expensive

- Predicting and communicating wildfire dynamics may be less a technical problem than an organizational one. There's competition between agencies over resources, and over which data are used
- There's perceived conflict between long-term and short-term public interests. The long-term benefits of active forest management and prescribed burns are often overlooked due to short-term challenges like air quality restrictions

Core needs

- A list of shared values. Agencies and the public aren't as far apart as they think
- A shared information platform for everyone, not just experts, to help agencies, communities & landowners understand and weigh management trade-offs
- Visibility into fuel loads, weather patterns, fire behavior, communities and infrastructure at local, regional & statewide scales
- An emphasis on monitoring. Projects are painstakingly designed and deployed yet rarely reevaluated. Is restoration as effective as we think it is? For how long?
- Integration among existing tools. Though every tool has its own caveat, many are reluctant to give up what they're familiar with. New datasets and models should be developed *with* existing tools, not *instead of*.

Envisioned use cases

- API access to best-in-class fuels, meteorology, and wildfire data
- Powerful, high resolution visualizations to drive alignment across agencies and stakeholder groups on forest management plans
- Clear visibility on fuels, weather & hazard to increase confidence to let fires burn when the conditions are right
- Monitor recent post-fire recovery & current active management activities. Use the past and the present to characterize and envision the future

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In their words

Land managers, scientists & foresters

"Planning and predictive tools, and monitoring, are the most important things we need. We're shooting in the dark right now. We present what we think will be better—but we don't actually know."

"We have to define resilience. For me: give this forest the chance to get 100 years older. If we get there, we might be able to give it enough time to last through climate change."

"Most people are focused on stopping catastrophic wildfires. I always ask: where are we trying to get to? How does what we do for the forest today inch us toward a bigger vision?"

"Every easy land management decision was made already. Today it's all about tradeoffs."

"The biggest money is tied to carbon. We have to create landscapes that can hold onto carbon as everything burns around it. We have to do the accounting now."

"With regard to wildfire mitigation treatments in frequent-fire forests we're really talking about tradeoffs between maximizing the carbon stock and stabilizing it."

"What society values is dependent on time: where we are in history, where we are on the landscape. If we can somehow portray these values using data—including what a local community specifically values—we can effectively communicate with the public."

"When society understands that the forest is going to go away, things will change."

"People have to understand that, if we do nothing, species that are already at peril will be at more risk. And future generations will not be able to enjoy the woods like we do."

"We want fire to play its role for healthy ecosystems so we're not in this place of catastrophic fire being the new normal."

“If people don’t see what we’re doing, we don’t get money to do it. We must make this work visible.”

“The biggest hurdle is actually delivering data products that support analytical needs in order to meet land management planning and objectives.”

“We need a killer planning tool that can become an Autodesk-like public visualization platform.”

Firestarters

“We need more modeling, more messengers, and more money in the budget”

“The state’s goal is to treat about 1 million acres per year. We’re only able to do about 125k acres per year today.”

“Governor Brown said it well: ‘we’re on the wrong side of nature.’ Fire defines the nature of what California is. When you look out the window, go on vacation, those trees and shrubs are dependent upon fire. We got fire backwards 180 years ago.”

“This is going to take public-private partnership and all hands on deck to get this done.”

“Because this is a slow moving disaster, people don’t understand the risk to property, health, and ecosystems.”

“Everyone’s got a map. What I can’t get is change over time.”

“If you have a piece of land that hasn’t seen fire for more than 100 years, what do you do? You can’t just burn it due to wildfire triggers and emissions. Do we thin first? We must devise strategies and work with insurance and citizens to take this on.”

“To date, smoke has been the only messenger that a prescribed burn is happening. It’s got to be paired with education.”

“We have to operate with empathy, sympathy, backed up with science. People are terrified.”

Emergency services

“Where we’re advanced is in building common, operational pictures*. But we’re behind on common operational* data*.”*

“We need to harness the tech that’s out there and combine it into a tactical use tool.”

“We need the Observatory to be the foundation for Calfire, USFS, OES, and SCOUT”

“You have to drive a new product through an organization. And show them how to use it”

“We need data on where the fuels are before a fire and after a fire went through, plus soil analysis [to estimate damage].”

“We need intel for that first engine to do its size up. ‘A grass fire transitioning to timber, immediate home threat, start me 5 helicopters, etc.’ We need an interface with information about where exactly the fire line is, critical infrastructure around it, and a road map. We don’t have tactical IR to show where a fire is in relation to critical infrastructure, which would drive better allocation of resources.”

“Right now, [the DOD] gets a watch list for counties. If we had better pre-fire intel on coming lightning, dryness and fuel loads, we might fly assets over to catch fires.”

“We need better imagery for damage inventory. We have tight timelines for products that help state and feds after the declaration of a disaster. A presidential declaration requires that 90% of structures are destroyed within 24 hours—if we had pre-post high resolution images and census data and the footprint of the fires this would be much easier. We often have to wait 3-4 days to know if your home burned or not.”

Wildfire personas

We grouped the leaders interviewed into three archetypes, though some work across multiple. Feedback from these personas will drive the development of the California Forest Observatory. The goal is to design a system that serves their needs via back-end APIs or front-end interfaces, for our team to define a user-centric, long-term product roadmap for our own work, and for this community as a whole.

Land managers, scientists & foresters

Forest ecologists, wildfire ecologists, meteorologists, climate scientists, remote sensing scientists, wildlife biologists, hydrologists, biodiversity specialists, foresters, fuels managers, land management decision makers

These individuals are responsible for measuring, monitoring & managing forested lands, often working to restore resilience to wildfire and climate change, and keep communities at the wildland interface safe from megafire.

Firestarters

Forest ecologists, wildfire and smoke experts, meteorologists, air quality & emissions mitigation agencies, NGO leaders, cultural ecologists

This group includes federal and state agency personnel working to update the state's prescribed burn planning, implementations and public communications systems.

Emergency services

Calfire intelligence and unit leaders, CA Operations of Emergency Services GIS and local teams, DOD/National Guard fire response support teams, hazard mitigation and evacuation planning specialists, emergency responders

These individuals anticipate and respond to wildfire-related emergency events: evacuation planning, emergency response, post-fire risk & recovery monitoring.

Current workflows

Land managers, scientists & foresters

1. It starts on the ground. Fuels specialists or foresters walk the land and use simple remote sensing datasets like Google Earth to better understand what areas might need treatment.

2. Using GPS mapping and available GIS datasets, estimate how they might divide up a potential treatment area by prescription type (e.g. mastication, mechanical thinning, prescribed burn) given the terrain, vegetation, and fuel characteristics.

3. Determine what the goals of each treatment area might be (e.g. minimizing the effect of wildland fire, improving forest resilience, increasing sensitive species habitat quality).

4. Decide what kind of data/tools they need in order to develop a comprehensive vegetation and fuels dataset by each treatment unit. Often, translates to the application of a quick and tailored plot protocol to treatment units. Plot data are often fed into software like the Forest Vegetation Simulator (FVS) to quantify current conditions in each forest unit and to simulate the effect of future potential treatments.

5. Effects analysis begins on the proposed treatment and alternative scenarios. Land managers will model, usually with FVS, vegetation and fuels changes from a treatment over time. It is intended to give decision makers an appropriate amount of information to select the proposed action or one of the alternatives. Modeling is needed to show trade offs over time, otherwise treatment impacts would almost always point the decision maker toward no action. For example, although a treatment will reduce canopy cover, which could negatively impact a threatened wildlife species, it will recover in 30 years to pretreatment conditions and will be resistant to the effects of high severity fire during that time period.

6. The project, with its incorporated effects analysis, is now shared with stakeholders and the general public. A public comment period ensues where

anybody can comment on the project. The land agency must respond to each comment.

7. A draft decision is submitted. However, stakeholders who made comments can still appeal a decision. Any appeal goes through a neutral, but internal review process before a final decision is made.

8. A final decision is reached after the conclusion of the appeal review process. Although it can still be challenged in court, without an injunction, contracts can be drafted and treatment preparations started.

9. Contract and field preparation begins. Treatment units are refined. Trees are hand marked based on the treatment prescription and a timber cruise (i.e., forest survey) is conducted on the marked vegetation. Only after a careful crosscheck between contract specifications and the environmental decision is a contract approved and put out to bid.

10. The contract is implemented with variable consistency in oversight and monitoring.

11. Monitoring can include: harvest inspectors, timber sale oversight, post harvest monitoring for water projects (local water board; state water board, etc).

Firestarters

1. Foresters/restoration planners translate burn site extents to GIS layers.

2. Fuel loads are assessed, and burn dynamics / smoke behavior are evaluated. Historical data is evaluated to understand legacy effects. Typically rely on plots, then conversations with local fuels experts. Ground fuels/dense fuels are of interest, as they're what drive emissions.

3. Fuel moistures evaluated, mostly through use of fuel sticks. Often inconsistent training for preparation and use—or no one to do it at all and they're guessing.

4. Elevation/topographic gradients evaluated to predict rapid air flow in areas with fast-burning fuels, which drives crown fires. Heavy logs on the ground can actually keep fires severity low as slow-burning fuels. Fuel-atmosphere interactions are critical but difficult to evaluate.

5. Emissions predictions calculated based on fuel loads and fire spread dynamics. Burn prescription priorities (reducing wildfire exposure) and emissions reduction priorities (reducing carbon emissions, smoke exposure) are often at-odds.

6. Write the burn plan, including objectives, landscape descriptions, desired fire behavior, expected weather conditions. Objectives include consumption of surface fuels, ladder fuels, ensuring an acceptable level of tree mortality, risk reduction. Many ways to craft objectives based on land conditions.

7. Apply for a burn permit. Some units say you only need a permit if burning in certain seasons. Permitting depends on where its performed:
    a. State responsibility areas - CALFIRE
    b. Local responsibility areas - local fire districts
    c. Federal responsibility areas - BLM, usfs.

8. Apply for an air quality permit, which is still done by hand in some areas. This is mostly to communicate predictions on potential smoke / atmospheric mixing.

9. Once the burn season starts in the fall, air districts set up the 1300 call. At 1 pm every day, National Weather Service forecasters talk about what to expect in the next 3-10 days, and burners report their plans & actions. Forecasters then provide feedback and make recommendations. Fuels management officers and burn bosses all participate.

10. 24 hours before planned ignition, PFIRS (ARB's prescribed fire information reporting system) makes the final approval.

Emergency services

1. A fire is detected.

2. Dispatch surveillance aircraft.

3. For every aircraft dispatched, create a map using SCOUT, a situational awareness tool developed by Cal OES, CALFIRE and Department of Homeland Security. This map includes information on recent vegetation management, census info & current fires.

4. Situational analysis performed to assist the duty chief in allocating resources. Analyses include what is threatened in the coming hours, what intel needs to be addressed in next hours and days.
5. If a fire grows to 30-50 acres, statewide resources are reallocated to prioritize the growing threat.
6. Incident awareness mimics military tactics: tasking and mission planning; rapid data collection, analysis and dissemination; rapid communications, including internal meetings and public briefings.
7. Data collection proceeds continuously on the ground, air & space (MQ9s C26s, helicopters, etc.)
8. Rapid iteration on analytics using GIS data using a suite of tools, including ArcGIS, Google Earth & ENVI. Results are shared and disseminated via the DOD's APAN, the biggest national data sharing and collaboration network.
9. The National Guard/DOD create fire maps. These are sent via FTP to CALFIRE and USFS. The watch desk staff at local fire stations often find, download and send data to SCOUT (for CALFIRE) and to the ENT geospatial platform (for USFS). Regular communications between CALFIRE and USFS.

Tools used

Land managers, scientists & foresters

Modeling software: vegetation

- Ecosystem Management Decision Support (EMDS): An ArcGIS extension, EMDS supports complex decision making when there are many variables and goals. Not suited for project level decision making because of its inherent complexity.
- Landscape Disturbance and Succession Models (LDSM): Good for landscape scale modeling efforts where vegetation succession/growth and disturbance is critical for understanding future or even past conditions. Is not designed for project level analysis due to the relatively simplistic succession and disturbance algorithms, but is spatially dependent. Examples: LANDIS/RMLands.
- Forest Vegetation Simulator (FVS): Based off growth and yield equations of the 1950's. Improved by FIA plot data. Is as robust as the data that feeds the model because it is spatially independent. The standard for modeling treatment effects at the project scale. Not built for landscape level analysis, but programs like F3/Fastmap apply FVS outputs across large areas.
- EnVision: visualize effects of different management treatments over time
- Forsys: simulation framework for comparing trade-offs of different treatment goals; currently requires treatment outcomes be pre-calculated.

Modeling software: wildfire

- FLAMMAP: a fire analysis Windows desktop application. It can simulate potential fire behavior characteristics (spread rate, flame length, fireline intensity, etc.), fire growth and spread, and conditional burn probabilities under constant environmental conditions (weather and fuel moisture).
- FSIM: Large fire simulator; a stochastic, monte carlo-based system that simulates the occurrence, growth, suppression and intensity of wildfires across a large landscape over thousands of simulated fire seasons. The wildfire occurrence sub-model of FSim is based on annual ignition likelihood, so FSim's results are on an annual basis.

- FLAMMAP and FSIM are not temporally dynamic. Need to recreate those results but in an environment that is faster, and more temporally dynamic.
- FARSIGHT: computes wildfire growth and behavior over time under heterogeneous conditions of terrain, fuels, fuel moistures and weather. Based on Rothermal spread equations that don't take atmospheric changes into account.
- Gridfire: raster-based fire spread and severity model that may be used for both static and dynamic calculations of various standard fire behavior metrics across a landscape. Optimized for computation speed and memory.
- ELMFIRE: an open source geospatial model intended for simulating wildland fire development using a more computationally efficient mathematical solver.
- BehavePlus: The system is composed of a collection of mathematical models that describe fire behavior and the fire environment. The program simulates rate of fire spread, spotting distance, scorch height, tree mortality, fuel moisture, wind adjustment factor, as well as other variables; so it is used to predict fire behavior in multiple situations. However it is spatially independent which requires the user to apply a spatial context.
- IFTDSS: The Interagency Fuels Treatment Decision Support System (IFTDSS) is a web-based application designed to make fuels treatment planning and analysis more efficient and effective. IFTDSS provides access to data and models through one simple user interface. Is limited by LANDFIRE inputs.
- WFDSS: Wildland Fire Decision Support System (WFDSS) integrates the various applications used to manage incidents into a single system, which streamlines the analysis and reporting processes. Requires inputs from skilled individuals and decision makers with fire knowledge, local knowledge, as well as WFDSS knowledge.
- Bluesky: modularly links a variety of independent models of fire information, fuel loading, fire consumption, fire emissions, and smoke dispersion. Critical for modeling smoke amounts and dispersion during a fire event. Isolated from other fire modeling exercises.

Data & data collection platforms

- LANDFIRE: Wall-to-wall coverage across the United States at 30 m resolution. Metrics include vegetation and fuels. Derived from Landsat and FIA plot data. Updates occur every 2 years and may require complex, customized update workflows. Widely used due to its comprehensive and consistent nature.
- ArcFuels: built to streamline the fuel management planning process, and provide tools for quantitative wildfire risk assessment in an ArcGIS

environment. ArcFuels is a toolbar implemented in ArcMap which creates a trans-scale (stand to large landscape) interface to apply pre-existing forest growth (e.g., Forest Vegetation Simulator) and fire behavior models (e.g., FlamMap) to aid in vegetation management, fuel treatment planning, wildfire behavior modeling, and wildfire risk assessments.

- ESRI - ArcGIS and Collector: The standard for most state and federal agencies for housing/using spatially explicit data. Collector provides the ability to collect in-field data and upload it to a collective system/other ARC GIS tools/datasets. Works when offline.
- Airborne Snow Observatory (ASO): airborne lidar platform used to collect data on the snow melt flowing out of major water basins in the western United States.
- Google Earth Engine: free web-based platform enabling researchers to access, process, and analyze large volumes of remote sensing data using Google's computational infrastructure.
- Cal Adapt: a web repository for tools, data, and resources to conduct research, develop adaptation plans and build applications around how climate change might affect California.
- National Ecological Observatory Network (NEON): a continental-scale data collection and observation program designed to collect long-term open access ecological data to better understand how U.S. ecosystems are changing. Includes multiple airborne remote sensing platforms.
- CalTrees database: Tracking all Calfire projects, such as acres treated by methods. Produces a report every year on status of forest resources each year.
- Multispectral sensor: passively capture reflected light from the Earth's surface (e.g., Landsat, Sentinel, Planet). Multispectral imaging measures light in a small number of spectral bands (typically 3 to 15).
- LIDAR: Active remote sensing technology that provides precise 3 dimensional data. However, compiling that data into information an end user can understand takes an exceptional amount of modeling and packaging. Traditionally, Lidar instrumentation is mounted on a fixed winged manned aircraft, but technology improvements have made it possible to make collections with unmanned aircraft in addition to satellite based scanning.
- Imaging Spectroscopy (IS) or Hyperspectral: Passive remote sensing technology that is the simultaneous acquisition of spatially coregistered images in many spectrally contiguous bands. Unlike multispectral sensors, IS measures many hundreds of spectral wavelengths. When simultaneous lidar and IS imaging is combined, an unparalleled vegetation dataset can be

created to determine numerous forest characteristics including individual species, vegetation stress, and above ground carbon.

- Acoustic listening devices: Used to identify owl habitat; can also identify other species.
- Rapid Assessment of Vegetation Condition after Wildfire (RAVG): USFS system to provide a rapid initial assessment of post-fire vegetation condition following large wildfires on National Forests.
- Weather Research and Forecasting (WRF) model: mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications.

Firestarters

- USFS Firelab tools
    - FireFamily+
    - BehavePlus
    - FARSITE
    - FlamMap
    - WindNinja
    - WindWizard
    - FireStem
    - FuelCalc
    - ArcFuels
    - Wildland Fire Assessment System
    - First Order Fire Effects Model (FOFEM)
    - Fire Weather Alert System (FWAS)
    - Fire Effects Monitoring and Inventory System (FIREMON)
- FSIM and FS Pro
- Hot, dry, windy index (HDWI)
- Topofire - contemporary fire danger based on 100 hour fuel moistures
- Cal EPA Smoke Sense
- PFIRS
- CONSUME - smoke predictions and modeling from USFS, National Fire Lab and Joint Fire Sciences Program
- Bluesky - a USFS fire modeling framework
- Sparkfire
- Pyrologix - independent analysts retained by USFS to run risk maps statewide
- WIFIRE - web-based hazard and risk mapping from FARSITE
- Coupled Atmosphere-Wildland Fire Environment (CAWFE)
- ArcGIS, ArcCollector, ArcGIS Online

- Google Earth - global, high resolution satellite maps and location info

Emergency services

- Wildland Fire Decision Support System (WFDSS).
  - System for documenting a fire after ignition
  - Input a series of data layers to make decisions around suppression activities; calculate costs based on decision.
  - Documents decisions. It's an antiquated system. Have to manually input forest standards and guidelines, manually input data, etc.
  - Provides fire weather forecasts
  - Without fire suppression efforts tracked, have to manipulate fuel composition data. Hard to track fuel dryness, compaction
  - Lacks support for the first engine doing size up (e.g. info on grass transitioning to timber, immediate home threat, need X helicopters)
- WIFIRE - live fire spread simulation modeling
- SCOUT - situational awareness collaboration tool
- WINDY, NOAA, National Weather Service - for weather forecasts
- Fire management assistance grants (FMAG)
- Android Team Awareness Kit (ATAK) - mobile-based real time situation awareness application
- ENVI - desktop geospatial analysis software
- ICS209 form - labor intensive form to fill out, describing what infrastructure is threatened, what the fire will do in the next 12, 24, 36, 48, 72 hrs; placeholder for weather, damaged/destroyed infra. Extremely antiquated
- IRWIN Wildland Fire Data - a national geospatial data portal with information on daily weather, infrastructure, fire behavior. Provides "end-to-end" reporting capabilities. Hosted on geoplatform.gov
- DART - unclear, appears to be a data sharing platform

Core needs

Land managers, scientists & foresters

- A common operating picture built for everyone, not just experts, to enable community and regional collaboratives to understand and weigh tradeoffs; not owned or operated by a government agency.
- A decision making SimCity-like tool for local land use decision makers that provides full context for weighing tradeoffs between impacts vs benefits of land use decisions. People need full context, presented simply.
- Provide a flexible tool to rapidly characterize key tradeoffs. Feature only a few key ones: fire risk characterization, cost of treatments, spotted owl habitat. Help characterize risk under current conditions, feed risk maps into fire response scenarios, and overlay treatment scenarios with more or less prescribed fire. Support for difficult tradeoffs like vulnerable communities vs carbon storage. Need clearer objectives we're wanting to meet and data-driven factors to weigh, including powerful visualizations.
- User interface to aid in decision making. Needs to include a library of possible decisions, and must include all processes from the inception of an idea to the application of an idea.
- Ability to update risk maps, prioritization maps, and where we'll get the most impact from treatments. From simulating fire scenarios to maximizing ecological function to weighing treatment tradeoffs. This could change the trajectory of planning on landscapes.
- Make it really easy for people to visualize the areas they care about, like their home, schools, county, recreation sites (e.g., Yosemite).
- Ability to toggle map layers like fire risk, forest health, timber volume, among others. Include user-defined polygons functionality to evaluate potential projects and calculate impacts to nearby watersheds and communities.
- We often talk about wanting the public to understand what a forest will look like 5-10 years after a treatment. We need powerful visualization tools to

simulate what a healthy conifer forest looks like to show diverse patch size with varying ages and habitat types. Importantly show what happens when wildfire hits, how it behaves very differently across these landscapes.

- Ability to do landscape scale planning that scales down to the local level, always with best possible science behind recommendations but ability to reflect local community values. For example, one community might only care about reducing fire risk while another wants ecological restoration and another wants to protect owl habitat.
- Help people come together around a short list of shared values - agencies and the public aren't as far off from each other as they think.
- Operating at the community level builds trust/social license, understanding and engagement with environmental orgs and local communities.
- A tree level view of forest structure, fuel loads, and species to plan forest unit restoration treatments, weigh trade offs, and quantify biomass supply.
- Landscape view for forest health, carbon, water connections, that scales down to forest unit level.
- Science and land management work are not integrated. Incorporate science into land management recommendations and decision making, but needs to be done without slowing down restoration progress.
- Hazard maps with ownership of each land parcel shown along with existing or previous fuels treatments. Allow users to calculate biomass quantification, identify endangered species or cultural sites, social status of residents (e.g., tribal, disadvantaged), and what agencies or organizations are involved in land management for a parcel.
- Videos for non-tech savvy stakeholders or interactive tools that visually walks people through a project plan.
- A tool that we can use across multiple agencies to manage natural resources, and measure ecosystem services benefits.
- A platform that has the flexibility to shift focus (swap in different data, models, decision tools as needed or mandated), and helps integrate or guide what to apply to a specific problem.

- Linking databases across multiple relevant state and federal agencies; correlating spatial info; tracking work done by each partner and data collectively.

- A system we can query with inputs like:
    - Given ecosystem conditions today (e.g., trees by species and size class) what will forest look like 30 years from now if we applied specific types of management to it (e.g., prescribed fire every 5 years, mech thinning every 10 years). Public will get a lot more out of spatial/visual vs numbers.
    - Ability to program in sequence of drought patterns/wildfire that might naturally occur.
    - Focus special attention on fire and ecosystem growth dynamics - from individual trees to whole systems. This is where the new frontier lies as a result of climate change.
    - Should be able to spatially optimize the location and type of treatments. Millions are being spent on treatments, but little to no monitoring or spatial optimization is performed. Monitoring can lead to correcting mistakes that were made.

- NEPA/CEQA planning and documentation support
    - Planning always gets ignored but if you don't have a clean NEPA on the shelf, no implementation will get done. We've got to enable action.
    - You can't get a NEPA document done for under $1 million in under 2 years—it often takes as long as 5-7 years. Hugely complex. Help speed NEPA process to get this stuff done on the ground.
    - Laws that apply are Endangered Species Act, Clean Water Act, Cultural Heritage.
    - Help 500 pg docs boil down to simple, clear visuals and data points. Show people simulations of different alternatives and trade offs to facilitate thinking about water and forest growth at every stage.
    - Ability to streamline mapping/documentation for NEPA/CEQA to move quickly on forest health.

- Biomass supply quantification:
    - A useful estimate of availability and accessibility of timber
    - On the ground verification; real-world input on landscape characteristics to make sure models don't generalize outcomes/supply.

USFS must quantify supply to reduce fears that we'll take more than the system can produce/function without.
    - Biomass use for energy production needs to be fully quantified and recognized for the fossil fuels it displaces.
    - There are multiple aspects of benefits of healthy forests, clean air, water, that haven't been valued. These include the value of upper watersheds where drinking water originates.
    - Ideas to assign value to these watersheds: A fee at the tap for end users to pay for restoration that protects these forested areas and ensures water supply. Legislation designating forested watersheds as infrastructure would open the door for infrastructure as forests and investment. Providing advances for people who have received cap and trade funded grants for forest health projects.
    - Better quantification of costs from all aspects of projects.
    - Save money/increase speed and efficiency of project planning, implementation, and monitoring post-project.
    - Eliminate some of the time spent surveying and entering things into a database.

- Monitoring and progress tracking:
    - A dashboard that rounds up all the key indicators of forest health into an at-a-glance view of how we're doing (watershed improvements, biodiversity, invasive weeds, etc). Note: desired by U.S. Secretary of the Interior.
    - Project verification that treatment prescriptions are done right and by a trusted entity - is a huge need and huge project cost.
    - Long term monitoring: Did the treatment improve desired outcomes? Are forests more resilient to climate change and megafire?

- Science support:
    - General:
        - We want to interact with the data: ability to select what I need spatially and temporally and schedule delivery through an API
        - Connecting dynamic data to dynamic analytics
        - We have enough science, it's just not put together in the right way. We need to be able to do this for foresters, ranchers, farmers—these are my customers.

        - Demonstrate the economic viability of applications. How can we either put valuation on ecosystem services or other outputs/benefits from the system that have price tags like water, recreation, carbon, and timber.
        - Outputs have to be simple, graphical, and spatially explicit.
        - Have all spatial data layers in one place, collated, available, synthesized, cross checked with each other. Just that alone would be hugely valuable.
        - Empower regional groups that do planning and prioritization with science-based support.
        - Define resilience and how we measure it: reduce fire risk, risk of mortality, wildlife habitat preservation, improve carbon storage, water supply. How do you weigh each one in any given area? What are the returns/ROI we can expect from a healthier system?
        - Having data layers and metadata that are clear and updated frequently.
        - Standard, well-vetted algorithms so we all know a glitch hasn't been introduced.
        - Land managers are lost on how to adapt their land management plans with climate change. ARB's projections don't have climate in them.
        - Open architecture, allowing researchers to continuously add and improve it over time. Make the Observatory a nexus for research.
        - Make the Observatory 2-way by allowing users to contribute. For example, AV data collection, fuel moisture field validations, other relevant data.
        - I want products I can trust; providing uncertainties hugely useful.
        - Calculating avoided cost of wildfire.

    - Vegetation:
        - A forest loss map/change map critical. Or a disturbance layer.
        - 6 layers - veg cover, veg height, stem density, canopy bulk density, base height, basal area
        - Dynamic veg layers - a modern LANDFIRE
        - Need day-to-day tree maps
        - Forest ecologists need catchment scale ~30 sqkm
        - Post fire burn indexes
        - Species maps

        - Tree mortality: spatially aligned with ground truth data
        - Need views of regrowth and regeneration - a piece missing from a lot of this
        - Veg change: need data and maps to allow for science on why it's changing
        - We need to create a systems view for the potential of forests to flip to an alternate state like grass or shrub lands. This will allow examination of patterns of drivers behind forest conversion. If I can tell people that a forest is approaching a tipping point, I can motivate them to do something now.
        - Resilience of a landscape; spatial and temporal predictions on where it's headed.
        - Veg moisture: thermal IR approach to look at dead and down fuel moisture

    - Carbon:
        - Carbon stocks and fire risk being done but the observatory mapping tree species out would be incredibly useful.
        - We have to create a standard way to account for carbon - makes it almost impossible in the policy arena to consistently and confidently make the case for forests and carbon.
        - Small landowners: to get an offset, have to be approved by carbon protocol. Should be as easy as "Press this button if you want simulations that show protocol/guidelines and resulting credits." Show me how much carbon I save? Help all land owners quantify. Prepackaged outputs of CO_2, water, recreational value.
        - Our context has so often been about carbon markets, that we could do with one level less. Is there a positive directional change from treatments, such as better water or more resilient forests. Cross checking at ground-level with remote sensing would be hugely helpful.

    - Meteorological and climate:
        - Real-time wind maps
        - One of the biggest uncertainties is climate data.
        - two key components: 1) computational weather prediction models - how wind velocity, pressure, temp water vapor, clouds change with time; need to be connected to fire models. 2)

infrared imagery recording active fires and analyzing how they change. Can infer velocities to look at phenomena in the fires and how fires spread.
        - Fuels moisture: info on the load, physical characteristics, composition of the fuels. Draw from weather stations that still have 10 hour humidity sticks.
    - Hydrology:
        - Surface geology and soil depth - key for hydrology
        - Hydrograph changes - canopy density and structure will be very useful to understand what upland conditions contribute to meadow health
    - Wildfire:
        - Built in a way that's easy/intuitive/don't need a PhD to run it
        - Fuel conditioning info: relative humidity, how long been around, surface fuel build up, evapotranspiration values
    - Scientist suggestions:
        - Link NAIP and LIDAR and then use Sentinel and Planet to get temporal resolution. That could get us to 1 meter resolution then get satellite data to see what changed
        - Could we have an iphone/tablet based ability to take pictures and characterize fuels. Take a pic of the canopy from below. Direct feed into the Observatory and continuously learn from field data
        - You have ecologists on our team - huge advantage because you're not just data geeks. Use ecology to blow people's socks off - knowledge Salo has on ecology is a differentiator.
        - Better data on ground fuels - remote sensed data not trusted
- Policy
    - To make land based climate solutions a core part of the state's carbon accounting and solution set alongside buildings, transportation, etc.
    - Need improved carbon quantification/methodologies, because money for forest restoration is tied to carbon benefits. Carbon emissions accounting for prescribed burns vs wildfire are inaccurate and arduous/slow to calculate

    - Impact on water policy is so much less tangible. For example, how will changes to mountain snowpack impacts agricultural systems? How will institutions deal with the fact that upstream water sources are changing? Looking at basins that are more or less sensitive. Discussing who we're targeting: Is it policy makers? Western regional governors?

- Powerful communications that represents why we all live here:
    - The natural, iconic landscapes of the state
    - How we see ourselves as Californians and what's at stake
    - Help people get it and take personal accountability
    - Move people to invest, act

Firestarters - core needs

- We need air districts to "get it" - to allow more managed wildfire on the land

- Better fuels data to better predict fire movement and emissions to get more "yes" days.
    - SparkFire and BlueSky provide satellite views of smoke - feeding them better fuels would help.

- Fuels moisture - make the spreadsheet spatial and devise a better way to have real time moisture data in the field

- Better data and visibility on the relationship between soil moisture and fuels moisture, and how they relate to spread dynamics

- Improved data to inform air quality management. Air quality regulations set up to avoid pollution, but burn effects often get lumped in with bad air days. Reporting based on PM 2.5 effects and smoke. Districts provide permits based on that. Perhaps moving to tons burned/acre to disentangle the two.

- Visibility into how the landscape changes after a fire - CO_2 release return. The current system is too slow, too coarse to capture cycling.

- Make PFIRS spatial and automated

- A prescribed burn planning platform that is more automated and connected to real time conditions

    - With input from practitioners highly reliant on boots-on-the-ground assessments that they trust
    - Otherwise, it turns into another *thing* people have to figure out
    - The biggest issues with the new Rx burn public application was there wasn't the bandwidth to involve air districts.
    - Everything has to be rolled out with local buy-in and ownership

- More tools that are easy to pick up and easy to understand

- Better visualization tools. Whoever has clear visuals wins public support

- There are a lot of paper maps of risk assessments. Opportunity to digitize and consolidate. Much of the paper data is "lost" - the California PUC doesn't know where 20% of power lines are. For the other 80%, coordinates are 200 yards off

- A statewide map, broken down by regional, local jurisdiction that displays when burn windows will open and close, tied to weather/circulation systems

- Increasing the burn season to other parts of the year (e.g. March - Nov)

- We need the data/predictions to build confidence for burners to burn more safely and for regulators to have more confidence to allow more burning. Hope to increase to 2 million acres/yr. Opportunity to re-scope the allowable PPM count to line up with how much we need to burn

- Marry air quality, safety, proactive work. Then relay info to the public. Modeled smoke vs actual. Airborne systems used to measure hazardous air quality - this is expensive and limited in scope. Need a synoptic view

- Monitoring whether prescribed burns are having a positive impact on wildfire hazard and ecosystem health will be crucial - this is often not quantified

- The fire restoration group's mission is to reduce barriers to burning, and do so in the most humane and protective way. Understanding, technology & communications are all used to do this, but we need a whole fire restoration brigade to do this at scale; not just reliance on suppression teams

- We need to change perception. The way we communicate about prescribed burns today makes them out to be bad - they're treated like emergency alerts

Emergency services - core needs

- Real-time data
- Rapid modeling under changing and unique scenarios. The fires today are showing us things we've never seen before
- Fewer, centralized sources of relevant usable data. Without this, interagency efforts are difficult to coordinate
- Need integration of centralized data with well-known models to provide consistent, interpretable feeds to CALFIRE and USFS response efforts
- Higher resolution. If you don't know the impact or what's been damaged, you can't plan. We have to take this seriously to make better, faster decisions
- We need 72 hour pre assessments of where it's dry and where risk lies
- Think of middleware for earthquakes, but for wildfire
- We need data on where the fuels are before a fire and, after a fire went through, including soil analysis, to calculate destruction
- Better imagery for damage inventory.
  - There are tight timelines for products to help state and federal efforts after disaster announcements.
  - FMAG form (fire assistance management) has to be signed so that people who lost homes get quicker turn-around on damaged/destroyed homes and get restitution faster
  - We need AI to count the structures damaged. Otherwise it's a drive by survey.
- Veg moisture - currently recorded in an analog system, then uploaded to the national fuel moisture data set. It's so antiquated it's become a massive issue. Just accessing it hard, let alone looking at a specific site. Need a better way to know fuel compaction, dryness & greenup much faster than we can
- We need better mechanism for knowledge sharing. Everyone wants the latest from the Missoula Fire Lab, and to know how to use these programs

- Ability to run fire behavior models based on what's ahead of the fire - buildings, trees, brush
- Monitoring fire retardant drops. When aircrafts drop retardant, the location of the drop isn't recorded. Knowing these locations would supplement situational awareness regarding where to increase or withdraw resources
- Aircraft pilots need better ground visibility. They're overwhelmed with so much input from helicopters, air traffic control, etc. They need a screen to show the state of fire operations and fire movement on the ground.
- Weather stations should be NRDS compliant - operating so the data can be pulled and analyzed into indices for dispatch and seasonal augmentation.
- Mesh network integrations to pull real time ground conditions
- Presilience - improved risk mapping and resource prioritization for mitigation before an emergency. Engaging communities in risk mitigation, including shared visual understanding and simulations of risk in different circumstances for evacuation planning
- Better intel on fuel loads and weather would allow confidence to let fires burn when conditions right - lead to policy change on suppression
- Need more civilians in chat instead of on email so communication is real time

Pain points

Land managers, scientists & foresters

- Social challenges:
    - Attention and resources are focused on disasters, not long-term resilience.
    - We don't have high resolution visualizations of what we're currently dealing with. If we can't see it we can't manage it.
    - Defining resilience: what is doable conflicts with that is idealized. A good portion of our 40 million population have asthma. Spanish explorers in Southern California made reference to the basin being full of smoke. Need to get our heads around the complexity of the problem and achievable conditions.
    - Different ownerships across CA. Sporadic timber production on Federal land, half the forests are privately owned. Commercial timberlands have more small trees, so what are resilient conditions on those lands?
    - No one knows what ecologists do. Trying to get OPM to rewrite the definition.
    - Naysayers: "I haven't seen the model but it won't work in our region" is something often heard. Conspiracy by the fuels people - all said the same thing.
    - Part of it is ignorance, fear of new, fear of tech, low budgets
    - If the Observatory team gets acquired/goes out of business, how will the effort continue?
    - Historically fire modeling has been done simply by practitioners in the field. Weather forecasts done with supercomputers in the east then distributed. Wildfire people work differently - simple, in the field. Cultural difference.

- Cognitive biases - we don't know what we don't know.
- Wildfire predictions are not necessarily a technical problem - a lot of political and cultural issues to changing tech used in agencies. They have their own models and would lose $millions in research if it were done from an atmospheric perspective. There is tension between the weather agencies vs the USDA who is focused on land.
- We may need to work toward conditions like Europe who has far more managed forests. How do we deal with the shock of how many trees (¾) need to be removed to create fire resilient forests?

- Time and resources:
  - Some of our National Forests are on dial up internet connections.
  - Our highest priority is to shorten the planning timeline. How do we get projects done in 3-5 years not 8-15 years?
  - There are so many expectations on us (USFS) right now with fewer and fewer resources. We need less time and money spent on monitoring owls, planning, and entering things into databases.
  - We don't have the resources (people, servers, skills, funding) to work with the data that's available today
  - Lack of qualified foresters, timber sale admins, timber contractors, timber/biomass processing infrastructure
  - Inconsistent skills, resources, and process in different areas of a forest, yet we're trying to do landscape scale management. Might have a district that has a veg management officer who is really clued in to lidar, modeling techniques for fire runs, etc; another district has none of this. No consistent process.
  - Small land owners can't afford the staff of scientists and contractors large commercial timber operators hire. Private companies lure talent away from USFS with higher salaries.
- The rate of change:
  - Restoration project plans are outdated by the time we start.

- Because of suppression, heterogeneous landscapes are mostly homogenized. South slopes already converted to oak woodland, north and top slopes used to less dense, and conifers have choked out oak. This all impacts wildlife and water. With less water available, less healthy forests that are more susceptible to disease and drought stress, which increases fire risk. Wildfires can then convert these forests to shrubland and grasslands. Need to help people see and understand the change and plan for it.
- With more people in the WUI, we're exposing firefighters' lives. When we have a disaster like a hurricane, we move away from the disaster, but with fire we put people directly at risk. How can we make them safer?
- We don't know rate of climate change/impacts, or what areas will be impacted how

- Data challenges:
    - How do we get usable, reliable data that will help inform the next 20 years of what the landscape looks like to inform our highest priorities?
    - We don't have long term historic temporal records - Landsat provides some data since 1984 but it is usually crude.
    - Keeping up with the rate of change of precipitation and other climate change factors, and updating restoration plans as new data comes in is challenging. There is no agility in the system.
    - Data inventory lags (Calfire data from 2007, Landfire, etc). Real-time data are crucial now and agencies don't have it.
    - Lack of data/info to support efforts/see tradeoffs when considering land management decisions (wildlife habitat, etc)
    - Data validation - ensuring what the fuels data says meets reality on the ground.
    - Don't trust data available on ground fuels from remote sensing. Current tech is missing 75-80% of what drives fire behavior. Leary that we can crosswalk aerial lidar to what we can see on the ground. Would need a

ton of drones to do this. Terrestrial lidar is great but limited in scope and expensive to analyze.

- Current approach to assess fuels on transects is painfully manual, slow and expensive
- When fire breaks out, we go to the local fuels person. Little trust in Landfire for this - huge data gaps, so we have to go outside to get the right data sets.
- If you've spent millions to evaluate your property, sharing your data is not desirable
- We're siloed in our data collection. We generally have standard procedures but they are sporadically implemented. Each effort has a database they feed input into (fuels, hydration, cultural sites, habitat, carbon, etc).
- Cultural site surveys for NEPA are crucial and very expensive - half our funding for NEPA goes to cultural surveying. Where we can do lidar, we do it - it's the most efficient way to survey.
- As an association, we don't have the resources to host everyone's data (and potential for privacy violations/antitrust issues); each commercial timber operator has their own way of collecting data, modeling risk, quantifying standing inventory.
- During an actual wildfire, we'll use whatever data is available and throw out the caveats because of gross inaccuracies. For example, we know this model is overpredicting because we know this burned last year or it's underpredicting because it's over fueled and dry.
- Estimating soil moisture: we don't know how much snow we have in the mountains or observations of how much snow falls at high elevations.
- We need better data when we're making localized decisions. More data doesn't help, instead we need better distillation methods to create conversational analytics.
- We know absolutely nothing about the forest floor/soils of mountain systems from a hydrologic perspective: how they hold water, how deep

they go. Hydrological models rely on soil maps along with some assumptions. Models often get calibrated again to make them behave. Data sources are limited and usually constructed for other purposes.

    - We do not know how much precipitation actually falls, especially in the mountains.

- Tools/models/tech challenges:
    - A lot of these tools don't get used because they're too complicated and that acts as a barrier to entry. It's why teams keep using old software; they are familiar with these systems.
    - Methods for GHG emissions reduction are continuously refined as part of cap and trade $$ from ARB. Required to account for every dollar spent and for each GHG reduction for each project, which becomes really hard. mitigating a future potential wildfire that may or may not occur Calfire has methods they like and are currently convincing ARB to accept those.
    - CARB can ingest data but they want to own what gets built.
    - Incredible how much time we spend on identifying data sets and getting them into the right format for our use. Getting the spatial data sets to do the science you need to do is crucial. Lots of conversations about the fact that we should have just a couple of sources of data.
    - We know what we want and need but don't have the modeling horsepower
    - Access to supercomputer resources is where the bridge isn't built.
    - Have something like Google Earth Engine that' amazing— using a supercomputer from a web browser. Querying enormous amounts of data. But, from a coding perspective, it's extremely limiting what you can actually do. If you're working in R and Python on your own computer, amazing what you can do. But can't put terabytes of data on your computer. You want to be able to query data any way you want but ability to do it like you would in Earth Engine.

- Scenario planning should generate action plans that are at the stand level. Region 5 has good data that should feed into this.
- Restrictions on what you can do - biophysical data; planning and administrative scenario planning.
- Agencies worry about liability of using data or tools from other agencies so they often just don't use them at all.
- Research to date has shown that if we can model fine scale winds, we can simulate quite well the evolution of that fire for the next day or two. Not easy but within our technical grasp to predict where a fire could go in the next couple of days.
- A lot of potential here if everything is available to see hazards.
- Terribly designed tools (e.g. FACTS database)
- We often try to build tools then have to have contractors redo them (IFTDSS a cost center)
- Accuracy of locating owls is only 7%. Can we just drop the two years of surveying? We know what good habitat looks like, let's just use data to manage to that condition.
- If I could just understand tree structure/size - that will predict owl habitat. Where on average there are too many small trees? Where are the largest trees.
- Our estimates on supply change and are way off - sometimes by 200%. Species have different markets.
- Industry - we need someone to do the work on our land. We have to quantify merchantable timber: how much in what sizes makes a big difference on whether we're paying them to remove it or they are paying us to buy it.
- Quantifications of biomass are manual, people in the field will estimate one plot, then they'll extrapolate out over the landscape They then mark trees with paint. Spending $500k this summer on this.

    - Since our forest invested in LiDAR acquisition, some of our specialists have embraced it but no one else uses it because they don't know how. Make the product stupid simple to use.
    - We're missing the tools to make progress on climate solutions.
    - State of CA doesn't like us to use outside platforms. For example, if we build on Google Earth Engine, they can't buy-in an enterprise solution.
    - Landfire. If there is only one data set of it's kind like this, they'll do their best to quantify uncertainty. They built a tool on Landfire, then landfire changed and made their model useless. This is why they don't like to rely on outside resources.
    - The Observatory's edge is flexibility. Landfire, because it is standardized, can't adapt to be flexible. The Observatory could include a standard layer but could have test data/research collections from someone's area they mapped.
- Economic challenges:
    - We're raising the bar on planning by bringing in economics. We have a lot of timber sales going out but no one buys them.
    - We simulated every tree - species, diameter, and cost to the mill. Realized, we had to figure out the economics of a whole area.
    - Nationally, we have timber targets mandated which is often at odds with our definition of resilience.
    - Computational power big issue. We've outgrown what we have - need to move to the cloud for real time processing.
    - Cost of making an error is extraordinarily high
- Political/public education challenges:
    - Every regime change slows progress tremendously - starting over each time; education, reprioritization - shared data platforms might help build institutional knowledge and capability
    - Managing across cross jurisdictional land ownership is really complex

- In the USFS, the biggest hurdle is internal - how employees fit in. If my program area isn't listed as a top priority, what role do I play?
- Getting scientific and land management teams together to work on balance of targets and restoration work
- Social license to do what needs to get done; building public trust
- Fighting people who are fighting us; unknowledgeable stakeholders
- How public wildfire education happens today: a public relations person. Is this sustainable?
- Even if we get everyone on-board with restoration, how do we pay for it? If through timber sales: how much material, of what type, and how do we pay to extract and transport it? And when we do that work, are we making a meaningful difference in fire risk? Will climate change flatten landscapes no matter what? Or do we have to cut so deeply to avoid negative consequences that it becomes something we don't want?
- With today's fire severity, we need to pool sociological resilience with ecosystem services to assess risk/damage. But it's hard to integrate all these complex components.

Firestarters - pain points

- Institutional silos
- How to scale the knowledge, skills, solutions, and public understanding of fire fast enough.
- Lidar-based fuels are of limited value for emissions tracking. Canopy fuels may improve wildfire behavior models, but surface fuels drive emissions.
- For managed wildfire, there are political and social factors at play, mostly around resource allocations. A local team might say "let it burn" but if there are 3 other large fires concurrently it's not perceived as a good time to let it burn.

- The tourism and recreation communities are some of the biggest challenges in deploying prescribed burns - need to talk to them more specifically.

Emergency services - pain points

- The Wildland Fire Assessment System desperately needs an update
- Few systems are sharable; most are internally firewalled
- Collaboration means in-person meetings at the moment - not via technology
- The California team at USFS is trying to get ahead of national USFS to keep up with DOD and CALFIRE. Fears that either everyone will get ahead of us or we'll all be left behind and create our own side systems
- As new technologies and processes come online, aligning everyone to use them is challenging. People are locked into how they already do things. It's an uphill battle if changing means increasing budgets. Agencies get excited about interoperability, but it's hard to get them to sink their teeth in, pay for costs & allocate people to make it happen.
- Cal OES is perceived as a big roadblock. They facilitate information flows to the county level and to those who need it. They need a leader or a concerted focus on thinking about remote sensing, data gathering and rapid dissemination

Imagined Observatory use-cases

Land managers, scientists & foresters

- A shared view of wildfire hazard that provides neighborhood and forest unit level resolution but is accurate across regional and state scales.
- Work with the Forest Management Task Force to develop a map of different landscapes/regions with similar ecological qualities, plus recommended actions.
- A platform/toolset that provides the ability to visualize various treatment scenarios and weigh inputs and outcomes.
- Powerful, high resolution visualization tools to drive alignment across agencies and diverse stakeholder groups on forest management plans.
- Efficient restoration project planning, cost analysis, NEPA/CEQA documentation, combined with more efficient project execution (GIS-driven)
- Visualizations simplified for public consumption to drive understanding of forest value, health, risk, and to build public support for treatments
- At-a-glance dashboard with current tracking of restoration projects, progress, benefits, and disturbance impacts
- Biomass quantification by species at the tree level, with standardized carbon accounting
- Verification for carbon sequestration and emissions, and monitoring of water resources
- Monitoring forest restoration impact on carbon storage, water quantity and quality, biodiversity
- Climate and conservation decision support.

Firestarters

- Accurate view of hazard that scales to neighborhood/forest unit level and up to regional and state level
- APIs to access best-in-class fuels, meteorological, and other data layers
- Possible integrations with Blue Sky and Sparkfire
- Improved forest carbon stocks & emissions mapping - including standardized carbon accounting & forecasting for wildfires and prescribed burns
- Monitoring prescribed burn progress, smoke movement and post-burn forest regeneration
- Quantify forest treatment effects. We're removing *X* tree volume; how much did we reduce risk?
- Real-time predictive modeling for smoke emissions and movement to increase "go" confidence
- Leapfrog current bureaucratic hurdles, like the NEPA process.
    - In planning thinning and prescribed burns over a large area, NEPA reporting becomes burdensome due to the detail required. T
    - his hampered prescribed burn and mechanical thinning plans over 300k acres in the Klamath, where they had to do a full NEPA evaluation before even knowing where they *could* burn. Then they still have to submit a rigorous burn plan after that.
    - Identifying priority treatment areas to limit the extent of where NEPA and burn plans might be required would streamline the process

Emergency services

- Better intel on fuel loads and weather would increase confidence to let fires burn when conditions right, and possibly lead to policy change on suppression
- Monitoring of infrastructure damage & inventory for community re-entry, recovery and FEMA/insurance funding
- High resolution hazard/risk mapping that intersects with:

- Wind and firenado/fire weather data
- Traffic data
- Fire hydrants
- Power access & status
- Water

Technical recommendations

Land managers, scientists & foresters

- Ensure forest structure, fuel loads, and hazard mapping is accurate and resolved at the tree-level, house, and forest unit all the way up to the regional or state level to drive comprehensive hazard mitigation/forest restoration prioritization and emergency response efforts.
- Large organizations like CALFIRE or the USFS have lots of technical expertise. Small landowners need to keep up with their management and planning activities, but they have fewer tools and less expertise. Supporting small landowners will help increase the number of treatments outside state and federal lands.
- The need for the same view of forests at all scales is crucial so managers and decision makers alike are utilizing the same data sources to inform action and see cumulative effects of disturbance.
- Aggregate and deliver the full list provided for intakes. Have all spatial data layers in one place, collated, available, synthesized, cross checked with each other; Harmonized, coherent data, normalized; formatted to readily be ingested by modeling software.
- Find a way to incorporate historic Landsat and other data to make the Observatory the key resource for long term temporal records over time.
- Build a carbon stock model that includes veg type, age, disturbance history to produce a set of carbon maps for live, dead, below ground pools with the CBM model. Can then model treatments that optimize for carbon storage with predictions of how each plays out over 50 years.
- Leverage the state's new electronic Timber Harvest Plan tool, which will host an array of useful public databases.
- Produce a stable time series of habitat suitability

- Need immediate improvements to surface fuel data
- Need immediate ability to map dominant species and/or tree lists
- Need real time weather and fuel information across topographically distinct landscapes.
- Bioclimatic envelope mapping and future modeling based on climate change scenarios - this will ultimately show what kind of vegetation and their densities can be supported on the landscape at a given point in time.
- Create a UI that can package and deliver this (or a subset of this) complex information to a wide audience.
- Tech improvements can help but can only get you so far. Knowing and trusting people, and strengthening the social contract, is the biggest hurdle.

Firestarters

- Crack surface fuels mapping, including how to distinguish between fast- and slow- burn/high emissions fuels
- Crack soil and fuels moisture data, and model relationship to emissions & fire behavior
- Make meteorological and climate data spatial and accessible
- In addition to hazard modeling, focus on forecasts that build confidence in when and where prescribed burns can be deployed

Emergency services

- Establish credibility with each organization. If you don't have a champion within each system to open up to other agencies and get them interested in sharing their data, you won't get anywhere
- Create MOUs with each agency, then let the software open up paths for integration and collaboration

- Build a clearing house of relevant data. If I wanted all the power infrastructure data, I would pull that out; the number of the people in the wake of destruction, pull that out; all homes damaged or destroyed, pull that out
- In a data chart, name the groups developing each piece. There isn't one authoritative source for many components. We might get population data from the census, but as people move during and after disaster we need alternative sources
- Build a system that subject matter experts can rely on, but is still accessible to a less tech-savvy audience. Let good visualization lead the way

Appendix 1: participants

Land managers, scientists & foresters

Adam Cummings, ORISE Fellow, Conservation of Biodiversity, Pacific SW Research Station, USFS (Meadow and illegal cannabis grow expert)

Adam Moreno, Air Pollution Specialist, California Air Resources Board

Adrian Harpold, Assistant Professor, UNR Department of Natural Resources and Environmental Science

Alan Ager, Research Forester, USDA-Forest Service

Ashley Conrad-Saydah, Former Deputy Secretary for Climate Policy, CA Environmental Protection Agency

Benjamin Sleeter, Research Geographer, U.S. Geological Survey

Brittany Dyer, California State Director, American Forests

Carlos Ramirez, Remote Sensing Project Leader, USDA-Forest Service, Region 5

Chris Keithly, Ph.D., Program Manager, CALFIRE

Dave Mercer, Cross Check Services (Timber harvester)

Dave Sapsis, Research Program Specialist (Fire Modeling and Behavior), CALFIRE

David Bunn, Director, California Department of Conservation

David Saah, Ph.D, Founding Principal and Managing Partner, Spatial Informatics Group

Debbie Franco, Senior Advisor, Water and Rural Affairs, Governor's Office of Planning and Research

Eli Ilano, Forest Supervisor, USDA-Forest Service Tahoe

Forest Schafer, Forest Science and Management Coordinator, California Tahoe Conservancy

George Gentry, Senior Vice President, California Forestry Association

Harold Mooney, Professor of Environmental Biology, Stanford University

Helge Eng, Deputy Director, Resource Management, CALFIRE

Hugh Safford, Ph.D., Regional Ecologist, USDA-Forest Service Pacific Southwest Region

Isabel Baer, Environmental Program Manager, CA Wildlife Timberland Conservation Program

Jad Daley, President, American Forests

James Strittholt, P.h.D, Executive Director, Conservation Biology Institute

Janice Coen, National Center for Atmospheric Research, Project Scientist at Mesoscale & Microscale Meteorology Lab

Jeff Brown, Reserve Manager, Sagehen Creek Field Station

Jeff Marsolais, Forest Supervisor, USDA-Forest Service Lake Tahoe Basin

Jenn Phillips, Senior Scientist, Governor's Office of Planning and Research

Jennifer Montgomery, Director, CA Forest Management Task Force

John Exline, Director for Ecosystem Management, USDA-Forest Service's Pacific Southwest Region

John Battles, Professor of Forest Ecology, UC Berkeley Battles Lab, Forest Management Task Force Science CoLead

John Chase, Natural Resource and GIS/Remote Sensing Specialist, USDA-Forest Service

Jonathan Kusel, Executive Director, Sierra Institute for Community and Environment

Lisa Wallace, Executive Director, Truckee River Watershed Council

Malcolm North, Research Ecologist, USFS Pacific Southwest Research Station

Melinda Barrett, Program Manager, Mariposa County Resource Conservation District

Nic Enstice, Regional Science Coordinator, Sierra Nevada Conservancy

Naomi Tague, Associate Professor of Hydrology, University of California, Santa Barbara

Pat Manley, Research Program Manager, Conservation of Biodiversity, USFS Pacific Southwest Research Station

Randy Striplin, Regional Fuels Planner and Fire Ecologist, USDA-Forest Service

Rich Gordon, President, California Forestry Association

Richard Macedo, Branch Chief, CA Wildlife Habitat Conservation Planning Branch

Rodd Kelsey, Lead Scientist, Land Program, The Nature Conservancy CA

Scott Conway, Founder & Principal Forest Ecologist, Conway Conservation Group

Stacy Drury, Research Fire Ecologist, USDA-Forest Service's Pacific Southwest Region

Steven Ostoja, Director, USDA California Climate Hub, Forest Management Task Force Science CoLead

Tadashi Moody, Senior Environmental Scientist (Wildland Fire), CALFIRE

Ted McArthur, Forest Supervisor, USDA-Forest Service Six Rivers

Van Kane, Research Assistant Professor, University of Washington College of the Environment

Firestarters

Bill Tripp, Deputy Director of Eco-Cultural Revitalization, Karuk Tribe

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Emergency services

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Risk management

note: these individuals were interviewed but notes on their sessions were not included in the original Ethnography document delivery. Their input will be reflected in the next document iteration

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Kevin Smith, Vice President, Sustainable Finance Group, Goldman Sachs

Mike Peterson, Deputy Commissioner on Climate and Sustainability, California Department of Insurance

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Appendix 2: an oral history of organizational priorities, relationships & challenges

California—and the Western U.S. broadly—declared a war on fire in the 19th century, as wildfire threatened timber resources, a core industry at the time. Only in the last decade have land managers begun to understand that the effects of fire suppression were counterproductive to long-term risk reduction. Prescribed and controlled burns were introduced to mimic the roles that natural and cultural fire had previously played in forests. But shifting the culture around fire is a major challenge.

Land managers, scientists & foresters

In California, ~55% of wildlands are under federal management, ~40% are privately owned, and the remainder are state or municipality owned. Historically, forest management was handled by the USFS and private landowners with little to no involvement by the public. Over the last few years, decision making about community protection and forest management has started to move to the local level, and has required engaging and aligning a diverse set of stakeholders. This includes local USFS district rangers; local Calfire units; NGOs concerned about wildlife habitat, water quality, or other issues; multiple state and local agencies concerned with safety, transportation, water, air quality; and concerned citizens. But collaborative planning and management tends to be sticky due to competing interests, a lack of shared, high quality and up-to-date data & useful scenario planning and visualization tools. It can take 5-10 years to complete the planning, alignment, and permitting process for a single project.

In addition to the goal of protecting communities through restoration and risk reduction activities, foresters and land managers work to restore forest health and increase resilience in the face of climate change, pests, pathogens & regular ecological disturbance. They have four main goals:

1. *Restore forest heterogeneity and increase spacing between trees*. Stem density is 10 times higher in some places than what it was 200 years ago, after clear-cutting was followed by lack of natural disturbance, leading to dense, uniform and stressed vegetation communities. Trees are fighting for resources, and many are dying or unhealthy. The state's tree mortality count

over the past decade is estimated at 149 million and counting. Stressed trees enable pests to proliferate, exacerbated by fewer annual freezes to keep bark beetle populations in check. High stem density is like having "too many straws in the cup," exacerbating the effects of climate change-driven droughts. These stresses can be alleviated by thinning out forests, restoring natural clumps and gaps, promoting multi-aged structure, and increasing prescribed burn frequency to continuously manage fuel loads and promote regeneration

2. *Reintroduce low-intensity fire after 130 years of suppression.* Historically, low intensity fires burned through California's forests every 10-30 years, clearing the ground. This enabled keystone species like Jeffrey Pine, Sugar Pine & Ponderosa Pine to germinate from seed. Today, Pine seeds struggle to penetrate thick understory layers of duff and slash—built up from decades of fire suppression—to establish in the soil. Those that do establish also rely on chemical smoke signals to germinate, which have been suppressed. Opportunistic and fire-prone species like Fir, whose seeds more readily germinate without smoke, have established and are growing at high densities. Prescribed burns and wildfires consume duff and slash, reduce ladder fuels, and kill off some small trees, just as natural or cultural fire would.

3. *Account for the benefits of forest restoration in the context of carbon and water markets*. Restoring forest heterogeneity and reintroducing low-intensity fires has other co-benefits: rapidly cycling nutrients, increasing soil carbon, increasing habitat for biodiversity, increasing water quantity & improving water quality. Supporting restoration will require us to value nature's benefits both economically and philosophically. Economic valuation could create incentives to pay for the services healthy forests provide: carbon storage, water storage and filtering, biodiversity, recreation & improved mental well-being. As institutions acknowledge that upstream resources are rapidly degrading, policies that value nature's benefits will be put in place.

4. *Build trust among collaborators and stakeholders, including the public*. Today the people driving or making decisions on land management are mostly using data collected through manual, on the ground processes. This includes foresters, silviculturists, fuels teams, botanists, wildlife experts, hydrologists & cultural experts. Each has datasets and tools they use in their own way. Developing consistent land management planning strategies, and filing NEPA/CEQA documentation, is arduous and labor-intensive. And it's not easy

to share data or visuals among stakeholders or the public to communicate why a particular recommendation or decision is being made. This leads to unnecessary arguments and legal disputes. High visibility, high resolution data could open a new world of collaboration, transparency & trust, enabling science-driven land management to be deployed at scale.

Firestarters

Restoring fire at an ecological scale across public and private land means burning around a million acres each year. Following Governor Brown's Executive Order B-52-18, California now mandates 500k acres of treatment per year, but is only able to burn around 100k acres per year. This is due in part to a combination of air quality restrictions that limit when burns can occur, negative public connotations of smoke, a lack of consensus on how to prioritize where burns should occur, burdensome bureaucratic administration for permitting & a very small workforce of trained burn personnel. Recent legislative and agency activities seek to address these challenges.

Driven by lobbying from Fire Chief Ken Pimlott, California passed two critical bills, SB1260 and SB462 in 2018 and 2019, respectively, which were designed to help shift Calfire, USFS, and OES culture to start fires, not just suppress them. SB1260 scaled back restrictions on the level of required state oversight for prescribed burns imposed by previous legislation. SB462 established new community college-based funding, courses and accreditation to rapidly scale the workforce of qualified burn personnel, which is, as of now, critically lacking. These bills also included incentives for WUI communities to harden homes and maintain defensible space.

The California Air Resources Board (CARB) is leading a prescribed burn working group as part of the Governor's Forest Management Task Force. It has four focus areas:

- Capacity - build a comprehensive map of all planned projects to help align projects (Federal, State, private, citizens, tribes): align resources; work effectively to prioritize and plan; get everyone on the same technical platforms; support cooperation at the local level
- Prioritization - identify shared priorities for burn projects across the state
- Communication - create a sustainable culture around fire. Give citizens more control, more information. This might include communicating whether smoke

is from a prescribed burn or a wildfire, or supporting the ability to plan to be away from a prescribed burn before it occurs
- PFIRs improvements - improve burn planning & burn day approvals and sequencing. Streamline this process to support all the fires that need to be done. The goal is to make most days burn days

CARB and the USFS are also building a smoke app focused on communication and getting public buy-in to what they're doing. A lot of communication centers around conveying to WUI communities that they live in a place that will always have fire. If people in these communities see or smell smoke, agencies should be able to help them locate where they are in relation to the smoke, and where it's coming from. The EPA recently developed SmokeSense, a research tool, which CARB will leverage.

Emergency services

With more people living at the wildland-urban interface, and with catastrophic wildfires posing greater and more frequent threats to these communities, wildfire response systems are rapidly evolving.

There are four main players in California's emergency response:

- Cal OES - facilitates all information flows during emergency response. They have a small GIS team that served the central office but is shifting now to support smaller municipal OES teams
- CALFIRE - leads wildfire operations and coordinates with municipal OES teams when wildland fires approach communities. They collaborate with the USFS fire team, and protect all private and state-managed wildlands
- USFS fire team - has its own fire operations to suppress or manage wildfire on federal lands. Often collaborates directly with CALFIRE
- DoD and National Guard - recently started supporting fire response operations with military intelligence, tools, and processes. They provide data and tools to CALFIRE, USFS, and OES teams. One key resource is the Incident Awareness and Assessment Program, which deploys satellites, aircrafts, UAV, and ground sensors to help manage response efforts.

It's worth noting how new military fire intelligence is. There was a great deal of scrutiny over whether this function breached public privacy concerns, and the program took time to build. But the National Guard now has the largest fire intelligence team in the country. The RJ3 division works with the state, supports fire crews and aircraft, including initial attack assessments and airlift support, and is developing relationships with remote sensing experts to develop new satellites for wildfire intelligence.

The emergence of the DoD and the National Guard as data providers and as orchestrators is fundamentally shifting response operations and priorities, primarily through the use of command-and-control tactics. Military-style operations have increased inter-agency cooperation, facilitating information sharing among federal and state agencies. Data-based decision making paradigms have prioritized increasing access to new data sets and tools. This manifests in the deployment of more aircraft and UAV imaging / radar systems, and in new service agreements between Planet and Cal OES for rapid satellite image tasking during an emergency. It's not yet clear to us how this rapid data gathering and the use of surveillance tools for military-style fire response will impact public privacy, or if concerns over privacy will be of a lower priority than decreasing the risks posed to communities by catastrophic wildfires. It does, however, reinforce the need for shared data and analytical tools in the emergency services world, where the priority is to reduce the exposure, vulnerability & damage done to communities.